SELCUK UNIVERSITY
FACULTY OF ARCHITECTURE

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architecture
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ICONARCH I

"ARCHITECTURE AND TECHNOLOGY"

INTERNATIONAL CONGRESS

PROCEEDINGS BOOK

15-17 November 2012
Selcuk University Süleyman Demirel Cultural Center, Konya

Selcuk University Faculty of Architecture Department of Architecture
&
Selçuklu Municipality of Konya

ICONARCH I "Architecture and Technology International Congress"

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CONGRESS PROCEEDINGS BOOK

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AIM AND SCOPE

Architecture is to form livable spaces and products under the decisiveness of function, user and equipment characteristics in the direction of its own basic principles and human requirements. Act of architecture reached today from the day human being existed by changing with him. The architectural products formed within this act reflect the social, cultural and economical structure, life style and philosophy, civilization level, and the technological and cultural improvement level of their period. Social, technological and economical improvements affect and change the architecture. Technology can be defined as whole of knowledge, ability and methods required to develop a new product by drawing inspiration from scientific studies and provide the service support. The developments and transformations in technology bring along the concept of change. The scientific and technological improvements have an effective role on the development of the creativeness in architectural design. With the improvement of new materials and building systems it became possible to build high-rise buildings and span large openings by the means of more economical and lighter materials. The controllability of indoor environment comfort conditions (lighting, air conditioning, heating and cooling) is another dimension of the reflection of technological improvements on architecture.

Today, rapid developments in building systems and building materials and new information technologies affect architectural planning processes. This affection form is seen in:

- New building systems and material usage
- Design, drawing and presentation techniques.

On the other hand using sustainable and environmentalist technologies plays an important role in removing the environmental negations caused by the building sector. Technical approaches providing the ecology and technology balance in architecture make it possible to limit the fossil originated energy consumptions and use the renewable energy sources.

Moreover it became an obligation to use contemporary technologies in documentation studies (survey, restitution and restoration) of the architectural works belong to past periods. The plastic and semantic

value of the architectural formation shaped by the usage of modern technologies is a subject to handle and debate in socio-cultural dimension.
Another topic to handle will be about the technology usage in municipality services and urban planning subjects. Today using technology in new municipality services is the basis of participating, clear and citizen focused management understanding and there is a necessity to transform the planning and service presentations into electronic environments by e-municipality applications.
In this congress in international level it is aimed to handle and debate these themes in a multidirectional way.

MAIN THEMES

1- Innovative Building Techniques and Innovative Materials

-Innovative materials
-Innovative building techniques
-The effect of innovative technologies on architectural design and formation.

2- Using Computer Software in Architectural and Urban Design Processes

-Computer aided design: Parametric, interactive and script modeling, knowledge and communication technologies applications
-Usage and importance of information technologies in architectural education
-Simulation software: building performance analyses, static and thermodynamic simulation programs for architects and engineers, computational modeling
-Building physics: indoor environment quality, artificial and natural lighting, heating-cooling, acoustics

3- New Technologies for Cultural Heritage

-Using technology in Cultural Heritage Documentation and Conservation Practices
-Digital Documentation, Interpretation and Presentation of Cultural Heritage
-Contemporary techniques and technologies in documentation studies

-Information Systems Applied to Restoration, Documentation and Management of Architectural and Urban Heritage

4- Environmentalist Technologies and Architecture

-Insulating techniques and materials
-Smart buildings, automation systems in buildings
-Energy efficient design approaches, buildings with low energy

5- Architecture and Technology Relationship in Social and Cultural Context

-Reflecting technology in architectural form and new identity values

6- Technology Usage in Municipality Services

-City information systems -Interactive municipality applications
-Technology usage in urban planning: Software and GIS database usage
-Technology/City interaction in urban planning

FOREWORD

As Department of Architecture we are happy to continue our education life we started in 1970 as Konya Government Architecture Engineering Academy and changed to be Selcuk University Faculty of Architecture now in 2012. Knowing this change as an opportunity we want to take a look at the horizon in this congress.

Almost 40 years passed from the time of Alvin Toffler's foresights about future like electronic house, scattered city. Now communication and IT technologies which Toffler took as basis go beyond his foresights. However did the reflections occur in the urban planning and architecture in the same dimension? Argumentative... Why? Where are we going? What do we teach to the next generations? These should be discussed...

As one of the leading professions in society could the architecture and urban design disciplines do their duties?

What is missing?

What is our – educators – role?

Are our governors and governance understanding, our law aware of this rapid and huge change?

How much are we ready for this phenomenon as we will inevitably come across with it in close future?

We must understand the character and future of this change and direct the process. The societies which fail to transform the institutes of industrial era into institutes of this new era in a controlled and rapid way are convicted to be drowned in this new wave.

What do we do and what should we do against the phenomenon of this new era capturing our lives as architecture circle and educational institutions? To share these ideas with you and search for the truths of common mind we reserved the theme of our first congress for "Architecture and Technology". Especially we wanted to realize this with local governments and in international level. With the hope of reaching results those will be useful for both our institutes of application and our academia aiming to catch the era and go far beyond the change...

With the belief that it will open new horizons for all of us welcome to ICONARCH –I. thank you for your contributions.

Kind Regards...

On behalf of the organizing committee
Prof. Dr. Ahmet ALKAN
Dean Selcuk University Faculty of Architecture

KEYNOTE SPEECH
(15 November 2012 Thursday, 11.30-12.00)

Uğur İbrahim ALTAY
Technology Usage Of Local Governments in Urban Environment Formation

TECHNOLOGY USAGE OF LOCAL GOVERNMENTS IN URBAN ENVIRONMENT FORMATION

UĞUR İBRAHİM ALTAY[1]

Developments in the technology lead to a transformation in social dimension. This transformation formed “information society”. Technological developments – especially in IT and communication – brought brand new expectations and understandings in municipality services, city planning issues and architectural activities. Municipalities – as public institutions accomplishing the expectations of information society – are effective actors in the formation of urban environment. The spatial identity of the city is somehow determined by the local governments by the means of both the creation of urban plans and architectural arrangements in the formation of urban built environment. Municipalities provide the most qualified, pioneer ideas and projects which will be most useful for the public. The effect and the contribution of the local government in the urban environment formation can be handled in two basic scales as urban development plans and architectural projects.
The preparation of the urban development plans is one of the most effective factors determining the quality of the urban built environment and the living comfort of the citizens. The developments in technology, IT and communication affected the services of municipality in urban environment formation. Both municipality services and urban planning have reached to an effective, contemporary and productive structure by the means of Konya City Information System Project. City Information System (CIS) is an urban based application of geographical information systems formed with the aim of examining the planning, substructure, engineering, basic services and governmental information in a rapid and healthy way which is needed to make the maximum decisions in fulfilling the urban facilities.

[1] Mayor of Selçuklu Municipality, Konya TURKEY

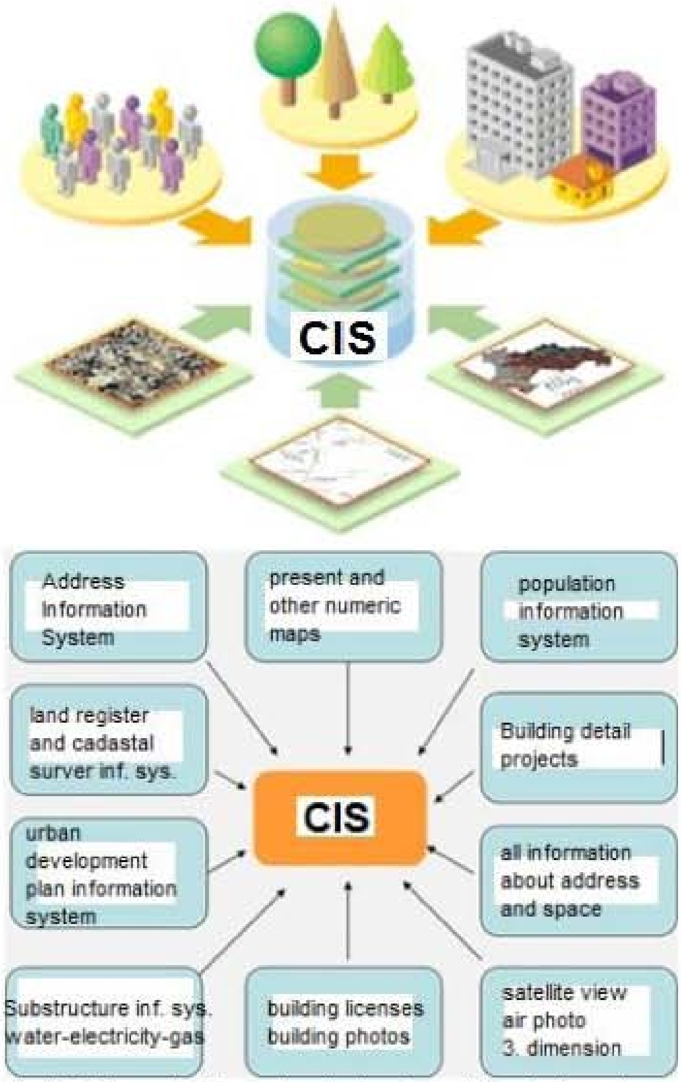

Figure 1. City Information System is effective in providing the formation of urban environment with the technology used by the local governments.

Geographical Information System Coordination Committee is formed with all institutions in Konya in 2004. As the present maps of Konya did not exist a serious and planned study is needed for constituting the system at the beginning. The formation of Information System is a structure not only limited with maps. Konya Master Plan is re-evaluated within an analyzing, evaluating and interrelating structure. The information belong to Konya like urban development plan, cadastral survey, present map, sub-structural map, water, drainage, natural gas, electricity, telephone, satellite view, land register information, tax information, socio-economical and demographical information, environmental pollution and construction license information are gathered and a database is provided by making use of technology. Local government provides an important contribution of technology to human and urban life by opening the "Konya City Guide" to public through internet. Urban development is provided as the City Information System, Ownership Information System, Address Information System, Social Texture Map and Information System, Disaster and Emergency Response Information System provide the function and actuality. Konya City Information System forms the most impressive example of using the technology in urban services with:

- Updating data directed at system analyses
- Obtaining images with high resolution
- City Guide study in web
- Digitization of Cadastral Survey Information
- Associating land register information and cadastral survey data
- Integrating cadastral survey and land register information to city information system
- Uniting urban development plans with topological data structure and integrating to city information system.
- Constituting topological data structures of present map information produced by İller Bank and integrating to city information system
- Field survey study and integrating survey data to city information system
- Making socio-economical analyses and preparing interfaces to have outputs of cartographic map.
- Having the potential of providing the software updating services with technical support to the system.

Discussions in wider expansion can be made upon the integration of urban development plans with technology in urban environment formation. However, as the agenda is about architecture and technology it will be more meaningful to concentrate on the architectural contributions of local governments to urban formation from the point of technology usage.

Any citizen even the ones have enough financial power cannot built public service buildings offered by local governments. In this sense, local governments become pioneer for the architectural identity and quality in urban environments. Local government, having the potential of producing architectural projects by using advanced technology and contemporary building materials has economical, legal and administrative efficiency to pass over the sectoral problems. It is in local governments' power to use the newest technologies, most contemporary building techniques in construction area for solving the social and spatial problems. Beside and beyond forming a synergy in quality of urban space with residence and office projects, local governments offer projects hard to realize with citizen power or individual efficiency like sport center, community home, congress center, hospital, culture home to the public. Local governments incorporate new visions to architectural environment by uniting aesthetical concerns in spatial solutions with

advanced technology while making architectural productions. In this sense living comfort of community increases and also contribution to architecture is provided by constructing new landmarks to urban identity with cultural and aesthetic values.
Selçuklu Congress Center is only one of the examples for the urban identity formed by the local government upon architecture in urban environment formation with its advanced technology in details, contemporary building materials and strong structural system. Selçuklu Congress Center should handled as a project which is an example of affecting the identity in urban environment by local governments providing good architectural projects and transferring the new technologies to pragmatic architects. Architect Murat Tabanlıoğlu designed a building here, which is a center of social integration and culture sharing, with the approach of handling independent blocks with different functions together under the same roof on 24464 m^2 site area with its 29700 m^2 construction area.
The patterns on the facade is used for solar control and provided an alive concept with its light-shadow games. This geometric form – blended with Anatolia texture by Seljuks, carrying the signs of traditional nomad culture – is stylized from the architectural heritage. The skylights on the roof provide maximum use of day light especially in foyers located between the main spaces. This space conceptually aiming the citizen to pass through itself besides spending time with various social and cultural reasons also forms a passage from the main street to the back entrance arranged as an open parking lot. The accessibility easiness is increased by this arrangement with alternative pedestrian and vehicle entrances from both facades. The square in front of the building is suggested to be "on a descriptive area of the city". It's sheltered and at the same time "open" attitude which encourage entering the building is supported by the electronic screen located on the facade towards the square. These details requiring technical perfection are the ones offered by municipalities upon architecture to urban environments. Visual communication of the activities and programs for the public is thought to be a fact increasing the attention. According to the architectural organization of the building, all spaces are open to common usage, also terraces and semi-open foyers create open air areas. The square surrounding the building is designed in a way to create possibility for urban meetings, open air exhibitions and activities. Murat Tabanlıoğlu mentioned that open exhibitions can be arranged in congress center in summer months. While he says "the terraces will be arranged with seating areas in spring-autumn months and this place will start to be a part of the city" actually he uses completely possibilities that technology offers to architecture.

Figure2. Selçuklu Congress Center Project is an example for the service offered by the local governments to the urban environment formation with usage of technology and architectural values.

Information society looks at the service offers with the focus of efficiency, speed, decrease in bureaucracy, transparency and sharing the administrative control. Usage of technology in municipality services is inevitably effective in both architectural projects and urban environment formation. City information system determines the urban environment formation in urban scale while contemporary building technologies provides it in architectural scale. The important fact is constructing the cities of future without compensating from sustainability, human rights, ethics and aesthetics and leaving more qualified environments to next generations.

KEYNOTE SPEECH
(15 November 2012 Thursday, 13.00-13.30)

Prof. Godfried AUGENBROE
Support of Energy Retrofit Decisions at Mutliple Scales

SUPPORT OF ENERGY RETROFIT DECISIONS AT MULTIPLE SCALES

GODFRIED AUGENBROE[1]

With contributions from:
Yeonsook HEO (Argonne National Lab)
Paola SANGUİNETTİ (Kansas University, School of Architectural Design and Planning)

ABSTRACT

This overview paper chronicles two recent projects conducted by the research group of the author dealing with retrofit decision-making at different levels of aggregation. Inspection of the projects reveals the contrast in resolution and scope of decision making that is typical of different retrofit contexts. At the aggregate level the benchmarking across a portfolio of buildings is supported including the selection of candidates for improvement. At the individual building level a drill-down analysis is supported by two modes of audit models, a calibrated simple normative model and a high fidelity dynamic simulation model. Both models contain explicit representations of uncertainty in the parameters and model assumptions and can thus be used to quantify the spread in energy performance of the proposed retrofit. This result is vital to support risk-conscious decision-making for retrofit stakeholders. This paper summarizes the findings of the two projects.

1. INTRODUCTION

Heo et al. (2012b) summarize the retrofit necessity and energy saving potential pointing to the fact that increasing the energy efficiency of existing buildings is one of the best ways to save energy and reduce CO_2 emissions. McKinsey & Company estimate a potential of 1.1 Quads in energy savings in retrofitting existing private and public buildings, not considering plug loads (Granade et al., 2009). In a meta-analysis on retro-commissioning projects for 643 existing buildings, Lawrence Berkeley National Laboratory found that existing buildings contain energy inefficiency problems in heating and cooling plants, distribution systems, lighting

[1] Prof., College of Architecture, Georgia Institute of Technology, Atlanta, GA

systems, and building envelope that, when retrofitted, yielded a median energy savings of 16% (Mills, 2009). These studies and energy data trends point to energy retrofits of existing buildings as essential to achieving reduction targets in energy consumption and CO_2 emissions from the commercial building sector.

In response to this need, federal, state, and city governments have established retrofit initiatives and programs to promote the reduction of energy consumption by the building sector. President Obama launched the "Better Buildings Initiative" with a target of reducing energy consumption by 20% in commercial buildings by 2020 through cost-effective retrofit interventions (White House, 2011). In response to the initiative, organizations so far have committed to enhancing the energy performance of 1.6 billion square feet of floor area (EERE, 2012). Reaching these targets will rely on the decisions made by public agencies in planning policy and incentives, utilities in executing energy efficiency programs, financiers in providing capital to the market, energy service companies in developing their business models, and building owners in investing in energy efficiency retrofits. These stakeholders face decisions that span individual buildings, portfolios of buildings, and large aggregates of buildings and are constrained by various degrees of available information about each building. Their decisions will be based on evaluations of the cost, benefits, and risks associated with the implementation of energy efficiency technologies. Currently, there are gaps in the analytic tools available to support these decisions.

The energy service company (ESCO) business model highlights one gap in decision support. For their retrofit projects, ESCOs typically perform an audit to evaluate the potential energy savings of feasible energy efficiency measures (EEMs). The audit involves collecting data about actual building physical and operational characteristics, establishing an energy baseline of the building, and evaluating the effects of EEMs. Moreover, ESCOs need to quantify risks associated with EEMs because their service is based on some form of energy savings guarantee or performance contracting that guarantees certain savings and compensates the customer for what has not been realized according to the contract clauses. In practice, they often rely on their historical experience and expert judgment to estimate energy-saving potential of candidate EEMs and quantify underperformance risks. The rule-of-thumb approach based on expertise tends to limit the set of EEMs to those with proven records while not properly evaluating all possible EEMs including advanced retrofit technologies. Properly supporting energy retrofit decisions can be realized by a formal method that can evaluate all feasible EEMs while accounting for all major sources of uncertainty.

Improving the energy efficiency of a large set of buildings requires a new generation of scalable and adaptable modeling methodologies. A new retrofit analysis framework discussed below is based on simplified and normative energy models that greatly enhance the cost-effectiveness of the analysis process cutting down on data collection, modeling, and computation effort.

2. URBAN SCALE ENERGY RETROFİT MODELİNG

The following summary is based on (Heo et al, 2012b) which articulates a scalable methodology as the core of a retrofit decision-making environment to support two distinct levels of analysis:
(1) Aggregated level decision-making by policy makers and planners. This analysis inspects buildings in a large portfolio to inspect the effects of different energy improvement scenarios over time. At this level, one can decide which level of intervention in certain categories of buildings is necessary to reach an overall energy improvement target.
(2) Individual level decisions by the building owner, i.e. the selection of the right mix of energy efficiency measures (EEM) while adequately recognizing financial risks associated with them. At this level explicit information about performance risks related to certain EEMs is made available to enable risk-conscious selection of measures.
In our framework, decisions at both levels are informed by normative building energy models for the reasons indicated above. At the individual level the normative energy models are refined through a Bayesian calibration to allow a more accurate prediction of the effect of each EEM choice on energy efficiency improvement. More information about the normative energy model can be found in (Heo et. al., 2011) and (Hogeling and Dijk, 2008).
The Bayesian calibration approach starts with specification of prior probability distributions for uncertain parameters and based on measurement data generates a set of accepted parameter values as posterior distributions. The calibration process is described in detail elsewhere (Heo, 2012a).
The retrofit decision framework draws from an exhaustive list of common retrofit technologies in the current market, stored in a database. The database includes 30 retrofit technologies for envelope, HVAC, lighting, DHW, appliance, and building energy management systems. The database further defines the input parameter adjustments that are required to represent the retrofits in the normative energy model. The details have been summarized by Zhao et al. (2011).

3. A RETROFIT EVALUATION AND DECISION ENVIRONMENT

Figure 1 shows the components and interfaces of the overall system in the Retrofit Decision-Making Environment. The two level analyses are based on normative energy models, but have different approaches in treating normative models and translating decision-making contexts.
The aggregate-level layer strictly follows the normative model standard and scenarios to benchmark buildings and evaluate the effectiveness of retrofit scenarios. This layer uses the energy model without calibration and is based on a deterministic analysis as this is deemed adequate for comparative raking and benchmarking.
The individual-level layer tackles the questions of what energy savings are achievable in absolute terms from EEMs and at with what level of confidence can we guarantee these savings. Hence, we apply two additional calibration steps in this

layer: (1) operational adjustment based on site visits and measurements, and (2) parameter estimation based on the Bayesian approach, such that the resulting baseline model can accurately reflect a building as operated and reliably predict potential energy savings from candidate EEMs. This layer no longer follows normative scenarios for building usage and operation, but makes operational adjustments to the model parameters such that the model is in alignment with actual building operation. Furthermore, this layer calibrates the model on the basis of the Bayesian approach to enhance the reliability of the baseline model and quantify uncertainty in the energy use predictions. Then, we incorporate uncertainties associated with the EEMs to provide probabilistic predictions of retrofit scenarios.

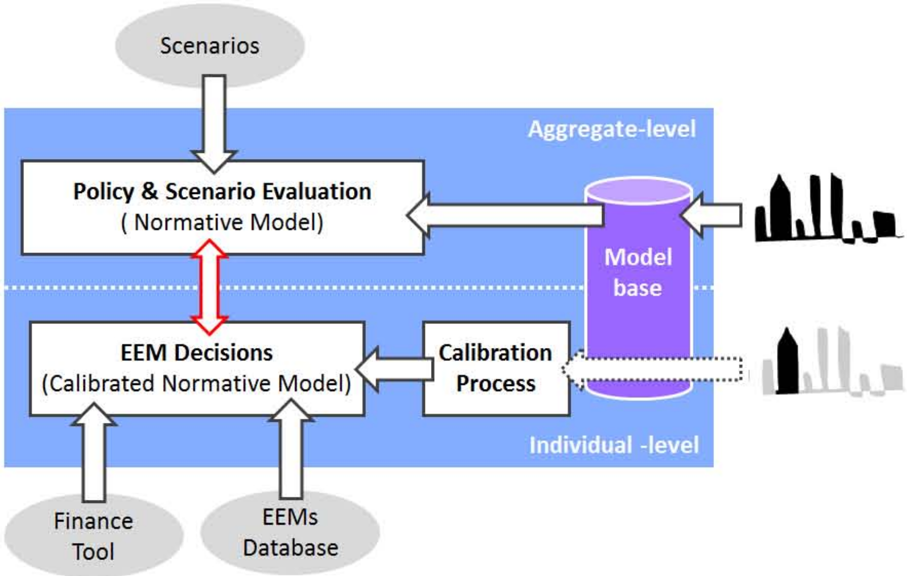

Figure 1. Scheme of the analysis environment

4. EXAMPLE ANALYSIS

Table 1 shows a typical example of the aggregate level analysis for a portfolio of seven buildings. It shows EPCs calculated for all buildings. These data show a significant range of energy performance amongst the seven buildings and indicate buildings with the greatest thermal loads and least efficient energy systems. The EPC_{need} and EPC_{del} are normalized outcomes of the energy demand and energy consumption. They are used as benchmark data point to the possible improvements that could be achieved by upgrading both the building envelopes, the mechanical and lighting systems etc. in the buildings.

The value of benchmarking with the normative energy model is the capability to evaluate the performance of buildings independent of differences in how they are occupied or operated. Further comparison of model benchmark outcomes against those based on measured energy consumption (for example Energy Star Portfolio Manager) will provide a deeper understanding of the actual versus normative energy use in the buildings and the focus areas for energy improvements.

Table 1. EPCs of seven case buildings

BUILDING	EPC_{need}	EPC_{del}	EPC_{pri}
Building 1	1.0	1.0	1.0
Building 2	1.8	1.6	1.9
Building 3	1.5	1.8	1.8
Building 4	1.5	1.8	1.4
Building 5	1.3	1.4	1.3
Building 6	1.5	1.5	1.4
Building 7	1.3	1.3	1.1

As the next step we chosse a set of retrofit palettes by grouping specific retrofit technologies. Then, we associate different palettes with different sets of buildings to create competing retrofit scenarios. Table 2 shows a typical result for retrofit palette 1 and retrofit palette 2 applied to the seven buildings.

Table 2. Specification of the two retrofit palettes

PALETTE	ENERGY EFFICIENT MEASURES İN PALETTE
1	High-efficiency Chiller / Energy Recovery Occupancy Sensor / Infiltration Reduction /
2	High-efficiency Chiller / Energy Recovery Occupancy Sensor / Infiltration Reduction / Triple Glazing, Low-e

We can now evaluated different retrofit scenarios in relation to a policy target or a mandated 30% energy reduction. Figure 2 for example shows that scenarios 1 and 2 reduce the total delivered energy expressed as Energy Use Intensity (EUI) by 10% and 20%, respectively, in comparison to the baseline. The results suggest the need for more aggressive retrofit strategies to achieve the 30 % savings target (green bars).

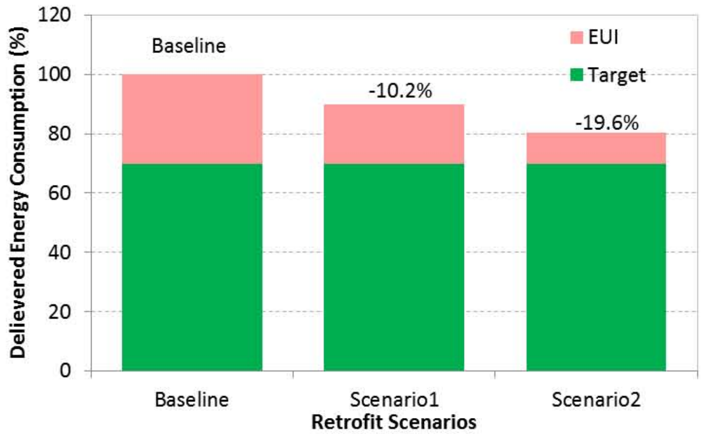

Figure 2. Effects of retrofit scenarios on energy consumption at aggregate level

5. DRILL DOWN INTO A SPECIFIC BUILDING RETROFIT MEASURE

The above approach is suited for large scale energy improvement planning. In many cases the underlying building energy model may not be accurate enough to correctly analyze an EEM in a specific building, especially when accurate information about energy savings potentials and costs of EEMs is necessary to make the right investment decisions. In those cases the normative model parameters need to be identified suchj that the model reflects the observed energy performance of the building. The calibration approach starts with an initial assumption of the parameter values. As we are using a Bayesian technique we need to estimate the prior distributions (rather than a single value) of these parameters.
Table **3** gives a snapshot of a particular example, showing the minimum, and the maximum value for model input parameters, compiled on the basis of industry reports, standards, and technical reports.

Table 3. Range of uncertainty in model parameters

PARAMETER	BASE	MIN	MAX
Roof U value (Btu/h·ft²·°F)	0.09	0.08	0.10
Roof Solar Absorptance	0.63	0.43	0.83
Roof Emissivity	0.91	0.87	0.85
Wall U value (Btu/h·ft²·°F)	0.09	0.08	0.10
Wall Solar Absorptance	0.63	0.43	0.83
Wall Emissivity	0.91	0.87	0.95
Window U value (Btu/h·ft²·°F)	0.32	0.29	0.36
Window Solar Transmittance	0.22	0.16	0.26
Envelope Heat Capacity (Btu/ft²·°F)	0.81	0.60	1.02
Heating Temperature—Occupied	72	68.5	75.5
Heating Temperature—Unoccupied	65	61.5	68.5
Cooling Temperature—Occupied	70	66.5	73.5

Cooling Temperature—Unoccupied	75	71.5	78.5
Occupancy Density (ft²/person)	208	46	245
Occupant Metabolic Rate (W/person)	80	70	130
Appliance Power Density (W/ft²)	1.63	0.56	3.16
Lighting Power Density (W/ft²)	1.34	1.11	1.58
Cooling System Mean Partial Load Index	0.84	0.83	0.99
Cooling Distribution Loss Factor	0.00	0.00	0.15
DHW System Efficiency	0.91	0.88	0.95
DHW Distribution System Efficiency	0.60	0.54	0.66
Infiltration Rate (ACH)	0.15	0.10	1.25

For a detailed account of the calibration technique we refer to (Heo, 2012a). The outcomes of the calibration method are the posterior distributions. To explain the idea, Figure 3 shows the calibration results (blue histograms) of two parameters against the prior beliefs (red lines). The heating temperature during the occupied hours proves to be likely to be 2°F higher than the expected prior estimate, while that during the unoccupied hours does not change much from the prior estimate.

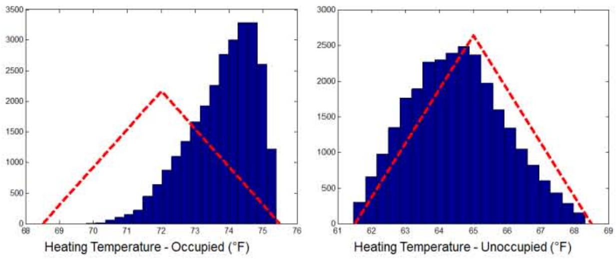

Figure 3. Calibration results for the setpoint temperatures in occupied and unoccupied zones (prior – red, posterior – blue)

The resulting calibrated model can now be used to study the different retrofit palettes. The outcomes are energy saving probabilities rather than deterministic predictions. Thus, the outcomes present (1) the energy savings achievable with the retrofit palette and (2) the magnitude of risk associated with those savings. Figure 4 shows a box plot of energy savings from the two retrofit palettes introduced above. The bottom and top bars of the box indicate the lower and upper quartiles, and the range between the whiskers includes about 99% of the distribution. The box plot suggests that the possible savings from retrofit palette 1 range between 9% and 12%, while the savings from retrofit palette 2 fall between 12% and 17%.

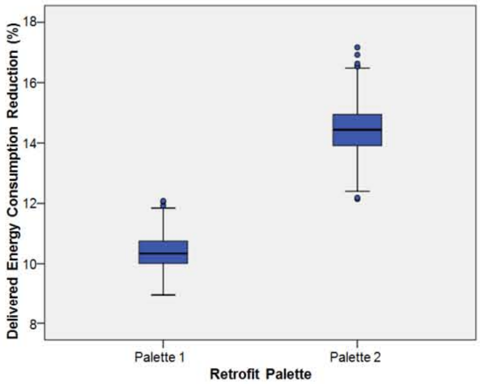

Figure 4. Effects of retrofit palettes on energy saving

6. DEEP RETROFIT DECISIONS SUPPORTED BY DYNAMIC SİMULATİON MODELS

Retrofit decisions cannot always be based on the calibration of simplified models. In some cases one has to resort to dynamic simulation models. This is for example the case when the EEM itself contains large physical uncertainty that obviously not be resolved through pre-retrofit calibration. An obvious example is a deep façade retrofit where the quality of the new façade improvement with respect to air leakage can only be guaranteed within certain limits of performance. The following is a summary of the work reported in (Sanguinetti, 2012).

Deep façade retrofit decisions should be related to a confidence level in the expected energy performance after the retrofit. If the confidence level can be computed, it can be used in a financial gain model with explicit quantification of the probability that a certain RoI will be achieved. Growth in the financial sector of the sustainable building market has in fact shown that the approach to the retrofit decision has changed from a lifecycle cost to an investment opportunity (Bernstein et al. 2008; Managan et al. 2012). In addition to owners and developers, a third group of stakeholders is beginning to play a key role in the investment decision. For example, the Property Assessed Clean Energy (PACE) and Managed Energy Services Agreement (MESA) models are two alternative financing models that involve the key stakeholders in the energy retrofit investment decision: the owner, the finance provider and the municipality or ESCO. From this investment perspective, the expected revenue must be evaluated against a quantification of the risks for each of the involved stakeholders. The ultimate decision will be the one that offers the most gain to each partner, without exceeding the risk accepted by any.

Two sources of uncertainty affect the façade retrofit evaluation: exogenic sources, such as the effect of the financing model on the cash flow calculation; and endogenic sources, such as the physical behavior of the façade retrofit components. Figure 5 shows how these uncertainties can be classified by their impact on investment and building performance assessments. Financial uncertainties in the investment assessment are linked to four sources: government financial incentives, interest payment depending on the financing model, initial investment of retrofit construction, and the cost savings due to improved building performance. Cost savings from the façade retrofit are obtained using an energy model for the building performance assessment. Four other sources affect this calculation: uncertainty in the scenario assumptions, physical behavior of the building systems, simplifications, and errors inherent in the energy model abstraction (Sanguinetti, 2012).

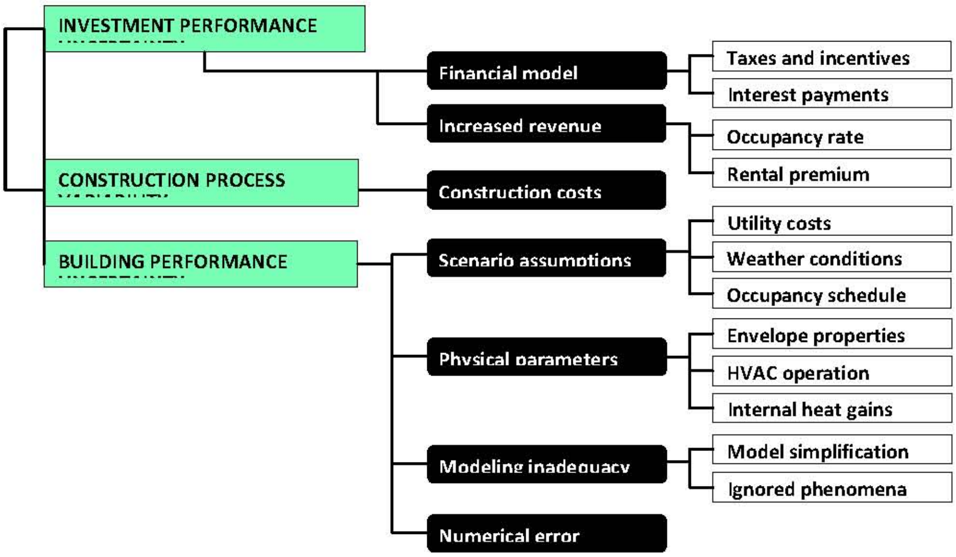

Figure 5. Sources of uncertainty in a facade retrofit evaluation

The integrated framework proposed in (Sanguinetti, 2012) accommodates varying approaches to investment risk. For the selection of a façade retrofit alternative, the final evaluation for retrofit selection involves:

- Determination of two reference values: minimum risk threshold, Tr, and a confidence target, Tc.
- Quantification of confidence and risk for each scenario could then be stated as follows:

$$P_{confidence} = \Pr\ y \geq Tc$$
$$P_{risk} = \Pr\ y < Tr$$

where y is the normalized improvement in the Net Present Value (NPV) of the façade, i.e. NPV of the retrofit investment divided by the NPV of a base case or existing (reference) condition.

Within this framework the selection of the most desirable retrofit alternative could be based on $P_{confidence}$ and P_{risk}, assuming that the decision maker can express his attitude towards expected gain and acceptable risk in the choice of these two (subjective) factors. Note that these factors represent a poor man's formulation of utility theory based decision-making.

7. CASE STUDY OF DEEP FAÇADE RETROFİT

Sanguinetti (2012) performed an analysis of three energy retrofit scenarios involving changes in the facade of the apartment building shown in Figure 6.

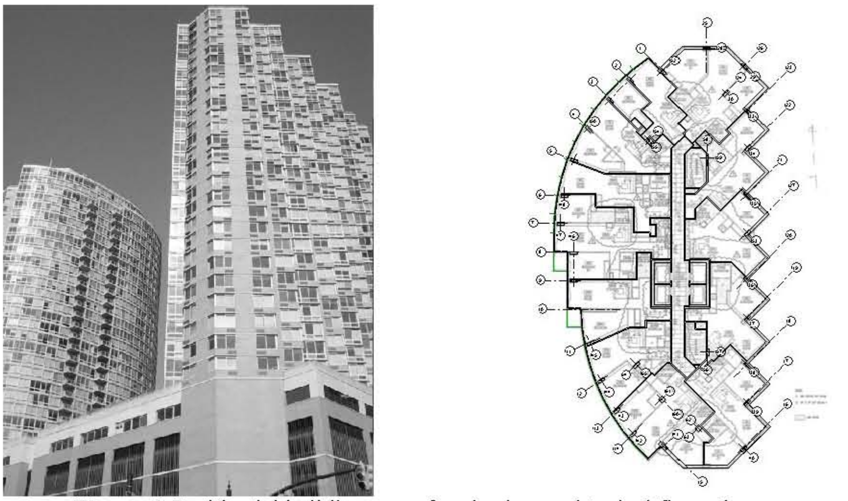

Figure 6. Residential building case, facade view and typical floor plan

A façade retrofit was proposed to increase energy efficiency and improve thermal comfort. Apartment renters complained of high utility bills. The façade was to be retrofitted to update the aesthetic appearance of the building and reduce the impact on energy consumption. Adding a new internal layer to the façade or replacing façade components were considered viable alternatives based on the potential to reduce energy use and the associated implementation costs. Table 4 provides list of three considered energy efficiency scenarios for the façade, including a description of the retrofit measures and financial models.

Table 4. Retrofit scenarios considered in the case study

Scenario	Retrofit measure	Retrofit delivery	Financing model
1	Low-e storm window through DOE bulk program (~25% reduced leakage)	Typical energy efficiency	PACE
2	Low-e storm window and air seal (~60% reduced leakage)	Deep retrofit	PACE
3	Window and packaged terminal heat pump (PTHP)	Deep retrofit	MESA

The analysis for each retrofit scenario involves an energy performance and comfort study of the pre- and post-retrofit situation. Given the fact that considerable uncertainty resides in the façade properties after the retrofit, special care was given to this in the whole building model. Therefore a sensitivity analysis was conducted to identify the most sensitive window parameters impacting the energy performance of the façade. A base case model of the window assembly was created in Therm 5 (LBNL 2012) and subjected to a detailed analysis. A result of THERM is shown in Figure 7.

Figure7. Example visualization of heat transmission at window head (before and after retrofit)

The analysis led to a good estimate of the uncertainties in the U-value and Solar Heat Gain Coefficient (SHGC) which were consequently used as input parameters in the whole building energy model, which was simulated for a full year of weather data. Uncertainties were propagated into the outcomes using a standard Monte Carlo approach. A similar (but more detailed) set of parameter uncertainties as listed in table 3 was included in the Monte Carlo approach. They are classified into physical façade parameters, building system and operation parameters, and financial cost parameters. For the cost analysis parameters, the National Residential Efficiency Measures Database (NREL 2012) was consulted to determine the associated first costs for each scenario. The National Institute of Standards and Technology (NIST) escalation rates for the cost of electricity were used for Net Present Value calculations. Other financial parameters were fixed including the 5% discount rate stipulated for (in this example) PACE financing.

The cost study found that scenario 1, which adds a new low-e storm window and reduces air leakage by approximately 25%, has the lowest cost and the narrower margin of error. Retrofit scenario 2, has the largest margin of error among the three options. Adding a new low-e storm window with an air leakage reduction of 60% will cost as much as replacing the window and changing the PTHP window unit.

The energy study found that a new low-e storm window and with an air leakage reduction of 60%, has the largest percentage of energy savings, ranging between approximately 10 to 23%. Retrofit scenario 3, which replaces the windows and the PTHP units, has the narrower margin of error. There is a lot of overlap in the results between scenarios 1 and 3, which means that in terms of savings, adding a new low-e storm window and with an air leakage reduction of 25% has the potential of producing the same amount of energy savings' as replacing the window and changing the PTHP window unit.

A thermal comfort study was also conducted; for details refer to (Sanguinetti, 2012). The effects of the thermal performance were translated into a rent increase and thus translated to additional contributions to the aggregated net present value of each retrofit scenario.

When all results were brought together and NPV computed for aq 20 year horizon, the following result (Figure 8) was found when plotted on the P_{risk} and $P_{confidence}$ axes:

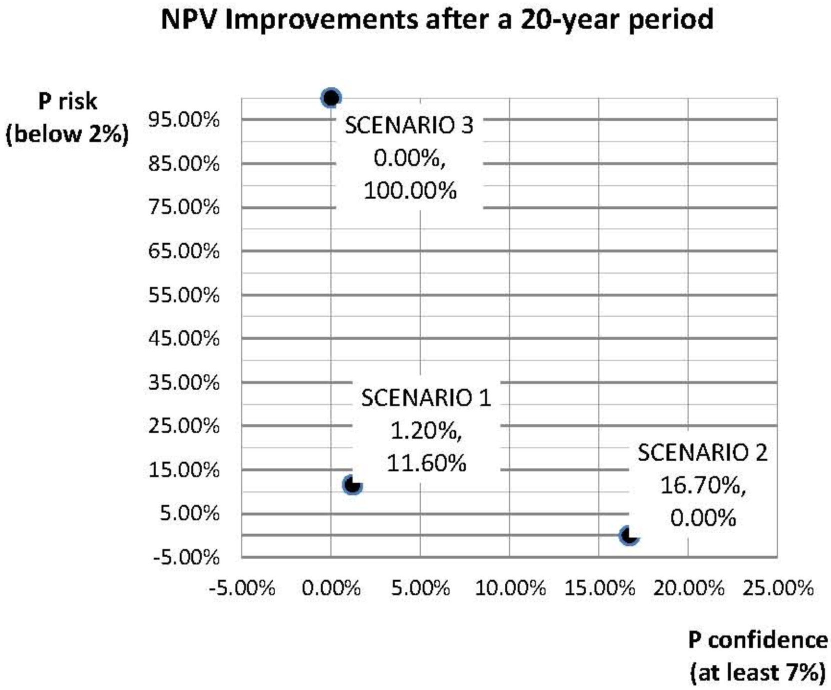

Figure 8. NPV comparison based on confidence target and risk threshold

It is obvious that scenario 2 gets the top ranking, with a 16.7 % confidence in meeting the target NPV improvement and 0% risk of being below 2%. Scenario 1 has a 1.2 % confidence in meeting the target NPV improvement and 11.6% risk of being below 2%. Scenario 3 is the riskiest option because there is a 100% probability of being below 2% improvement.

8. FİNAL REMARKS

We have discussed risk conscious selection of façade retrofits based on expected performance with consideration of uncertainty in energy and comfort assessments as well as uncertainties in cost predictions. Different model fidelities have been proposed for different levels of aggregate decision making. The ultimate decision will be driven by the (subjective) threshold of confidence and risk of the stakeholders involved in the decision. The framework and its embedded models will be tested in more retrofit situations, with different stakeholders, different contracting methods, and multiple retrofit intervention technologies.

ACKNOWLEDGEMENTS

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SESSION 1

15 November 2012 Thursday, 13.30-14.45

Topic: Innovative building techniques and innovative materials, Environmentalist technologies and architecture

Chairperson: Assoc. Prof. Dr. Pieter De WILDE

Res. Assist. Onurcan ÇAKIR, Tech. Josef LECHLEITNER, Prof. Dr. Ardeshir MAHDAVI
Simulation Model Assessment of a Sound İnsulating Double Façade System With Openings For Natural Ventilation Under Guidance of Laboratory Measurements

M.sc. Eng. Hanaa DAHY, Prof. Dr. Jan KNIPPERS
Rice Straw Fiber Bicomposites Potentials in Contemporary Architecture

Linda SKORUPPA, Res. Assist. DI. Ulrich PONT, Dr. DI. Matthias SCHUß, Res. Assist. DI. Robert ZACH, Prof. Dr. Ardeshir MAHDAVI
Field Station of the National Park Academy in Petronell, Austria: a case study evolving thermal performance expectations

Assist. Prof. Dr. Gülsu ULUKAVAK HARPUTLUGİL
Assessing The Accuracy Of National Calculation Methodology Of Turkiye (Bep-Tr) By Using Bestest

Res. Assist. Selcen Nur ERİKCİ
Building Energy Performance (Bep-Tr) As a Calculation Methodology: Comparison With Other Energy Certifications

SIMULATION MODEL ASSESSMENT OF A SOUND INSULATING DOUBLE FAÇADE SYSTEM WITH OPENINGS FOR NATURAL VENTILATION UNDER GUIDANCE OF LABORATORY MEASUREMENTS

ONURCAN ÇAKIR[1]
JOSEF LECHLEITNER[2]
ARDESHIR MAHDAVI[3]

ABSTRACT

Noise control and natural ventilation are two main building physics issues which have contradictory principles. While natural ventilation needs openings on the façade in order to let fresh air in, the desired acoustic insulation is provided with minimum openings or without any opening on the wall. This paper presents a comparison between the simulation model results and laboratory measurements of a double façade system which is proposed in order to minimize outdoor noise coming through façade openings in naturally ventilated buildings. The double façade with twenty five openable equal-size particleboard panels on each side was constructed as a full scale model in the laboratory and the same setup was modeled in a computer simulation program. Different parts from these two parallel walls were taken out and the effect of the distance between these openings on the sound reduction value of the system has been analyzed. After the measurements; materials, their sound absorption coefficients and the reverberation times of two rooms were calibrated in the simulation program accordingly and simulations were run in order to check if it would be possible to continue this research only with computer models. The results are compared and differences between the simulation and laboratory measurements are stated in this paper.

Keywords: Noise control, natural ventilation, acoustics, sound insulation, simulation.

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1. INTRODUCTION

Ecologic approaches lead architects to behave more carefully about protecting natural resources and therefore to design energy efficient buildings. Technology brought houses many comforts mostly by using extra energy. Thus, conventional physical environment methods came out to solve this problem, but with modern materials and techniques. Natural ventilation is one of the ecological solutions for indoor air quality which has also economic benefits since no additional active systems will be necessary. However, natural ventilation and sound insulation have contradictory principles because natural ventilation requires openings on buildings' facades while openings reduce the acoustic insulation rate of the facade.
Inhabitants are mostly annoyed by road traffic as noise source and people are unsatisfied with their neighborhoods mostly because of noise problems (Kuerer 1997). There are different ways to attenuate sound during natural ventilation. Acoustic louvres, elevated screens, balconies, courtyards and porous duct linings can be used for attenuating mid to high frequencies; quarter wave resonators and Helmholz resonators for low to mid frequencies; panel resonators and active noise control for low frequencies; and closable apertures for all frequencies (De Salis et al. 2002). Former studies show that the expected sound insulation performance of an open window is approximately between 10-15 dB according to international and regional standards (Nunes et al. 2010). The scientific report of Napier University provides results of a series of measurements done with seven window models and with a total of twelve different opening types (Napier University 2010). Open window sound transmission is assumed to be through a 0,05 m^2 opening and the measured Dw results are between 14 and 20 dB. It is also found that increasing the open area on the façade reduces the level of acoustic insulation. The glazing specifications and frame materials did not affect the sound attenuation of open windows.
Taking former research into consideration, a modular double façade system is designed in order to have natural ventilation and acoustic control at the same time (Mahdavi et al. 2012). That study introduced the laboratory measurement values as base for this present paper. During the design stage of this flexible structure, the sound phenomena 'diffraction effect of barriers', 'sound absorption by reflection' and 'the attenuation due to distance' are taken into consideration. In this system, two particle board walls are designed which are carried by an aluminium structure. Each wall consists of twenty five removable parts, which can be considered as windows of the façade system. By arranging the openable windows vertically reverse situated on the inner and outer side of the double facade, direct sound paths from the lower side (e.g. traffic road) will be prevented geometrically. Similarly, using a shifted irregular aperture arrangement on the inside and outside in the horizontal direction will provide sound attenuation due to the diffraction effect of closed parts. Figure 1 represents the main principles of this system on a schematic plan diagram.

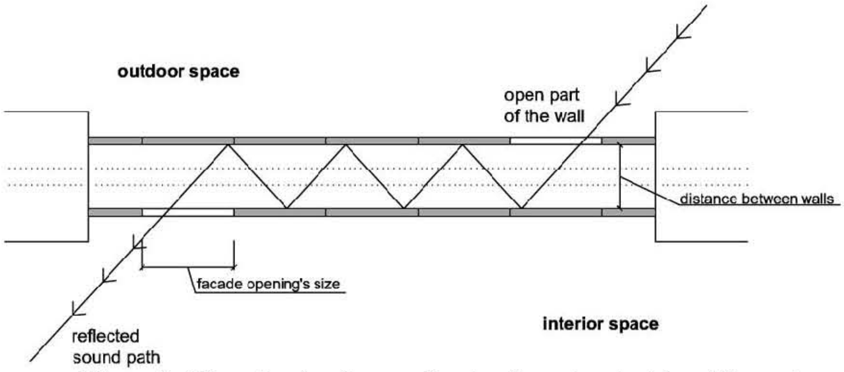

Figure 1: Schematic plan diagram showing the main principles of the system.

In order to test the performance of this structure, laboratory measurements and computer models are carried out. Laboratory measurements and simulation model calculation results from the computer program Odeon are compared and analyzed in order to check the reliability and conformity of the simulation program to continue the study without measurements.

2. COMPUTER SIMULATION MODEL

2.1. Room Setup

Acoustic measurements are done in the Building Science and Technology Laboratory of Vienna University of Technology. A grid aluminium frame structure is designed for building up a double facade model in the opening between two rooms in the laboratory. The opening is 3,08 m high and 3,08 m wide. The distance between two walls of the proposed double façade model is 35 cm. Each wall of the double façade has a fixed frame part outside with the width of 29 cm. The five to five grid structure inside this frame consists of square divisions with the dimensions 50 x 50 cm. In order to define all parts of the grid clearly, each element is given a certain number on each side of the double façade as it can be seen from Figure 2.

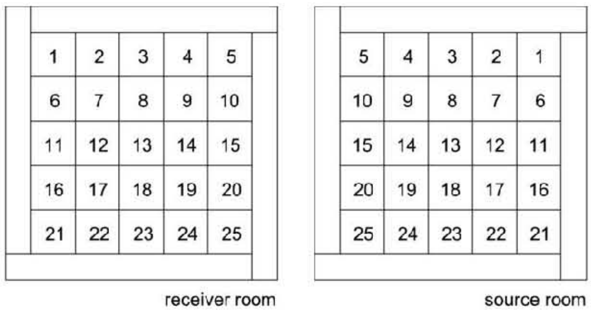

Figure 2: Numbering the removable grid parts of both walls.

A computer model with the same room dimensions and settings is prepared in order to check the possibility to get near results to the laboratory measurements. A 'dxf' file of the model, which can be seen on Figure 3, is created with layers according to materials and this file is imported into the program 'Odeon version 9.2'.

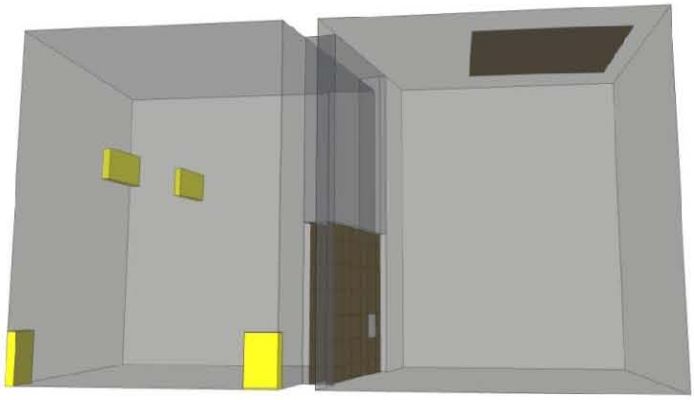

Figure 3. Source and receiver rooms in the simulation.

Two source positions and five receiver positions for each source point according to the standard ISO 10140-4 are determined as shown in the Figure 4 (ISO 2010).

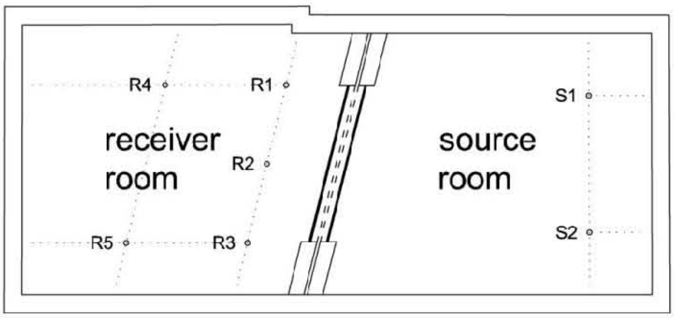

Figure 4. Plan of the source and receiver positions both in laboratory and simulations.

2.2. Calibration

In order to make a reasonable decision about the sound absorption coefficients (α) of each material in the room, the reverberation times according to laboratory measurements and the Odeon simulation results have been calibrated. Table 1 shows the α values which are used for the computer simulations.

Table 1. Absorption coefficient values which are used in computer simulations.

Absorption coef. (α)	**125**	**250**	**500**	**1000**	**2000**	**4000**
Concrete (for walls)	0,02	0,03	0,04	0,04	0,04	0,04
Rockwool	0,53	0,98	0,98	0,97	0,97	0,97
Particle board (sanded)	0,04	0,04	0,06	0,06	0,04	0,04

In the receiver room, rockwool plates are placed in order to have reasonable reverberation time values. With the aid of properly selected materials, a great agreement is reached between the laboratory measured reverberation times and simulated values as seen in Table 2. Experiment walls in Odeon are defined as 'transmission walls' which allow sound transmission according to their R values for each one-third octave frequency.

Table 2: Reverberation time comparisons of lab. measurements and Odeon results.

Reverberation Time [s]	**125**	**250**	**500**	**1000**	**2000**	**4000**
Receiver Room - Odeon	3,65	2,84	2,22	2,14	1,96	1,52
Receiver Room - Lab.	3,80	2,63	2,37	2,48	2,16	1,50

3. RESULTS

The cases 'one closed wall' and 'two closed walls' are examined firstly. The comparison between the sound reduction values for the façade structure derived from Odeon simulation models and laboratory measurements are given in the Figure 5.

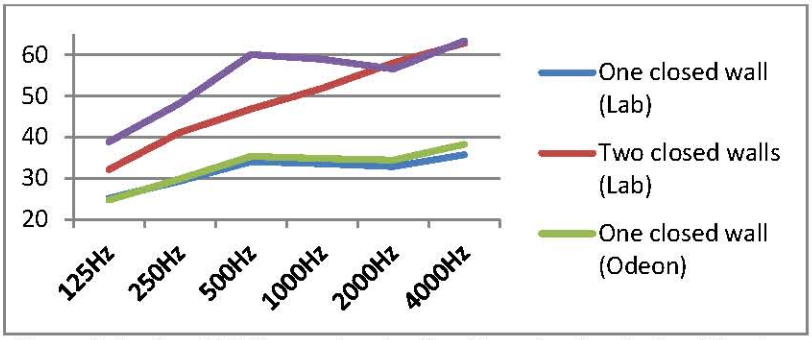

Figure 5. R values [dB] for one closed wall and two closed walls from laboratory measurements and Odeon simulation program.

In the case 'one closed wall', simulation and laboratory measurement results tend to be quite similar to each other even though they have some small differences. In the case 'two closed walls', Odeon overestimates the sound level difference between the rooms at lower frequencies between 125 and 1000 Hz, where it slightly

underestimates at high frequencies like 2000 and 4000 Hz. Especially at 500 Hz there is a major difference between laboratory and Odeon results.
Secondly, the removable grid element with the number '6' on the receiver room side is kept constantly open. On the source room side, the elements '16-17-18-19-20' are erased in the simulation one by one and calculations are done. The graphical comparison of the cases with one opening on each wall according to Odeon simulation results is shown in the Figure 6.

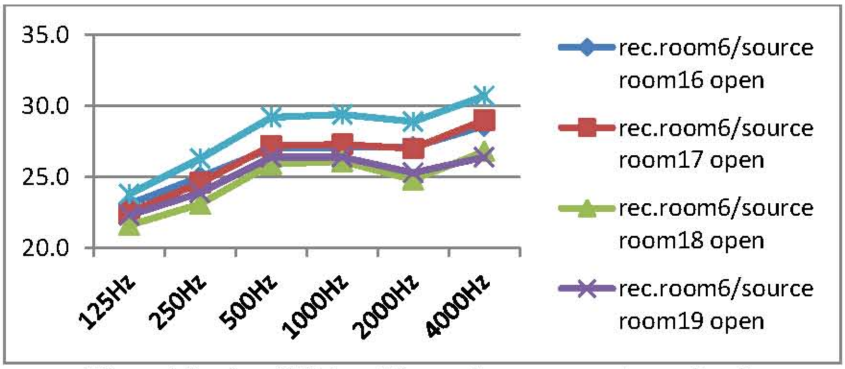

Figure 6. R values [dB] from Odeon with one open part on each wall.

In order to compare the values, sound reduction values depending on frequencies taken from laboratory measurements are given in the Figure 7. Taking both the values from Odeon and laboratory measurements into consideration, following interpretations can be done:

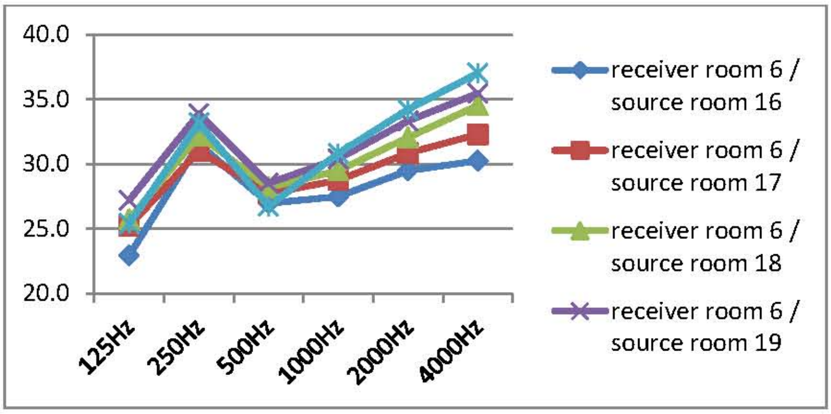

Figure 7. R values [dB] from lab. measurements with one open part on each wall.

It would have been expected that the sound reduction were greater due to diffraction effect when the distance between the inner and outer wall apertures increased. The laboratory measurements show similar results to this prediction with some differences. At high frequencies like 1000 – 2000 – 4000 Hz the order of the graphs is as it was expected; in other words, the sound reduction increased when the distances between the apertures were increased. But at 500 Hz, the case 'receiver room 6 / source room 20 open' has lowest sound attenuation compared to the other cases, while the other cases' graphs continue the predicted right order. At 125 and 250 Hz there are also some slight changes in the order of sound reduction values. It is also recognizable that all cases' R values, in general, have the tendency to increase especially at the frequency 250 Hz, while they mostly have a regularly raising graph line at other frequencies.

Analyzing Odeon calculations, same assumptions were valid again, as it was by laboratory measurements. The simulation calculations show quite different results to these predictions. The case "receiver room 6 / source room 20 open" has the highest sound attenuation at all frequencies as it was expected, but all other cases' graphs have a different order than it was foreseen. The case "receiver room 6 / source room 18 open" has the lowest sound attenuation in all the other cases, according to simulation results.

By all these five cases where the sixth panel of the receiver room wall stays constantly open, it can be inferred from the results that Odeon underestimates the sound level difference between the rooms each time. While the graph shapes of the cases derived from Odeon usually seem to have a constantly and regularly rising tendency, the actual laboratory measurements' graphs have generally an instant rise at 250 Hz and a higher rising slope at higher frequencies like 2000 and 4000 Hz. This can be caused due to the underestimation of the panels' diffraction effect by the simulation program.

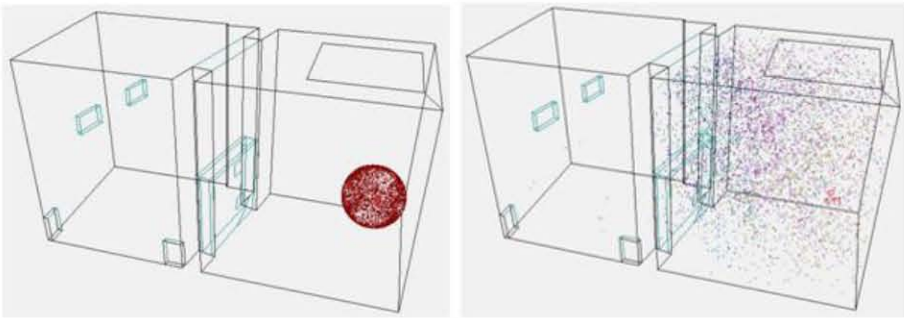

Figure 8. Screenshots from Odeon simulations.

4. CONCLUSION

This study was carried out in order to prove whether it would give reliable results or not if the research would be continued only with simulation programs. The comparisons between laboratory measurements and simulation results show that the acoustic simulation program Odeon version 9.2 is not sufficient enough to calculate the diffraction effect of the walls and the transmission of the sound through the wall at the same time, because mainly underestimated sound reduction values by the cases with openings and overestimated values by the cases with closed walls came out from the simulations. Apparently, with the calculations so far, this research cannot be continued only with computer simulations. As next steps of this research's simulation part, it is foreseen that newer versions of the program Odeon or a different acoustic program can be examined in terms of sound reduction.

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RICE STRAW FIBER BIOCOMPOSITES POTENTIALS IN CONTEMPORARY ARCHITECTURE

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JAN KNIPPERS [2]

ABSTRACT

Compared to synthetic fibers, natural fibers have many advantages such as renewability, availability, low cost, biodegradability, non-toxicity and other excellent properties. Rice Straw Fiber (RSF) is considered to be an important but still abundant natural fiber when compared to other known industrial natural fibers like jute, kenaf and hemp. Inspite of the fact that RSF is considered one of the highest biomasses in the world, it still lacks much more deep research to investigate all its possible potentials in different industrial fields, especially in the building industry. On the other hand and as a result, this fibre with all its potentials is still illegally burnt in huge amounts worldwide causing extreme environmental damage as it's still considered an agricultural "waste", much more than a "resource" of its own.

Thus, the main objective of this paperwork is to highlight the potentials of rice straw fiber as an active filler together with its reinforcement activities in biocomposites as well as the “as –is” method of using this fibre in its raw form in direct building applications that should be also discussed. This will be achieved through the analysis and synthesis of a number of technologies, examples and applications of rice straw fiber composite materials. In addition, different technologies used in the industrialization of such biocomposites will be illustrated according to the outcome product reached, and categorized.

Key words: Rice Straw Fiber, Agricultural Waste, Biocomposites, Straw-based fibre and particleboards, Straw Bales

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1. INTRODUCTION

One of the main types of biomass is the agricultural residues. Agricultural residues in specific has been for a long time only directed towards the conventional cattle fodder usages, or beddings. It has even been burnt in huge amounts, especially straws, due to its huge amounts that overflow such usages. One of the most promising applications of such wastes' "resources" is the natural fibre reinforced polymers- Biocomposites- and their applications in building industry.

Natural industrial fibres include specifically jute and hemp that are planted especially for the fibre usage and not for feedstock purposes. Unlike such fibre types, wheat, rice and maize are planted especially for feedstock purposes, whether for humans or for cattle or both. In any case, the main interest in such annual crops' agriculture is the seed itself- the cereal- and not the residues left over after harvesting. That's why huge quantities of such residues are so often burnt after re-using relatively small amounts of them in conventional applications.

On the other hand, and as the problems of conventional limited usages of straw aren't completely been solved, fibre application industries are in great thirst to new available and cheap fibre types. Paper, furniture, boards and fibre reinforced composites' industries are examples of such industries that have long depended mainly on wood as a main source for such industries. The steady increase in the demand of the wood fibre is gradually leading to a worldwide shortage of wood fiber supplies. Since the 1980's, depletion of the world's forests has steadily increased the price of raw wood and wood-based products (Sun 2010). One possible solution to this problem lies in the use of annual non-wood plants, where straw is a direct available presenter of them.

Legislations had even participated within this issue, especially in North America and Europe (Mo 2005). In Europe, many legislations were set to force to find other solutions than landfilling (EU Legislation), the thing that led industrial owners fetch through researchers on other methods to become more sustainable.

2. WHY RICE STRAW

2.1. Cereal straws' quantities

Cereal grains compose up to 80% of the world food supply according to the United Nations Food and Agricultural Organization (FAO) in 1984. The total amount of cereal production in 2010 is approximately 2422 million of metric tons – fig.(1) , whereas the highest cereal crops' productions are the maize, rice and wheat respectively, forming around 87% of the whole cereal annual production- fig.(2).

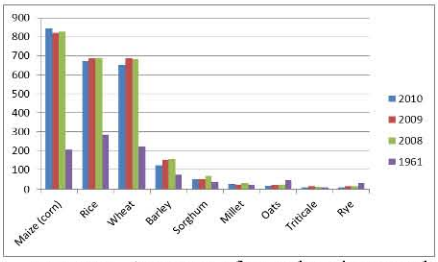

Figure 1. Amounts of cereal grain annual production for the years 1961 in comparison to 2008, 2009 and 2010 . (wiki-cereal)

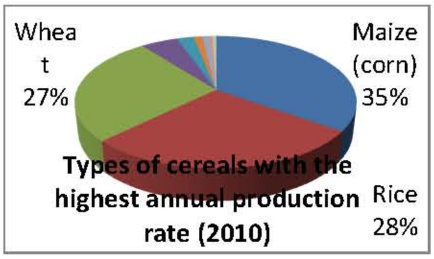

Figure 2. Percentages of the highest crops' production rates for the year 2010. (Derived from the data available –see left.)

Straw, the stem of the cereal plant that remains after the seed needed for nutrition is removed, composes about half the total dry weight of the crop (Sun 2010). For many centuries, straw has been utilized as animals feeding livestocks, bedding and many other limited applications. However, these limited applications have never been enough to consume the huge straw amounts produced annually worldwide.
In addition, the drawbacks of the straw as an animal fodder increased dramatically the problems of the accumulated straw. The feed value (digestibility) problems are the main reasons for such drawbacks of the straw when used as a fodder due to the chemical structure of the straw. (Han et al 1974)

2.2. Rice Structural and chemical composition of rice straw in comparison to soft- and hardwood

Rice straw is a plant similar to wood in its inner components of cellulose, hemicelluloses and Lignin but with different percentages that makes the inner properties totally different and of other potentials.The length of rice straw varies widely from 30 to 500cm, depending on cultivation methods (Mo 2005). The top section of the straw is branched and consists of the thretched-out remains of the grain-bearing particle.Rice straw fiber (RSF) has a length in the range of 0.65-3.48 mm and diameter of 5-14 μm, with a long aspect ratio of 170 (Atchison 1983).
Rice straw has the highest silica contents within all crops species (9-14%). Secondly comes wheat straw with high potentials as well uptill (4-10%), while wood has less than 1% silica contents (Pekarovic et al 2008). These huge silica contents are of great potential benefits regarding the flame retardant when used in building industry (Buzarovska et al 2008).
Chemical composition of rice straw in comparison to wheat straw and wood , in percent of dry matter, can be described within table. (1) as follows:

Straw/Plant	Cellulose	Hemi-cellulose	Lignin	Silica	Ash
Rice straw	28-36 [a]	18–25 [c]	12-16 [a]	9-14[a],[d]	15-20 [a]
Wheat straw	38-46 [a]	20–32 [c]	16-21[a]	3-7[a]/4-10 [d]	5-9 [a]
Soft wood	40-45 [a]	7-12 [e]	26-34 [a]	-[a]/<1[d]	<1 [a]
Hard wood	38-48 [a]	20-25 [e]	23-30 [a]	-[a]/<1[d]	<1 [a]

[a] Tappi, 1983. [b] Roxas et al (1984). [c] Galletti A. et al.2011 [d] Pekarovic et al 2008. [e] Chander et al 2007.

<u>Through the previous comparison, the following facts can be after analysis concluded as follows:</u>

- Potentials of cereal straws and rice straw specifically, are focused in the high contents of ash and silica, which are of anti-flammable characteristics that can be well used in building applications. In addition, silica works against rapid biodegradability which can be of much higher potentials when combined with biodegradable polymers, to increase the life time span as well as increasing fire resistance and mechanical behavior.

- Lower lignin contents are as well a factor that shows the non-tendency towards rapid combustion as in the case of soft and hard-woods.
- Hemicellulose content is much higher in straw than wood, which is an important source of many chemical industries including adhesives, paints and others (Sun 2010).
- Layers of wax, silica and protein represent together a dense coating on the straw's surface working for natural defense for the epidermis, ie. the single-layered group of cells covering the inner plants' parts (wiki-epidermis), against moisture loss. These layers prohibit the proper bonding of the fiber with the resin, posing problems in straw-fiber and particlebordas production (Schmidt et al 2002). In many researches, chemical treatments are applied for better compounding and polymer binding to obtain better mechanical properties (John et al 2008). However this cause an extra cost factor in the manufacturing process in addition to losing important potentials of the fibre as silica contents that has already its high potential as discussed. It's here therefore suggested that the fibres are better to be mechanically treated by chopping without extra chemical modifications, better than making another burden on the environment through chemical wastes released, instead of only agricultural wastes present, which makes the problem doubles. Chopping will give the opportunity for the outer surface of the fibre to be opened and easily subjected to the polymer when combined and hence better encapsulation and performance (Mantanis et al 2001).

3. STRAW-BASED BIOCOMPOSITES; PARTICLE-; FIBRE- BOARDS AND PANELS

As straw contains the same basic chemical components of wood, as previously declared, it can be crushed to chips or particles that can replace the wood particles and fibres in boards applications. But the difference in the chemical properties between them still poses challenges to produce straw-based panels using existing manufacturing technology for wood panels (Xiaoqun 2005) Therefore, great efforts for developing straw-based panels with similar and alternative technologies in addition to various fibre physical and chemical pre-treatment before compounding, has been highly established.
Compatability between the fibre and the binding polymer in this case is of great concern. This is in addition to the manufacturing technique itself. Polymers have huge varieties through which varieties in types and forms of achieved products can take place. Through the following criteria, a collection of different possibilities of rice straw biocomposites' manufacturing and applications according to the binding materials- the polymer types- being applied with the fibre:

3.1.Applications with organic binders:

This includes the 3 known branches of polymers including the thermoplastic, thermoset and elastomeric types, where each type can be of either bio-based or petro-based origin and can be either bio-degradable or not.
Generally, the mechanical properties of thermosetting polymers have much higher mechanical performance than that of thermoplastic ones (H.Ku et al 2011).

3.1.1.Thermoplastic Biocomposites

3.1.1.1 Non-biodegradable composites

This was achieved in many researches including binding rice straw with petro-based thermoplastics including PE (Polyethylene), PP (Polypropylene)and PVC (Polyvinyl chloride).

Commercially, examples of available products out of other straw types (as wheat straw) and recycled plastics are: TerraFenceTM and TerraDeckTM, in addition to Ricycled TM from recycled PVC and rice husk .

3.1.1.2. Biodegradable composites

Many researches since the past decade have been applied in this area, examining the improvement of the mechanical properties of the biodegradable polymers using natural fibres, including straw (Avella 1993,2000). In addition, many investigations on reinforcing bio-foams like PLA by straw fibres as an effective eco-filler, has been applied. In France, the research team in Materials Research Centre in Ecole des Mines d'Alès , has established a new material generation in this direction of biodegradable wheat straw fibre reinforced starch foam (Bergeret et al 2011). The applications for such composites are still limited in the packaging systems, agricultural purposes, but not yet in the building industry.

The challenge is always the critical limited life time of the final product that is crucially needed in case of building applications, regardless of the biodegradation at the end of its useful life time (v.s.). Fire behavior is also a great issue that can either be improved through mineral phosphorus additives (Matko 2005), or through the fiber itself,as here suggested through the natural high silica contents present.

The authors have already tackled this area through flammability tests (according to UL-1694 and UL-94) occurred on poly lactic acid /Rice straw fibre (PLA/RSF) and conventional polypropylene/Rice straw fibre (PP/RSF) samples, in which only the fire behavior was studied without reaching a specific material class. The result was that PLA/RSF showed much more stability when ignited and was in many samples first self-distinguished before being secondly ignited. On the other side PP/RSF started melting directly after ignition and parts were dropped on the indicator directly combusting it. It is believed that the high compatibility between the natural fibre and the biopolymer are the reasons behind the better behavior of the green composite. The comparison was achieved between the two composites, where the same fibre type and the same fibre loading (uptill 20% by weight) was applied. This shows another positive aspect for the rice straw in biocomposites' applications.

3.1.2.Thermoset Biocomposites:Natural fibres are here bonded by thermoset polymers whether petro-based ones like conventional polyesters and epoxies, or plant-oil bio-based polymers.

Products out of such bio-based thermoset resins to binde rice straw of different origins were designed and produced by the authors and students of the third year in the faculty of architecture- University of Stuttgart within the framework of a course named "Do it Yourself" in SS11, supervised by the first author. The products are composed up to 40% by weight of fibre contents, figs. (3) and (4) .In addition, Rice straw/classic epoxy resin with different coloring and textures were also achieved, fig.(5)

Figure 3. TraShell™ from rice straw, organic ash and bio-resin.

Figure 4. BiOrnament™ applied as inner cladding, out of rice straw, bio-resin and natural pigments.

Figure 5. Strawave™ applied as inner cladding, out of rice straw and uncolored conventional epoxy resin.

3.1.3.Elastomeric Biocomposites:Waste tires binding rice straw is an example on this type (Yang 2004). After physical treatment of cutting and milling the fibre, polyurethane binders applied together with hot pressing to produce sound absorbing insulating boards. The produced products are recyclable, but not bio-degradable.
Another example achieved by the authors is a biocomposite of rice straw and thermoplastic elastomer in powder form, through which uptill 80% fibre -by weight- were binded to form insulation inner boards.

3.2. Applications with inorganic binders
This includes the cement and phosphate binders' technologies. In case of Cement bonded boards and blocks, fibre is applied to reinforce the cement when bonded with it, as well as decreasing the amount of cement being used by replacing it through the added fibre content. Another application with cement is the replacement of the cement itself through the straw ash, due to its pozzolanic activity, according to (El-Sayed et al. 2006). Applications include building blocks and ceiling panels

3.3.Applications without binders or fiber modifications- 'as-is':
3.3.1. Non-adhesive bonded boards for insulation:This is often known as "self-binding", and it occurs if the fibres are pressed in high temperature and pressure releasing its inner lignin components (van Dam,J.E.G. et al. 2003), hence combining the straw fibres without the need of external binders.
Such boards are not for structural purposes, but more for heat and sound insulation, inner partitions as well as decoration purposes.
3.3.2. Baling, walls and filling systems:There are two systems to build with straw bales, either when stacked tightly to form load bearing walls systems that can hold

its own load in addition to the roofing, or can be stacked as a non-structural insulating walls between timber, metal, or masonary structural frame supporters of the roof. In both cases, the bale walls are either plastered or stuccoed on both sides, indoors and outdoors. This system guarantees perfect heat and sound insulation in addition to fire resistance due to the dense packing of the bales as well as the natural inner high silica components (John et al 1996).

In addition to all previously mentioned potentials, many chemical industries serving the building industry can be derived from the inner chemical components of the rice straw, especially the hemicellulose, including coatings, paints, adhesives and chemicals (Sun 2010).

4. CHALLENGES AND LIMITATIONS:

4.1. Compatibility with polymers:

Compatibility of the natural fibre with the thermoset resins in specific is not that high because of the hydrophilic nature of the natural fibres in opposition to the hydrophobic nature of the resins. This causes plasticity nature during the compounding process that causes undesirable lower mechanical properties than expected. That's why alkali-treatment was the solution for many researchers to overcome the uncontrolled humidity in the natural fibre, through strengthening another aspect in the fibre-resin adhesion factors, which on the other side caused chemical wastes with recovery difficulties.On the other side, the fibre's combination with thermoplastics is pushed back with the limited processing temperature (maximum 200 degrees), otherwise the natural fibre itself would decompose. That’s why the compounding of the natural fibres with thermoplastics are limited to plastics with relatively low-melting points like PP and PE (Kakroodi et al 2007).

Some applications and forms (especially free form panels of thickness more than 2-3 mm) would need more than 200 degrees to be thermoformed for instance. In such cases, a partial degradation of the fibre might occur before even being applied and hence lowering the desired and needed mechanical properties. However, using plasticizers and additives can overcome such temperature problems.

4.2.Manufacturing techniques

4.2.1. Humidity control: One of the main problems is the humidity control, which is a drawback for natural fibres in general. Chemical modifications can improve this problem greatly, however has its own problems concerning releasing chemical wastes and cost effectiveness.

4.2.2. Machining: Most of the machining used for thermoplastics are applicable with natural fibre reinforced thermoplastics as well especially in the case of short fibres’ usage. This includes extrusion, injection molding and thermoforming. In case of thermoset polymers, limitations for short fibres’ applications largely exist, especially that lots of these techniques are based on long fibres’ processing. Press moulding therefore together with Hand layup are applicable in short fibres’ appliance, while filament winding technique is applicable in case of continuous fibres. Technologies for production of rice straw mats should be further applied to increase the

opportunity of the fibre's processing potentials and manufacturing possibilities. In fig (6), an example of a weaving straw machine is shown.
4.2.3. Dust control during chopping: One of the main problems in the chopping process is the huge dust released causing dust clouds, with risks of lung diseases. Therefore, an appropriate ventilation system together with an acceptable method of soaking out the dust at the same time should be applied and connected directly to the machine at the same time of chopping/milling- as shown in fig. (7).

Figure 6. weaving straw machine, supported by Zhengzhou Thoyu Import & Export Trading CO., LTD

Figure 7. The chopping machines is directly linked and integrated with the collector and dust absorber, avoiding the dust clouds. Machine is supported by

6. CONCLUSION

Current applications of straw-based biocomposites and boards are still in the early stages of development. Chemical modifications of the natural fibre before compounding to optimize the adhesion quality between the fibre and the matrix applied, might not be the optimal method to be used. Hence, other compatible matrices with the natural fibre with the least possible applied chemical modification should be further investigated. One of the suggestions would go further towards bio-based polymers which are derived from a much nearer base than a fossil-base, to the natural fibre itself. In this case, further investigations on life time of the final product and aging should be properly examined so as to suit the applications in building industry.
Rice straw can have much further applications when rice straw mats are applied in industry on much wider scales. In addition, the problematic huge volume of the loose straw or even the bales themselves can be much decreased, especially when straw mats can be directly manufactured in fields and moved in this form to industrial applications.
In addition,further efforts are needed to take place to raise up the level of the architectural applications and reach up to much more attractive architectural

products. Colouring, textures and forms are very important keys in the architectural design of the products. With the help of natural pigments, laser cutting, free-form panels' manufacturing much more attractive products could be reached replacing the conventional ones in the market.

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FIELD STATION OF THE NATIONAL PARK ACADEMY IN PETRONELL, AUSTRIA: A CASE STUDY OF EVOLVING THERMAL PERFORMANCE EXPECTATIONS

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ABSTRACT

Sustainability in the construction sector is increasing in importance. Due to a number of factors such as energy resource limitations and increasing occupancy expectations, the thermal performance standards concerning buildings are becoming stricter. In this context, it would be useful to document in practice, to which extent such developments in the standardization domain have affected the actual performance of buildings. The present contribution describes a research effort toward documentation of the evolving thermal performance of a specific building's refurbishment in Petronell, Austria. Subsequently, solar-thermal collectors and photovoltaic elements were added to explore the potential for utilizing renewable energy sources. In 2011, a new effort was initiated to capture the actual thermal performance of the building and its various components and systems in a structured and systematic manner. Thereby, a monitoring system was installed to collect data concerning indoor climatic conditions, user behavior and energy consumption. To put the performance of the building in the pertinent microclimatic context, a weather station was installed on the building. The collected results facilitate the treatment of a number of salient questions: Has the thermal retrofit of the building resulted in the expected performance improvement? How do previous standards compare to the currently valid thermal codes and requirements? What would be the potential of further improvement in building's energy efficiency if the implications of occupants' habits and behavior are considered? What is the actual output of the installed renewable energy harnessing systems? What lessons from the present monitoring exercise can be learned and applied to the context of other building projects? The paper concludes with a summary of the existing and necessary answers to these questions.

Key words : thermal performance, monitoring, thermal retrofit

1. INTRODUCTION

Buildings are suggested to be responsible for about 40 % of the world's whole energy demand (IEA 2012). In the last decades many attempts have been made toward energy use reduction. New technologies have been developed to increase the use of renewable energy resources. Numerous buildings have been planned and equipped with such technologies. The present study deals with a building (referred to, hereafter, as NAT) after its refurbishment in 1996. It was planned according to newest energy standards at that time. This building was selected as a case in point in view of comprehensive performance monitoring approaches.

2. MOTIVATION AND BACKGROUND

2.1. Motivation

In 1980, Austrian federal estates agreed to minimize energy demand for building structures. The European Union requires all member states to create an energy certificate for new buildings (EPBD 2011). Additionally, building performance requirements were tightened both for new buildings and building refurbishments. Buildings constructed before 1900 are estimated to have an U-value (building envelope) of 1.6 $W.m^{-2}.K^{-1}$. In the 1960s, constructions were required to have U-values of 1.2 $W.m^{-2}.K^{-1}$ (OIB LF6 2011). The refurbishment of the aforementioned case study building in 1996 targeted with layers of plaster, 25 cm bricks and 14 cm special cork insulation boards, a value of 0.25 $W.m^{-2}.K^{-1}$. These changes of guidelines and requirements prompt several questions: What is the magnitude of saved energy (if there is a saving)? How can we measure this energy saving? Are there any further impacts on buildings, people or the environment?
Figure 1 includes visual material pertaining to NAT before and after the renovation.

Figure 1. From left clockwise, NAT sketch (areal view), facade (before renovation), courtyard (before renovation), courtyard (after renovation), facade (after renovation); pictures: Lötsch, Deubner

2.2. Background

The case study building NAT is located in Petronell, Lower Austria, 50 km east of Vienna. In 1996 it was renovated (see Figures 2 and 3). The goal was to realize a building that performs better than the minimum energy standards of the time. Furthermore, the owner intended to use renewable, eco-sensitive products (to be obtained – to the extent possible – from the near vicinity of the building site). Prior to the refurbishment, the building's function was combined residential and commercial. Since completion of the renovation, the building houses the "Nationalpark - Akademie" of the Vienna Museum of Natural History. NAT serves educational, administrative, and short-term residential functions. The new construction mainly uses natural and regional products, with the exception of the insulation material (a high-performance cork product) for walls, roofs and floors, which was not produced in Austria, but was imported from Spain. Electricity demands are covered in part by roof-mounted photovoltaic panels. When solar radiation is not sufficient, the electricity from grid is used. Solar collectors provide energy for room heating and domestic hot water. The heating system is also supported by a wood-pellet burner. To reduce heat losses through building elements, very low U-values were targeted.

Given this context, it would be interesting to find out how the building has performed since 1996 and is performing today. Thereby, changes in standards and guidelines are to be examined. Can NAT still be considered an energy efficient and ecologically sustainable building?

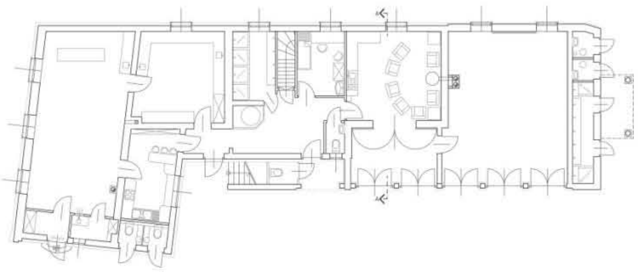

Figure 2. Ground floor (NAT), plan: Deubner

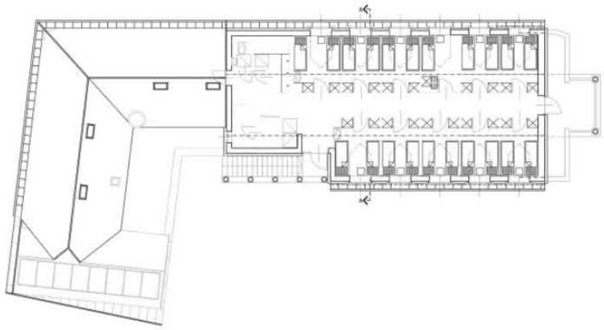

Figure 3. First floor (NAT), plan: Deubner

3. METHODOLOGY

3.1. Historical data acquisition

To evaluate the energy performance of the building in the time before the installation of a monitoring system, we need "historical" data. In this case study, information from various sources were obtained. Documented quantities of deployed pellets were considered as well. Table 1 provides an overview of the different data sources.

Table 1. Historical data acquisition

Information	Period	Remarks
Pellet consumption	2006 - 2012	Handwritten list, partly incomplete, approximate values
Weather data	1982 - 2012	Data from weather station in Seibersdorf (30 km west of Petronell), gaps in data
Occupancy	1996 - 2012	General information based on NAT's administration

3.2. Monitored data

For detailed analysis of energy use, occupancy, and energy gains of the renewable energy-systems, a monitoring system was installed in NAT in March 2012. Several sensors regularly collect data and send it to a database. Data is stored and provided via MOST-system, a toolkit for building monitoring, data processing, and visualization (Zach et al. 2012). Table 2 illustrates the measurements and devices applied in the building.

Table 2. Installed sensor types in the case study project

Sensor type	Unit	Information
CO_2	ppm	Carbon dioxide concentration
Contact	boolean	Opening/closing of windows/doors
Electricity meter	Wh	Electricity use
Illuminance	lx	Light levels
Occupancy	boolean	Presence of people
Compact heat meter	Wh	Heating energy
Relative humidity	%	Relative humidity in a specific location
Compact heat meter	MWh	Solar energy
Temperature	°C	Indoor air temperature of a certain area
Flow meter	l/h	Water usage

The building can be functionally divided into nine different zones with individual characteristics concerning temperature, occupancy, and user behavior. In Table 3 the zones and their size are summarized.

Table 3. Zones in NAT

Zones	Office	Kitchen	Bed-room	Cellar	Corridor
Areas [m^2]	36.7	12.5	89.4	114.9	40.8
Zones	Bath-room	Ancillary	Stair-case	Storage	
Areas [m^2]	17.3	19.2	2.9	22.4	

Energy certificate

In Austria, one of the main energy performance indicators for buildings is the heating demand per year and m² gross area. This is mainly dependent on geometry, construction, and the local climate. The calculation for the energy certificate was conducted with the software tool ArchiPhysik 10 (A-Null 2012), which incorporates applicable standards. The calculation was executed for seven scenarios (see Table 4). Each scenario corresponds to different qualities of the thermal envelope (U-Values). These are: "Prior to refurbishment", "Minimum requirements of 1988" (OIB LF6 2011), "Refurbishment (1994-96)" (OIB LF6 2011), "Minimum requirements of 1996" (OIB LF6 2011), "Minimum requirements of 2012" (OIB RL6 2011), "Passivhaus building components" (without and with controlled ventilation) (Energiesparen 2012).

Table 4. Heat transfer (U-values) of building elements of NAT in [$W.m^{-2}.K^{-1}$]

Building element	Prior to refurbishment	Min. req. of 1988	Refurbishment (1994-1996)	Min. req. of 1996	Min. req of 2012	Passivhaus
Outside wall	1.50	0.50	0.25	0.40	0.35	0.15
Window	2.50	2.50	1.30	1.80	1.40	0.80
Floor adjacent ground	1.20	0.70	0.28	0.50	0.40	0.12
Roof	0.60	0.25	0.40	0.22	0.20	0.10

4. RESULTS AND DISCUSSION

4.1. Energy certificate

The development of U-values and calculated heating demand is summarized in Table 5 for all seven scenarios. The results of the energy certificates' calculations (heating demand) are also depicted in Figure 4. Note that the mean U-value of NAT as targeted in the refurbishment of 1994-1996 was lower than the applicable requirement of the time.

Table 5. Heating demand and mean U-values for the scenarios

Scenarios	Year	Heating demand $[kWh.m^{-2}.a^{-1}]$	mean U-value $[W.m^{-2}.K^{-1}]$
A	Prior to refurbishment	136.00	1.58
B	Min. req. of 1988	88.02	0.51
C	**Refurbishment (1994-1996)**	66.93	0.41
D	Min. req. of 1996	66.22	0.41
E	Min. req of 2012	54.46	0.35
F	Passive house without ventilation	21.47	0.19
G	Passive house with ventilation	9.19	0.19

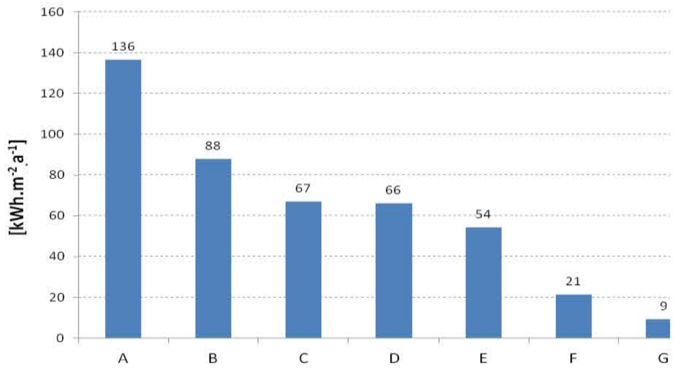

Figure 4. Comparison of seven different energy certificates for NAT according to the applicable requirements at the respective time period

In comparison to the state prior to the refurbishment (136 $kWh.m^{-2}.a^{-1}$), the calculated heating demand was 51% after completion (67 $kWh.m^{-2}.a^{-1}$). Virtually implementing today's minimum requirements would reduce the heating demand to 54 $kWh.m^{-2}.a^{-1}$ (39% of the value "prior to refurbishment"). The planning of the refurbishment (starting in 1994) exceeded the demands of 1988 and fulfilled the demands of 1996. The Passivhaus scenario would reduce the heating demand down to 21 respectively 9 $kWh.m^{-2}.a^{-1}$ (depending on the use of a controlled ventilation system with heat recovery).

These results demonstrate that the refurbishment intention (generating an energy efficient construction) was on target for its time. However, considering today's expectations towards low energy buildings, the heating demand is not low enough. It has to be mentioned that heating demand does not take into account the ecological performance of used building materials. Given the use of cork as insulating material, such an indicator would possibly yield a favorable evaluation. Hence, NAT could be seen as a progressive instance of low energy buildings of the 1990s. Its development could still provide lessons for today's building planning.

4.2. Energy use records

4.2.1. Pellets

In the period of 2007 to 2011, NAT's annual heating energy use is between 15225 and 23428 kWh per year (Table 6). For this period, the highest heating demand was recorded in 2010, the year with the highest heating degree days. Concentrating on monthly values, January and February show higher energy use. In August the burner is switched off. The usual summer period without any heating is assumed to be from April to November. The heating is switched on only on demand (Figure 5, Table 6).

Table 6. Heating demand, heating degree days, and solar gains for 2007 – 2011

Year	Heating energy use (pellets) [kWh]	Heating degree days [Kd]	solar heat gains [kWh]
2007	17 491	2887	6 309
2008	15 225	2933	n. a.
2009	17 346	2946	n. a.
2010	23 428	3437	n. a.
2011	21 004	3083	11 323

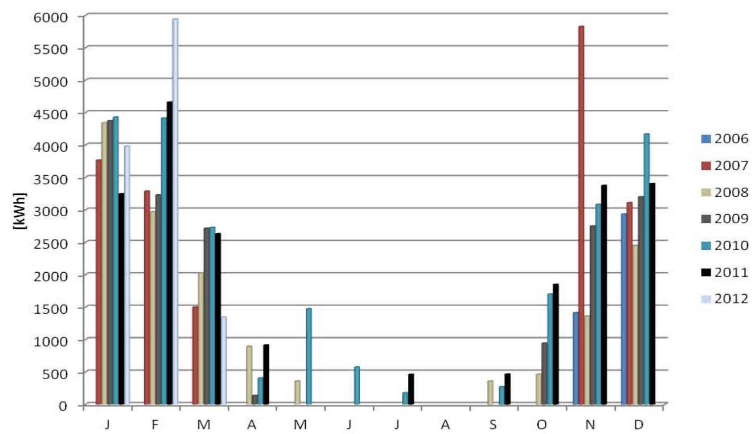

Figure 5. Mean heating demand (2006-2012) per month (pellets) in [kWh]

4.2.2. Solar gains

Given the few data available, the period from April to September is the most productive in terms of solar gains, while the gains during the winter months December and January are very low (see Table 6). In Figure 6, mean monthly heating energy use is compared with solar gains

Table 7. Mean monthly heating energy use (2006 – 2011) and solar gains (2007, 2011); mean monthly outdoor temperature

	Mean monthly energy use [kWh]	**Mean solar gains** [kWh]	**Mean outdoor temperature (Seibersdorf)** [°C]		
			2007	**2010**	**2011**
Jan	4024	50	5.42	-2.22	0.41
Feb	4084	307	5.32	0.72	0.18
Mar	2157	948	7.56	5.99	6.11
Apr	587	1633	12.58	10.43	12.88
May	916	1380	17.54	14.33	15.68
Jun	576	1292	20.70	18.70	19.60
Jul	319	1200	21.49	22.40	19.51
Aug	n. a.	1359	20.16	19.34	21.06
Sep	365	1655	13.87	14.44	17.92
Oct	1239	782	8.88	7.78	9.86
Nov	2968	274	4.02	7.06	3.19
Dec	3211	48	0.31	-3.18	3.09

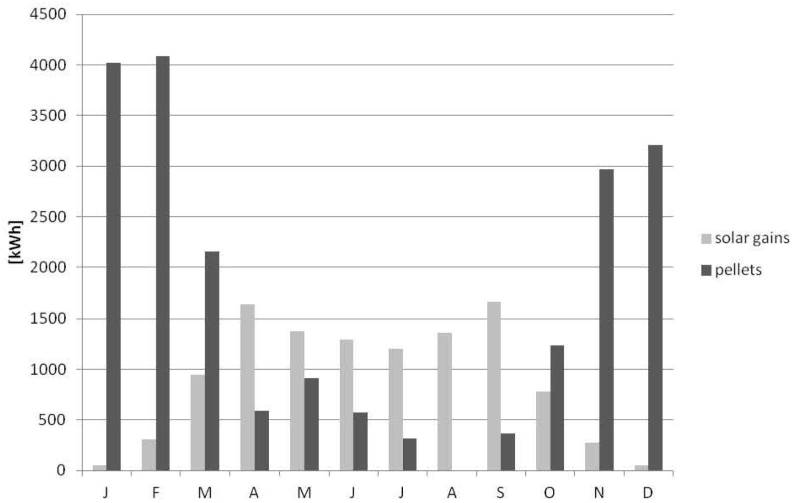

Figure 6. Comparison of mean monthly heating demand and solar gains (2006, 2007, 2011, 2012)

4.2.3. Climate

Figures 7 to 9 provide data on solar radiation and outdoor temperature for the NAT location (Seibersdorf weather station). Despite multiple gaps and inconsistencies in the available microclimatic data, certain tendencies can be extracted from the data. For instance, both heating energy use and solar energy gains can be shown to be consistent with microclimatic information.

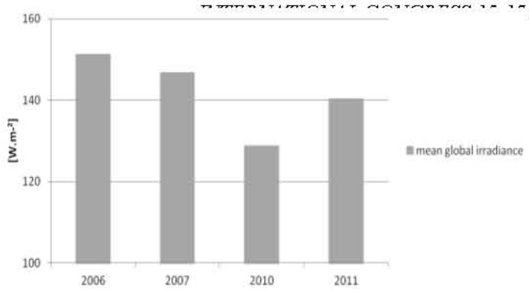

Figure 7. Mean global irradiance for 2006, 2007, 2010, and 2011 in W.m^{-2}

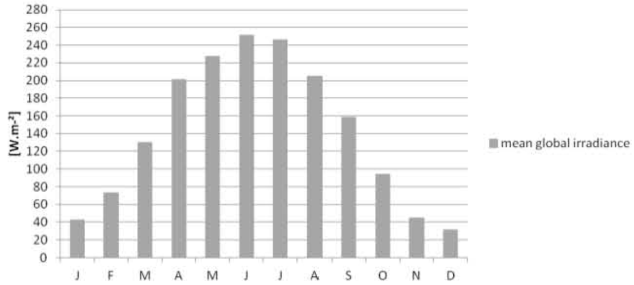

Figure 8. Mean monthly global irradiance and outdoor air temperature (2007, 2010)

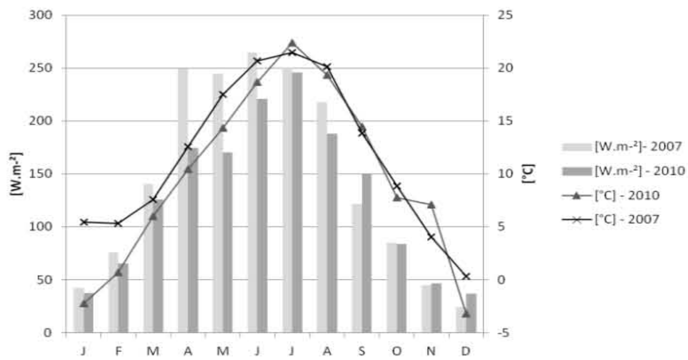

Figure 9. Mean monthly global irradiance (over the years 2006, 2007, 2010, 2011)

4.3. Ongoing monitoring

4.3.1. Heating

From April 2012 onwards, the energy use of the heating system is monitored on a continuous basis. April was the last month of the heating period, before the burner was switched off. In this month, the heating energy use was measured as 321 kWh for the whole building. The monitoring system gives the option of determining the exact working hours of the pellet burner. With the newly installed monitoring system, it is possible to estimate the energy delivered via the floor heating systems not only as a whole, but also in terms of individual zones. Hence, it becomes possible to state which zone or part of the building requires which amount of energy at which time.

4.3.2. Solar gains

Metering the solar gains started in June 2012. The total gain measured in June and July was 1568 and 1468 MWh respectively. On an average day in June, the solar collectors produced 52.3 MWh, in July 56.5 MWh. The maximum gain was measured end of June with a daily value of 102 MWh. Regarding solar gain, the most productive hours during the day were found to be between 9 am and 1 pm.

4.3.3. Thermal comfort

Beside internal CO_2 concentration and relative humidity, the temperature was analyzed in comparison to outdoor conditions. Figure 10 and 11 show internal and external temperatures for one month in winter and in summer (February and July) in 2012. In February the mean indoor air temperature was around 20°C while the outside air varied between -10 °C and +10 °C. Regarding the summer period, there is not much difference between inside and outside temperature (in average 25 °C). During the winter period, an indoor temperature of 20 °C is maintained using the pellets burner.

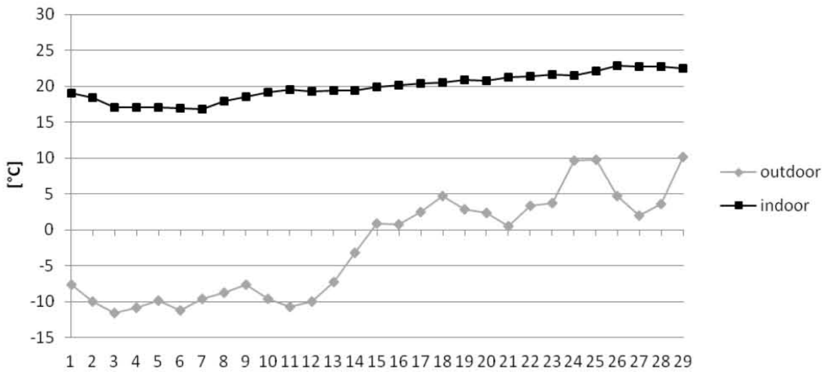

Figure 10. Daily mean outdoor and indoor temperature in February 2

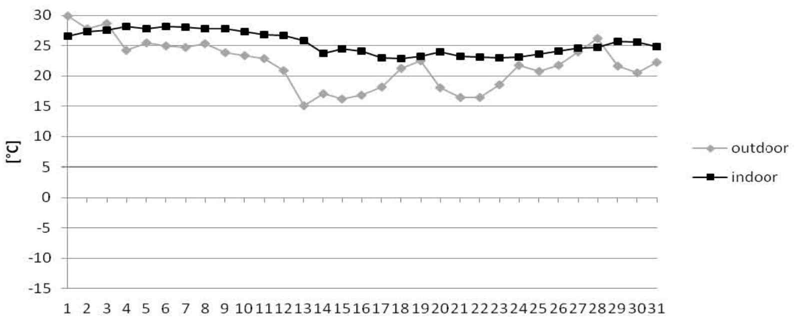

Figure 11. Daily mean outdoor and indoor temperature in July 2012

5. CONCLUSION AND FUTURE RESEARCH

The NAT case study illustrates the possibility to construct, following the guidelines, an energy efficient building that deploys regional – ecologically advantageous – products and incorporates systems to harness renewable energy. With regard to today's energy standards, NAT could be placed in medium level performance category. Given the newly installed comprehensive monitoring system, further potential for energy efficiency and indoor climate improvement can be detected and exploited. The monitoring system in NAT offers various analyses opportunities. Not all capabilities of this system have been exploited so far. The ongoing research shall further capture this building's performance in detail. Moreover, we shall use the monitored data for calibrating simulation models in order to further analyze and interpret the building's actual energy and indoor environmental performance, demonstrated in the context of microclimatic dynamics and user behavior. Moreover, the solar gains and electrical energy generation shall be analyzed to obtain data that would not only benefit system performance in NAT, but also installation and operation methods for future projects.

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The authors would like to acknowledge the support of Professor Bernd Lötsch and Dr. Claudia Roson toward conducting the project presented in this paper. We would also like to thank Architecture Atelier Deubner (Vienna, Austria) for providing us with plan documentation on the case study building.

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ASSESSING THE ACCURACY OF NATIONAL CALCULATION METHODOLOGY OF TURKIYE (BEP-TR) BY USING BESTEST

GÜLSU ULUKAVAK HARPUTLUGİL[1]

ABSTRACT

Energy performance in buildings issue has become one of the most important subject matters in Turkiye, especially regarding the procedure of accreditation within European Union. There are many studies conducted in the context varying from developing standards and regulations to inventory of buildings in the frame of energy performance parameters.
In this paper, it is aimed to evaluate building energy performance regulation that became mandatory since 2010 and its calculation methodology called BEP-tr. There are several problems announced by the users of BEP-tr many of whom are mechanical engineers. Based on the critics related with national calculation methodology, it is necessary to reveal the capacity of the software by testing accuracy.
The content of the paper includes a deep review of Turkish Building Energy Performance Regulation and its calculation methodology regarding the importance of regulations as a big step forward to high performance buildings.
The evaluation of national calculation methodology (BEP-tr) has been performed in order to reveal substantial problems. An internationally recognised validation and diagnostic procedure, BESTEST was applied to test the accuracy of calculation methodology.
The first part of the paper is dedicated to a discussion related with the current status of the regulation. Then, the results of BESTEST cases were interpreted in order to find out whether the national calculation methodology is inside the confidence interval. The results highlighted the basic errors of calculation methodology and project a vision for further improvements of the software.

Key words: Regulations, BESTEST, BEP-tr

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1. INTRODUCTION

It is well known that in most industrialized countries approximately one third of primary energy supply is consumed in buildings. As a consequence the building sector is essential to realization of energy savings and reduction of carbon emissions. From this point of view, improvement of the energy performance of buildings has a great potential towards the realization of total energy efficiency strategies. In Turkiye, there have been many studies executed on energy efficiency measures over the last decade. First of all, revision of the Thermal Insulation Requirements for Buildings Standard (TS825) was finalised in April 1998 and issued by the Turkish Standards Institute. Yet this only applies to new buildings, although Turkiye has a huge existing building stock. The goal is to decrease total energy consumption in buildings with roughly one half, but so far has not met that expectancy. Furthermore, the "Law on Renewable Energy Sources" was effectuated in 2005 and the government released a new "Law on Energy Efficiency" in the first half of 2007.

In the light of the introduction of the Energy Performance of Building Directive of the European Union, a big step was taken in Turkiye with releasing "Building Energy Performance (BEP) Regulation" in 2009. Moreover, the related national calculation methodology and its tool (BEP-tr) became mandatory in 2010.

This paper aims to evaluate the scope of BEP regulation and the ability of national calculation methodology (BEP-tr) towards performance-based approach. A deep review of calculation methodology has been performed and several inadequacies have been listed. As an evaluation methodology, BESTEST is going to be applied to test the accuracy of calculation methodology. The results are discussed and several suggestions are listed towards the improvement of the methodology.

2. CURRENT STATUS IN TURKIYE

Energy performance in buildings has become one of the most important subject matters in Turkiye, especially regarding the procedure of accreditation within European Union. There are many studies conducted in the context varying from developing standards and regulations to making inventory of buildings in the frame of energy performance parameters.

The most recent and the important one of those regulations is "Building Energy Performance Regulation" which released in 05 December 2008 and became effective in 05 December 2009. The aim of the regulation is stated as follows:" to manage [a] the rules of calculations which is going to evaluate whole energy consumption of the buildings considering climatic conditions, indoor space requirements, local conditions and cost efficiency; [b] classification of buildings regarding primary energy and carbon emissions; [c] defining minimum energy requirements for new construction and major renovations; [d] assessing the possibility of renewable energy source applications; [e] control of heating and cooling systems; [f] reducing greenhouse gas emissions; [g] defining the criteria of

building performance and the rules of its applications; [h] executing environmental saving." [BEP, 2010].
Here, the primary energy is defined as the sum of heating energy consumption, cooling energy consumption, ventilation energy consumption, lighting energy consumption and domestic hot water.
One of the requirements of this regulation is to prepare an "Energy Performance Certificate". In order to use during preparation of the certificate, building energy performance calculation methodology has been developed. The aim of the calculation methodology is to evaluate the effect of each parameter that has a role on energy consumption of the building on energy efficiency. Besides the objective includes assessing energy performance of all types of current and new constructed buildings that is covered by the regulation as residences, commercial buildings, educational buildings, health buildings, hotels, malls.
Building Energy performance calculation methodology includes;

- Calculation of net energy amount that building needs during heating and cooling,
- Definition of total heating and cooling energy consumption considering system performances and loss from the systems which is foreseen to meet heating and cooling energy needs,
- Definition of ventilation energy consumption,
- Calculation of lighting needs and consumption during the period that day lighting not available and where no day lighting effective,
- Calculation of energy consumption for domestic hot water. [Bayram, 2011]

Depending on the requirements of calculation methodology, new software was developed based on local conditions called BEP-tr. In the regulation it is stated that the only mandatory tool to implement national calculation methodology is BEP-tr software. Besides, the software must be used by the experts who are licensed by Ministry approved courses.
As a base standard, TS EN ISO 13790 is accepted for energy calculation methodology of heating and cooling needs of buildings.

3. EVALUATION OF BEP-tr BY BESTEST

BEP-tr is internet based software of national calculation methodology. It is aimed to collect all the data under the control of Ministry and develop a detailed tracking system and a database related with whole the buildings in Turkiye. Since 01 January 2011, using BEP-tr software is mandatory for preparation of building energy certificate. As this is defined clearly in the regulation, it is not possible to use any other tools that code the underlying calculation methodology.
Early researches executed with BEP-tr stated that the software needs to validate and should be tested. [Yılmaz, 2011]. One of the well known methodology to test energy performance evaluation tools is BESTEST. It was developed in IEA SHC Tasks 8, 12 and 22. Recently, it is accepted as a valid Standard called "Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs" as ANSI/ASHRAE Standard 140-2001 [Judkoff, 1995].

Within BESTEST it is possible to compare tools by analysing box models in different detail levels. The capacity of the tested tool can be revealed by help of those different box models and different input detail levels. The model defined in BESTEST method is a single zone sized 8x6x2.7 m^3. For several tests, the zone has no window, in some others; there is a 3x2 m^2 opaque window, for the rest a transparent window faced to South (Figure 1).

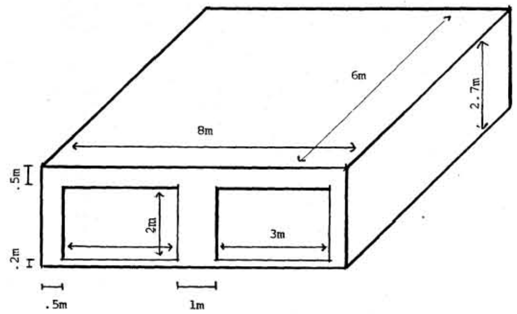

Figure 1. BESTEST test box [Judkoff, 1995].

BESTEST has two different test system. One is diagnostic test, the other is quality test. For each test procedure needs to define different levels of model. In this study, BEP-tr national calculation tool has been tested with the lowest level case box of both diagnostic and quality tests. The input parameters and the values of the model can be found in Judkoff, 1995.

BESTEST 230 and 410 models allow to test infiltration ability. The windows of the model defined as leak proof and only envelope performance based energy demand are evaluated. Different values of infiltration applied to the model and deviation of the results analysed to reveal the infiltration ability. In BESTEST 230 model air change rate value is 1.0 ach; in BESTEST 410 model it is 0.5 ach. Although in BEP-tr national calculation tool it is not possible to change infiltration value, here the table (Table 1) is used for air change rate values advised for different building envelope types. For 0.5 ach infiltration value, BESTEST 410 case is applied and the results for heating and cooling energy demands are shown in figure 2 and 3.

Table 1. BEP-tr national calculation tool air change rate levels.

	Multiple surfaces			Single surface		
	Leak proof			Leak proof		
	low	medium	high	low	medium	high
Non-protected site(Rural area and high rise buildings in urban)	1,2	0,7	0,5	1,0	0,6	0,5
Light-protected (Urban -low density)	0,9	0,6	0,5	0,7	0,5	0,5
High protected (Urban-high density)	0,6	0,5	0,5	0,5	0,5	0,5

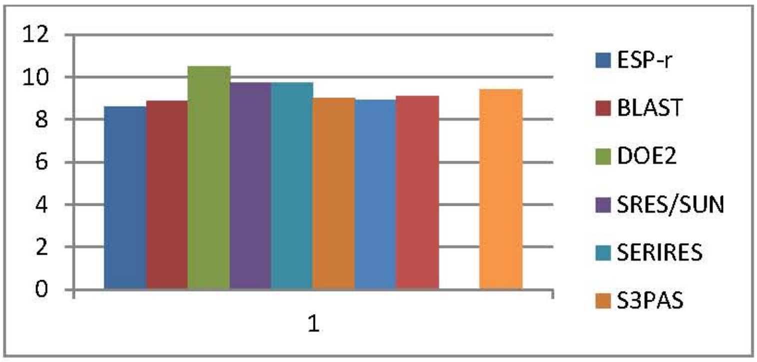

Figure 2. Comparison of annual heating energy demand (case 410).

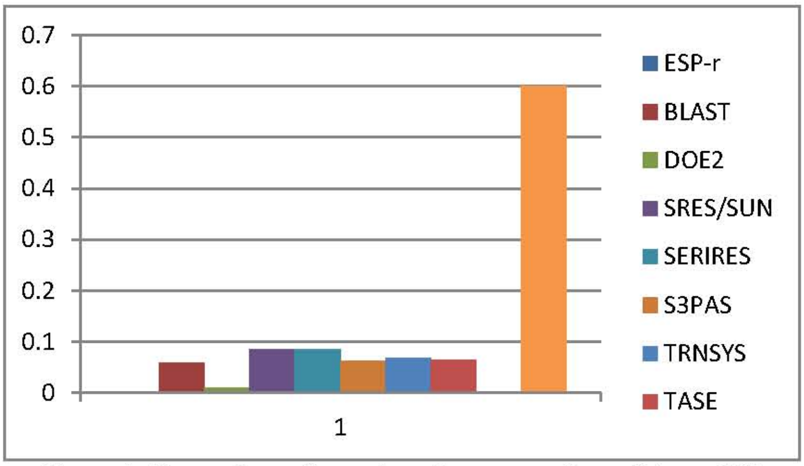

Figure 3. Comparison of annual cooling energy demand (case 410).

In BESTEST 410 model while infiltration value is 0.5 ach, heating energy demand level calculated with BEP-tr is within acceptable range. However, cooling energy demand is calculated so higher than the maximum level of the rest and 86% deviation is detected. During modelling, whole envelope of the box is defined as opaque surface, so the cause of high cooling energy demand should not be the results of direct solar gains. Internal heat gain is the possible reason of this result. If it is possible to change the infiltration level, based on the deviations of results, the critics on the software default values would be more detailed.

Another step of the diagnostic test includes solar transmission. Here, the window of the model defined as transparent. The comparative results of BESTEST 270 case can be seen in Figure 4 and 5. BEP-tr software is within acceptable ranges of calculating both heating energy demand and cooling energy demand. In another words, BEP-tr is successful in calculating solar transmission.

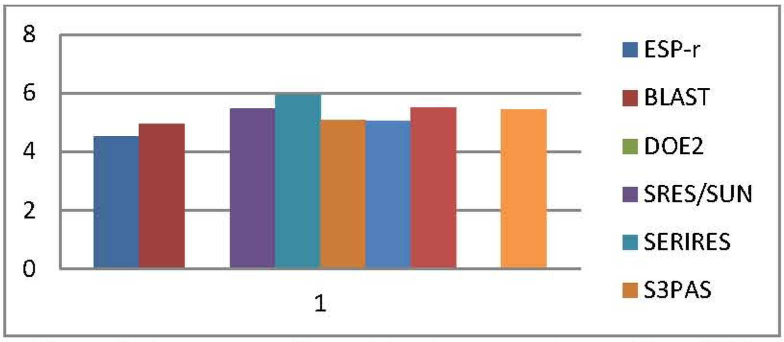

Figure 4. Comparison of annual heating energy demand (case 270).

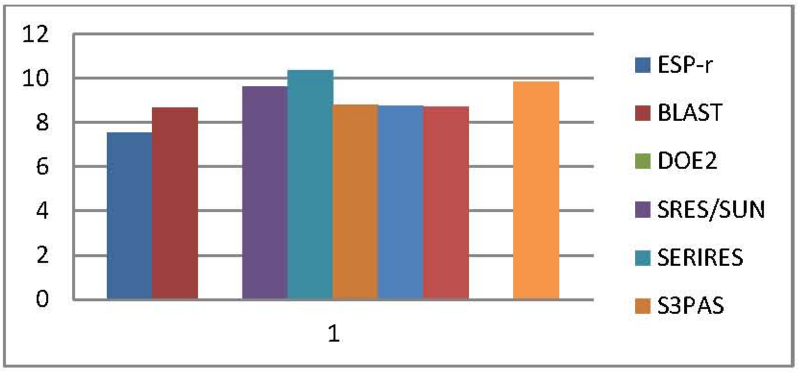

Figure 5. Comparison of annual cooling energy demand (case 270).

The basic model of quality test of BESTEST is case 600. By this case, it is possible to test parameters as windows at different sides, vertical and horizontal shadings, thermostat settings, greenhouse that effect on heating and cooling energy consumption.

The results of the analysis done with BESTEST case 600 can be seen in Figure 6 and 7. Similar to the heating energy demand results of case 410, here BEP-tr has acceptable results, as well.

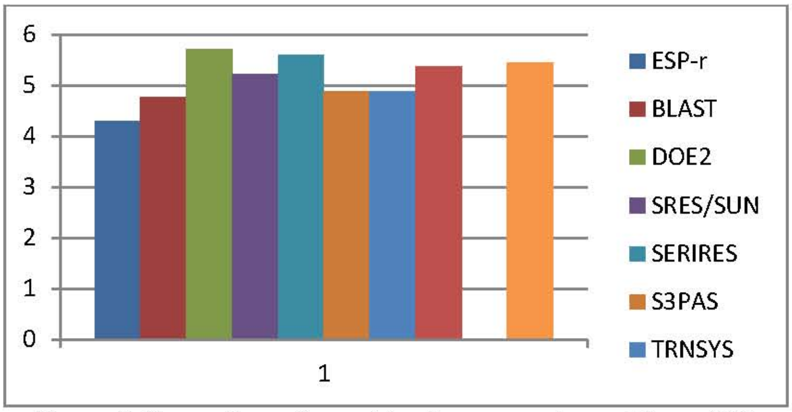

Figure 6. Comparison of annual heating energy demand (case 600).

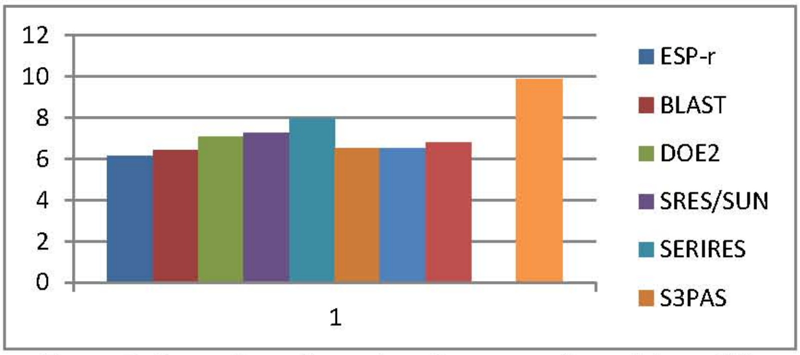

Figure 7. Comparison of annual cooling energy demand (case 600).

On the other hand, annual cooling energy demand calculated with BEP-tr is higher than the rest of the tools. The calculation methodology accepts the basic assumptions of TS825 Heat Insulation Standard which puts heat loss and heating energy consumption forward. However, Turkiye's localisation needs to consider cooling energy demand as much as heating demands. Yılmaz [2011] stated in the research she executed that there is a big potential in reducing cooling energy demand in Turkiye. A deviation occurs in cooling energy demand calculation of BEP-tr. The result is 19.2 % higher than the maximum result of the other tools.

A very simple and superficial analysis shows that the calculation methodology of BEP-tr has several problems. Particularly the calculation of cooling energy demand has deviations. It is necessary to review cooling energy demand calculations and renew the data, defaults and variables of heat transmission of building envelope, internal gains and infiltration.

It should be noted that all the analysis executed here is possible with the input values that BEP-tr software permits. Several necessary data for BESTEST could not be changed and left as assumption of BEP-tr or could not be considered at all. It is *obvious that a deep review of the software should be done by the developers of the software to reveal the real limits of the tool.*

4. DISCUSSION

The results of BEP-tr is compared with the results of validated 8 simulation tools in BESTEST and the deviations are analysed. Although those 8 tools are dynamic, hourly computed-detailed tools, there are two reasons to test monthly, simplified tool-BEP-tr with BESTEST tools. One is to use the opportunity of prepared (ready-to-compare) results of BESTEST cases, the other is to reveal inadequacy of BEP-tr in the means of considering parameters in detail while it is necessary to make an energy analysis.

First of all, there are several difficulties revealed during application of BESTEST method. All alterable data of BEP-tr is considered among input data of BESTEST model, however some of BESTEST data is not included in calculation or cannot be discovered how to included in calculation. For instance, the values of internal heat gains listed in BESTEST model could not be defined in BEP-tr; values of infiltration could not be changed. Moreover, there is no possibility to change indoor thermal comfort ranges in BEP-tr which is also a variable of BESTEST model.

The biggest difficulty during application of BESTEST method is climate definition. BEP-tr analysis allows defining the city of Turkiye to regard climatic conditions. That information is obtained from TS825 standard which defines 4 climatic regions in Turkiye and this climatic definition is not enough for meeting the requirements of Building Energy Performance regulation [Yılmaz, 2007, Yılmaz 2011]. The heating and cooling degree day values of the region that BESTEST used are compared with the same values of the cities in Turkiye [Bulut, vd., 2007] and the closest values are found in Muş. The values are listed in Table 2.

Table 2. Comparison of heating and cooling degree day values

	BESTEST	MUŞ
Heating degree day	3636.2*	3563*
Cooling degree day	487.1*	208**
*reference value 18C **reference value 22C		

Consequently, the difficulties of analysing with BEP-tr are listed below;

a) For modelling, there are only a few basic geometric forms can be defined as building in BEP-tr. Particularly for multi-zone, complex buildings, it is very hard to simplify geometry to basic forms. Besides calculation of simplified forms will deviated the results in high rates.
b) BEP-tr has a library for input data. However it is not possible to insert a new data to library or change a data in the library. For instance, old (for renovation), new or different-innovative material cannot be defined.
c) For solar gains, it is very essential to consider "thermal mass" in calculations. However in TS825 heat insulation Standard, from where the calculation

methodology is obtained, heat transmission coefficient is calculated by only regarding convection and conduction. So for calculations of BEP-tr there is a statement that "*since there is no information related with specific heat values of construction materials in standards, in this calculation methodology, a default value is defined. The value is assumed that building has a medium weight and a medium thermal capacity. If the values of materials related with heat capacity will be available, thermal mass will be considered in calculations in detail.*" Passing over thermal mass effect in calculation is a deficiency for BEP-tr.

d) Definition of internal heat gains is essential for energy calculations. BEP-tr accepts only one default value for all internal gains (lighting, appliances, etc.). This value cannot be changed, or enlarge on. Particularly for cooling energy consumption, internal gains are one of the important parameter and should be defined in detail.

e) In national calculation methodology there is a list for definition of comfort conditions for different building types and for different zones. However, in the software (BEP-tr) there is no possibility to change the values. There is no option to define a comfort band or thermostat setting for heating and cooling.

f) In order to run calculation, it is necessary to define a cooling system. For the buildings with only heating system defined (for instance houses, apartments, etc.) cannot be calculated.

g) For the system definitions (heating, cooling, ventilation) there are very limited and static data is enough for calculation. Although energy performance regulation recommends innovative solutions of systems, there is no possibility to integrate innovative system options to the model in BEP-tr.

h) When several alterations are done at any data value (ie. material of envelope construction) of BEP-tr model, heating and cooling energy demand has been changed. Related with energy consumption, it was expected any change at the value of carbon emission but there is no or very slight change occurs.

i) Another recommendation of BEP regulation is renewable energy system integration where possible. However, the software does not allow identifying renewable energy system.

j) BEP-tr can only be used by internet connection. The tool runs on a web based system. This is another handicap of the tool, since the accessibility of the tool depends on the limits and speed of your connection. The most complaint of the users is the problems occurred during connections.

5. CONCLUSION

Today it is obviously accepted that in order to reach high performance building level, energy performance evaluation from the very beginning of the design process with an interdisciplinary team is a must. Concordantly the expectations from a national calculation tool-BEP-tr are higher. Although the national calculation methodology released by the Ministry includes almost all the parameters (internal gains, solar gains, air change rates, thermal capacity, etc.) in detail, the tool use assumptions or accept most of those parameters as default values.

Basic expectations from BEP-tr as an energy analysis and modelling tool are as follows:

Modelling: Although it is enough to model as simple as possible, parameters like form, size, surface specifications, etc. should not be simplified. It is necessary to reduce assumption requirements and develop an interface that allows user to select the data or to modify it. At this point, an expert knowledge and an expert support are required.

Calculation: superficial definitions in the model-if any-, particularly HVAC system configurations, should be set as default. At that point intelligent defaulting is very essential. The tool user should be sure of the tools reliability. The definition of "intelligent defaulting" is very hard.

Analysis of the results: the results should have an ability to give advice to the further stages of design. The optimization and alternative solutions can be able to guide the designer during design decisions.

In addition to all the requirements listed above; it should be accepted that national calculation tool- BEP-tr is not a "design tool" but a "performance confirmation tool". Therefore the tool cannot be used during early phases of design and all the information related with building should be available by the user. Hence, it should be emphasised that there should be no necessity to "assumption" or "intelligent defaulting" during modelling.

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BUILDING ENERGY PERFORMANCE (BEP-TR) AS A CALCULATION METHODOLOGY : COMPARISON WITH OTHER ENERGY CERTIFICATIONS

SELCEN NUR ERİKCİ[1]

ABSTRACT

In this study, differences between BEP-TR National Building Energy Performance Calculation Methodology and the widely used environmental assessment methods for buildings are investigated. Parameters as paths taken in the calculations, priorities, energy classifications through the simulation tools of the methods are evaluated. The most appropriate system or implementation for Turkey is mentioned along the comparison of these assessments in terms of energy classifications. The necessity of an energy performance calculation methodology is emphasized according tolocal properties and preconditions.

Key words: BEP-TR National Calculation Methodology, Building Energy Performance Certification, BREEAM, LEED, Energy Classification.

1. INTRODUCTION

In parallel with the development of information and communication technologies, the sensitivity displayed by the designers for making the buildings environment friendly has increased and in various countries around the world, energy-effective building certification systems have been developed. Global climate change and ever-decreasing fossil energy resources have resulted in energy effectiveness and energy efficiency concepts especially in construction sector. Among these systems, there are certification systems such as CASBEE, Green Star, SBTool, BEES, ECOPROFILE besides those which are worldwide known and commonly used such as BREEAM and LEED. For the buildings to be designed energy-effective, all these systems audit various procedures in the design process, determine the results of these audits with scoring method, and find the energy class of the examined building with the evaluations as a result of determined scores according to the reference building. Carbon emission amounts occurring depending on the required energy for

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heating, cooling, lighting and ventilating of the building and on consumption of this energy and building energy performance which is "the consumed amount of energy for providing the comfort conditions to meet the different requirements connected with the standard use of the building" [1] are important factors in energy-effective building classification.

In our country, studies on Calculation Method of Energy Performance of Buildings (BEP-TR) which were started in December 2008 by R.T. Ministry of Public Works and

Settlement were completed in December 2009 and in December 2010, it became official. BEP-TR method which will be used for issuance of Energy Identity Certificate (EIC) which is mandatory for all buildings in EU countries was developed for Turkey conditions via the methods stipulated by EPBD (Energy Performance Building Directive). BEP-TR which is the national calculation method is based on "Simple Hourly Dynamic Calculation Methodology". This mandatory system was formed in a way not to include detailed energy simulation tools based on the requirement to follow more simple methods for ease of use and quick certification. EIC, which became mandatory for buildings to be made after July 2011 and for the existing buildings until 2017, has a great importance in ensuring energy efficiency in Turkey.

When parameters affecting the energy performance of buildings (light, climate, passive system parameters, parameters of electrical and mechanical systems, etc.) and many variables within these parameters are evaluated, the certification systems developed to calculate the lifelong energy costs of buildings use detailed energy simulation tools. BEP-TR which is the national calculation method is based on simple hourly dynamic calculation methodology. Not having a certain common evaluation and not stating the energy classes of these buildings with equal values in these studies performed with this calculation methods form the basis of the study. The importance of being able to carry out accurate studies on using energy effectively and saving energy from the design stage to the end of building process is emphasized in terms of architects. In this study, the differences between BEP-TR and other certification systems' energy performance scoring evaluation systems of buildings and inequalities between the results will be stated with comparative analyses and evaluated. This study is the comparative evaluation of energy simulation programs used in determination of energy class values obtained as a result of studies performed with these systems with the aim to determine the energy classes of buildings, the data taken as basis by these programs and resulting building energy classes. This study is limited with the examination of BEP-TR, LEED and BREEAM systems.

2. CALCULATION METHOD OF ENERGY PERFORMANCE OF BUILDINGS

National Calculation Method of Energy Performance of Buildings - BEP-TR which became mandatory for existing buildings and buildings to be made (residence, buildings for commercial and service purposes, etc.) by being published in Official

Gazette as of 7 December 2010 will be used to form the EIC of all these buildings. Therefore, it is aimed to create awareness about the energy consumed by the buildings in the society and their damages to the environment. It is aimed to find the energy classes of buildings used for different purposes and decrease their damages to the environment with the measures to be taken.

"Calculation Method of Energy Performance of Buildings includes
1.Calculation of net energy amount required for heating and cooling of the building,
2. Determination of total heating and cooling energy consumption of the building considering the losses resulting from systems which will meet net heating and cooling energy requirement, and system efficiencies,
3.Determination of ventilation energy consumption,
4.Calculation of lighting energy requirement and consumption for time of no daylight utilization and areas where daylight is not effective by considering the effects of daylight in the buildings,
5.Calculation of energy consumption necessary for sanitary hot water [2]".

Building net energy inputs and outputs included in the calculations are seen in Figure 1.

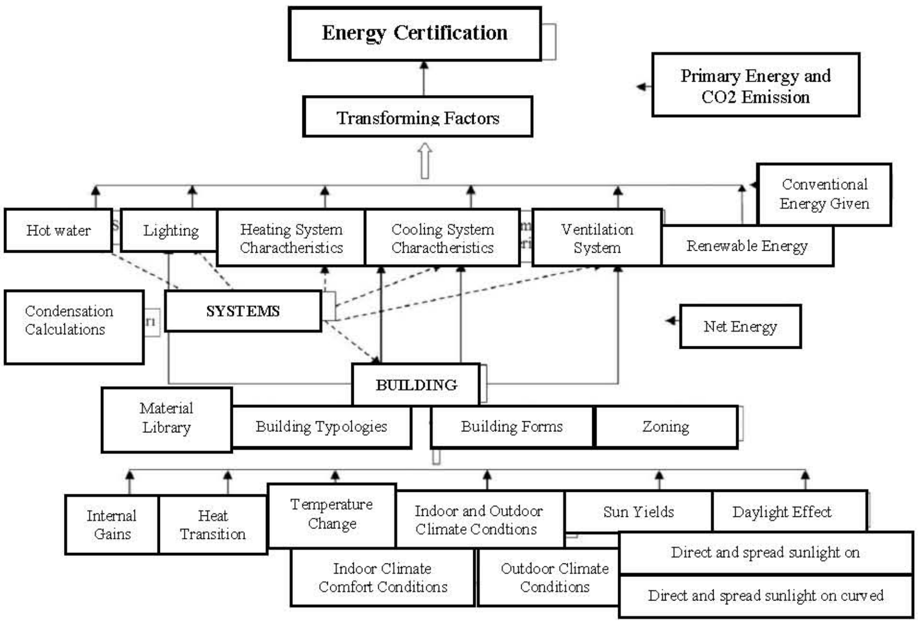

Figure 1. Net Energy Data Inputs and Outputs[3]

When the above data are considered, BEP-TR consists of three parts which are

- Meeting the building heating and cooling net energy requirement
- Determination of lighting loads and

- Calculation of energy consumption with the mechanical systems which will fulfill the building net energy requirement.

"TS ISO 13790 suggests three models in calculating building heating and cooling net energy amount;

- Monthly / seasonal static calculation method,
- Simple hourly dynamic calculation methodology,
- Detailed dynamic calculation method[4]".

BEP-TR calculation method was formed using related EU standards and when required ASHRAE and Turkish standards. The method used is "Simple Hourly Dynamic Calculation Methodology". The basis of choosing this method is impracticability of detailed dynamic methods, not essentially requiring to determine the heating and cooling seasons as it is in monthly / seasonal static methods and being able to calculate the net energy amount in changeover seasons.[5]

"Simple hourly dynamic calculation methodology;

- is a half dynamic calculation method. Hourly climate data and time schedules are used.
- RC (resistance-capacity) model can reflect hourly thermal behavior of the building in a more real-like way.
- It allows for comfort conditions to be identified depending on the operative temperature.
- It calculates the operative temperatures with hourly calculation steps and required net energy which will provide for the comfort requirements according to hourly time schedule[6].

Methods which calculate only the heating requirement taking as basis the climate data due to the geographical positions in general of the EU countries and which use monthly / seasonal static calculation method are used and thereby sun yields and shading effects are not considered. Determining cooling requirements of our country is an important parameter which should be emphasized just like heating requirement net energy amount and therefore it is ensured that in BEP-TR sun yields and shading effects are calculated and building net energy amounts are found. In determining heating and cooling energy requirements, direction of the building and daylight affecting the building surfaces, inclination of surfaces which are exposed to sunlight and sun control elements are simply included in the calculation.
BEP-TR algorithm makes calculations in a level which can be deemed sufficient basically for residence and office buildings. However, since there are points which were left indefinite and incomplete in ISO 13790 and other standards it was directed (sun yields, shading effects, relations with zone in heating transitions, internal yields, etc.), analyses were made according to EU standards.
BEP-TR calculations vary according to functions of each building and are based on zoning and including in calculation. In the stage of zoning the building, each floor for detached houses and each independent unit (flat) in apartment type residences are considered as a separate zone. In calculations made using the method, heat losses

occurring via conduction and convection are taken from the tables which include thermal transition coefficients (U values) for glass and joinery types in our country. In Figure 2, structure components used in BEP-TR calculations are given as zones. Locations which are affected by the outside weather are considered as "climatized zone" and locations which do not interact with outside weather are considered as "non-climatized zone". These zones in which air flow occurs via wall, flooring and foundation and joinery are grouped and separated into types.

"Sources which are accepted as causing air flow in BEP-TR are as follows

- Natural ventilation through windows and doors,
- Leaks coming through openings and cracks in structure shell (infiltration),
- Air flow from non-climatized adjacent zone (winter garden, etc.) and
- Air flow from mechanical ventilation systems [7]".

Temperature correction factors are used in including heat losses arising out of such air flows in calculation. The required details are considered accurately according to the source of air flows and thereby heat transitions/losses are included in the calculations.

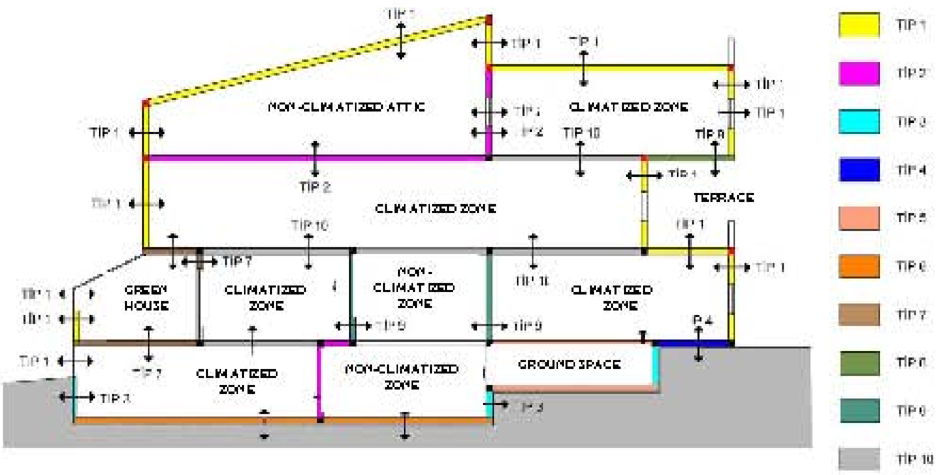

Figure 2. Structure Components Which Zone Thermal Conditions for Heat Transition Calculations[8]

Since following more simple methods is taken as basis for providing ease of use in BEP-TR calculation method and for fast certification, related standards were used in determining accepted internal yields arising out of humans and devices according to the function of the building. It is assumed that buildings with same function are used in same hours in daily time zones.
It is ensured that building shell components are gathered in two main groups which are opaque and transparent components and yields resulting from insulation effect are calculated. In this stage, parameters such as sun yields gathered via transparent

and opaque components in the building, obstacles in the exterior wall, shading effects of the buildings on each other are taken into consideration.

After zoning the buildings, determining building components according to types considering heat transitions / losses, including internal yields arising out of humans and devices (lighting devices, mechanical goods, hot water utility, etc.) and calculating sun yields of the building via the transparent and opaque components, heating and cooling net energy requirement of the building can be calculated. In calculating net energy amount, "resistance-capacity" model which is suggested in EN 13790, but whose details are not included for not being used commonly is used.

This model calculates the heating or cooling requirement of the building's each previously determined zone hourly. In this stage, thermal capacity of the building is considered as an approximate value and an average mass temperature is calculated. *Operative temperature* which is defined as indoor comfort consists of temperature which is hourly calculated by the model and cumulative average of thermal mass temperature of the building. If this operative temperature is lower than the temperature accepted for heating, that zone needs heating, if it is higher than temperature accepted for cooling, it needs cooling. If operative temperature is a value between temperatures determined for heating and cooling, that zone needs neither heating nor cooling [8].

Calculation Methodology of Energy Performance of Building which is a national calculation method has been prepared for our country and is based on existing measurements and evaluations which are used in terms of geographical, architectural and construction techniques. It aims to calculate net energy amounts of buildings, determine their energy classes and create certain awareness in issues such as harms to the environment and CO_2 emission amounts. Thanks to the application in new buildings to be built as of July 2011 and imposing an obligation to give EIC to the buildings, it is among the most important expectations that it will play an important role in terms of exhausting energy sources and accelerating the solution processes for them.

In energy performance evaluation, separate classifications are made for energy consumption and CO_2 emission. The interims in the table define the BEP-TR performance values.

Table 1. Energy Classes According to EP Building Performance Values [9]

Energy class	Ep interims
A	0–39
B	40–79
C	80–99
D	100–119
E	120–139
F	140–174
G	175-…

3. DEFINING OTHER INTERNATIONAL CERTIFICATE CALCULATION METHODS

International certificate methods which will be compared with each other and with BEP-TR national calculation method in the study are chosen among the widely known certificate programs in the world. LEED (Leadership in Energy and Environmental Design), BREEAM (Building Research Establishment Environmental Assessment Method), GREENSTAR, CASBEE (Comprehensive Assessment System for Building Environmental Efficiency), SBTool (Sustainable Building Tool-Canada), GBC (Green Building Challenge) are among the most used certificate systems in the world.

Especially BREEAM and LEED are the primary international systems which are used most in building and promoting the energy-effective buildings. In both systems, analyzing the building energy amounts and determining energy class are taken as basis in the process from design stage to auditing during construction.

LEED is one of the certificate systems which were developed by US Green Building Council (USGBC) and which have a global brandname value. BREEAM is an internationally recognized certificate system which makes the energy class identifications of the non-residential buildings in England in 1990 and which has been commonly used in England and Europe.

LEED measurements are performed in the following subjects

- Sustainable premises
- Water efficiency
- Energy & Atmosphere
- Materials & Resources
- Indoor quality
- Settlements & Connections
- Awareness & Training
- Innovation in design
- Regional priority

BREEAM calculations are performed in the following subjects

- Building Management
- Health and Comfort
- Energy
- Water
- Land Use and Ecology
- Transportation
- Material
- Wastes
- Pollution
- Innovation

and building gradings are formed with scoring system.[10]
In both systems, detailed simulation tools are used. Evaluating buildings' annual heating and cooling requirements and consumptions and daylight lighting performances is only possible with the use of these simulation tools. Detailed simulation tools which are used in determining building energy performances can make simultaneous-multiple zone calculation (zones in which thermal conditions are different and in which thermal relations of these zones with each other are simultaneously considered).[11] Energy Plus is a detailed simulation method which is supported by USA Ministry of Energy and used most commonly in the world and in our country. In addition, they support detailed simulation tools such as DesignBuilder, Ecotect, DOE-2 to be used in energy modeling. EnergyPlus is a detailed simulation program which dynamically calculates the energy amount consumed by the buildings in design stage or existing buildings due to heating, cooling and ventilation loads and displays the energy performances of these buildings in design stage before the construction and allows for the designer to choose the most proper one for the project.[12] In detailed simulation tools, many program modules work together and make the necessary calculations to estimate the energy used by the building for heating and cooling. It is necessary to analyze the "building, system, installation" parameters which form the three main component in energy consumption. Especially in energy certification evaluations of complex buildings (hotel, education, health buildings, etc.) whose energy consumptions are very high, which have different thermal requirements and which consist of many places, detailed simulation tools are used.

3.1. COMPARING LEED and BREEAM CERTIFICATE SYSTEMS

LEED and BREEAM take as basis the abovementioned criteria and make analyses by choosing the most proper one according to usage targets of detailed simulation tools. As a result of the analyses, they can identify building energy performances according to scoring systems. LEED scoring system uses a scoring system of maximum 110 points and BREEAM uses a system of percent weight over 100 points.[13] Both certificate system generally require the following data

- Construction records
- Architectural drawings/diagrams
- Engineer calculations
- Energy model report/Energy Performance Certificates
- Written statements by project owner or project developer about the project[14]

Both certificate systems use their own existing standards and plans. In the beginning stage, two different teams, design and audit, consisting of separate experts in two individual topics are formed. Regularly collecting the data from the individuals in the design team, audit team perform the audit process according to the standards of the systems (individual standards arranged for LEED and BREEAM). Energy performances of the buildings are found for certain prices. In addition, BREEAM may perform site audit for the certificate to be valid when necessary. There is no site audit in LEED.

Table 2. BREEAM Technical Details[11]

BREEAM CATEGORIES	**New Buildings, Additions, Big restorations**	**Fit-Out**
Management	12	13
Health and Wellbeing	15	17
Energy	19	21
Transportation	8	9
Water	6	7
Material	12.5	14
Waste	7.5	8
Soil Use and Ecology	10	No
Pollution	10	11

Table 3. BREEAM Classification[11]

BREEAM CLASSIFICATION	SCORE (%)
FAIL	<30
PASS	>=30
GOOD	>=45
VERY GOOD	>=55
PERFECT	>=70
EXTRAORDINARY	>=85

Table 4. LEED Technical Details[11]

LEED CATEGORIES	New Buildings, additions, big restorations
Sustainable Lands	26
Water Effectiveness	10
Energy and Atmosphere	35
Materials and Resources	14
Indoor Air Quality	15
TOTAL	100
BONUS SCORES	
INNOVATION AND DESIGN	6 (If 5 innovation credits +1 credit LEED AP is used)
REGIONAL CREDIT	4
TOTAL	110

Table 5. LEED Classification[11]

LEED CLASSIFICATION	SCORE
CERTIFIED	40–49
SILVER	50–59
GOLD	60–79
PLATINUM	80 points and above

NOTE: These scores depend on the certification systems' (BREEAM and LEED) calculation methods. They are totally automatic and come out from the software. They are variable both with the project's features and also with the program that is used - BREEAM or LEED-.

In the tables above, the categories used in scoring systems of BREEAM and LEED certificates and the scoring evaluation classifications they get according to these categories are seen. Measurements are made over similar parameters in both certificate systems, however scoring evaluations differ from each other quite much. Similarly, there is a standardized preconditions list for both systems. These preconditions determined in BREEAM can be said to be too much for LEED. It is known that LEED give more right to decide to the designer than BREEAM.[15] The interims for different building typologies and total scores to be obtained in LEED show difference.

Unless applications fulfill preconditions determined for BREEAM degrees such as

- Commissioning
- Effect of construction site
- Building user guide
- Decreasing CO_2 emissions
- Water consumption
- Storing recyclable wastes

they cannot have certificates. [16] For LEED, 8 parameters similar to the abovementioned topic are included in the precondition list of the system.

Although both systems generally have similar properties, BREEAM focuses more on environmental effect and LEED prioritizes health and comfort of the user. [17]. Despite of the fact that the criteria on which both systems are based on have similar properties, England's legislation's having more strict rules than those in America makes application of BREEAM much more difficult than LEED. Accordingly, scoring systems also differ due to having different priorities of the criteria.[18]

4. COMPARATIVE EVALUATION OF BEP-TR WITH OTHER SYSTEMS

National building energy performance methodology, BEP-TR, which uses simple hourly semi-dynamic calculation method exhibits different properties and evaluations from BREEAM and LEED which use detailed dynamic calculation methods.

With the publication of BEP-TR as regulation in Turkey in December 2008, it became mandatory to get EIC for buildings to be built as of June 2011 which have an indoor area of 1000 m². However, it is necessary for national calculation method BEP-TR to make correct calculations in every building typology and by including any kinds of criteria. These calculations examine the thermal behavior of the building in hourly time frames and include them in the calculations. In addition, both heating and cooling net energy amounts should be calculated due to geographical position and climatic data of our country. Besides, it also considers the shading and insulation conditions which are among the most important parameters for our country. BEP-TR is an appropriate method for simple residence buildings whose thermal behaviors are not very different and which do not include many zones. The main purpose in the method is to find the energy consumption amounts of the buildings in a simplified way.

BREEAM and LEED are the certificate systems which have global brandname value in the entire world, which are commonly used and which have local calculation types arranged by various countries according to their own data. EU member states and USA make it obligatory to determine the energy classes according to CO_2 emission amounts produced by the buildings and this does not establish any obligation for the countries in terms of choosing the certificate system which will realize this. These are the systems which are arranged to perform its calculations during the lifetime of the building in terms of decreasing building energy consumption and CO_2 emission amounts. They make the building energy modelings of systems which use detailed dynamic calculation methods. Detailed simulation tools are the interfaces which can make simultaneous calculations with many modules in their contents between zones whose thermal conditions are very different from each other. Therefore, making energy modelings of hotels, healthcare buildings and non-residential buildings used for commercial purposes and calculating their net energy amounts are only possible with detailed simulation tools.

Although the criteria and preconditions they use show similarity, there are certain differences especially in the parameters they set as priority. The availability of differences especially in terms of score evaluations in two systems which make calculation with detailed dynamic methods and which have similar parameters is important for us to be able to see its differences with a method which uses a simple hourly calculation method such as BEP-TR.

There are ongoing studies on the arrangements which use detailed dynamic methods for BEP-TR to be applied in complex building calculations. In addition, Turkish Green Building Council (TGBC) which was founded in 2007 signed agreements with BRE-GLOBAL in 2009, with DGNB in 2010 and with LEED-INTERNATIONAL in 2011. The short-term aim of the council is arrangement of the existing systems such as BREEAM, LEED, IISBE, Green Star, CASBEE or DGNB for Turkey conditions. In long-term, the aim is to form a system for our country. [19] There are ongoing studies performed by TGBC for developing BREEAM which is one of the oldest environmental evaluation systems under the adaptation resolution taken in Turkey in 2008.

5.CONCLUSION

These methods constitute a sample for the measurement tools used. They include criteria which should be observed and followed in architectural, design, mechanical, electrical installation solutions according to construction order of the building and in all of the construction processes. Countries require calculation methods which are arranged according to their local condition and properties. The method which is prepared by prioritizing the local dynamics in points such as climatic data, priorities, energy classification, materials used will give the best result. Renewability criterion should be considered according to changing conditions and properties in time.

In this case, a calculation method should be chosen by taking into consideration the conditions of our country (geographical, climatic, architectural, materials, etc.) and in a way to be applicable for all building ty pologies. Neither BEP-TR which uses simple hourly calculation method neither systems which use detailed dynamic calculation methods such as BREEAM, LEED can produce a complete solution choice for our country. All criteria included in the content of the methods should be developed for Turkey conditions improvement and applicability should be provided in the most convenient level in all buildings to be made.

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KEYNOTE SPEECH

(15 November 2012 Thursday, 15.00-15.30)

Prof. Dr. Ardeshir MAHDAVİ
A *Predictive Approach to Iıntelligent Building Systems Control*

A PREDICTIVE APPROACH TO INTELLIGENT BUILDING SYSTEMS CONTROL

ARDESHIR MAHDAVI[1]

ABSTRACT

This keynote presents the implementation of a novel predictive approach to intelligent building systems control. The implementation specifically pertains to the utilization of passive cooling in buildings. Thereby, numeric simulation is deployed as an integral part of the control logic to predict future implications of alternative control options (alternative positions of windows, shades, etc.) and identify the best performing control option. A genetic algorithm was developed to generate a manageable set of alternative options from the corpus of all possible control actions at any given time. Five rooms in two office buildings in Austria were used to test this method. The paper describes the approach and implementation in detail and presents the results.

Key words: building systems, predictive control, performance simulation, passive cooling, genetic algorithms

1. INTRODUCTION

The cooling energy demand in middle Europe is rapidly increasing, due in part to developments regarding climate change and urban heat islands. Conventional cooling systems are energy-intensive and problematic from the environmental point of view. Development of alternative energy-efficient alternatives for space cooling in new and existing buildings is thus of paramount importance both environmentally and economically. One innovative possibility to address this challenge is to explore the potential of technologically revisited and updated passive cooling techniques, which are primarily based on outdoor day-night temperature amplitudes and buildings' inherent thermal inertia. The intelligent use of passive control methods combined with innovative building systems as well as advanced sensory and actuating components have the potential to significantly decrease the energy use for space cooling (Lomas 2006, Garça et al. 2003, Krausse el al. 2007, Salmeron et al.

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2009, Mahdavi and Pröglhöf 2004, 2005, 2006, Mahdavi et al. 2009). This possibility was explored within the framework of a number of recent research projects. Thereby, the primary ingredients of passive cooling (thermal mass and amplitudinal variation of outdoor temperature) were optimally harnessed via a sensor-supported simulation-assisted predictive system control strategy. To evaluate this method, it was implemented and tested in five offices in two office buildings in Vienna and Stallhofen, Austria.

2. A PREDICTIVE SIMULATION-POWERED CONTROL APPROACH

2.1. General structure

The aforementioned novel predictive simulation-assisted control method was deployed toward intelligent passive cooling in office buildings. The application of the underlying concept in the building performance domain was introduced in (Mahdavi 1997) and further elaborated, amongst others, in Mahdavi 2001. This concept, which should not be confused with model-predictive control (García et al. 1989), involves the incorporation of explicit numeric performance simulation in the control core of buildings' environmental systems (in this case for window ventilation and shading controls). Thereby, candidate control options (i.e., alternative combination of the possible state of different control devices) for a future time instance are proactively evaluated via performance simulation. The simulation results for these alternative control constellations are compared with regard to the control objective. Thus, better performing control actions are identified and instantiated, either directly by the building's control unit, or through informed occupants' actions. A number of virtual and prototypical implementations of this concept have been introduced in the past, especially in the field of lighting and shading controls (see, for example, Mahdavi et al. 2000, Mahdavi 2008). Further studies augmented the simulation-based predictive building systems strategy with agent-based technologies and machine-learning methods (Chang and Mahdavi 2002, Mo and Mahdavi 2003). More recently, we have explored the application of simulation-powered control systems to the natural ventilation and passive cooling domains (Mahdavi et al. 2009, Schuss et al. 2010).

In the present implementation, the control method generates and evaluates alternative operation possibilities using genetic algorithms and the multi-domain simulation results. Figure 1 illustrates the basic sequence involved in the approach, which is typically instantiated on a regular basis (e.g. once every hour). The control procedure was implemented in the matlab environment (Matlab 2010) and uses HAMbase (van Schijndel 2007) and (Radiance 2010) as embedded simulation tools. Services for data monitoring, communication, and weather forecast were programmed in C and run independently. Monitoring data (internal and external sensors) together with the web-based weather forecasts data were stored in a SQLite database.

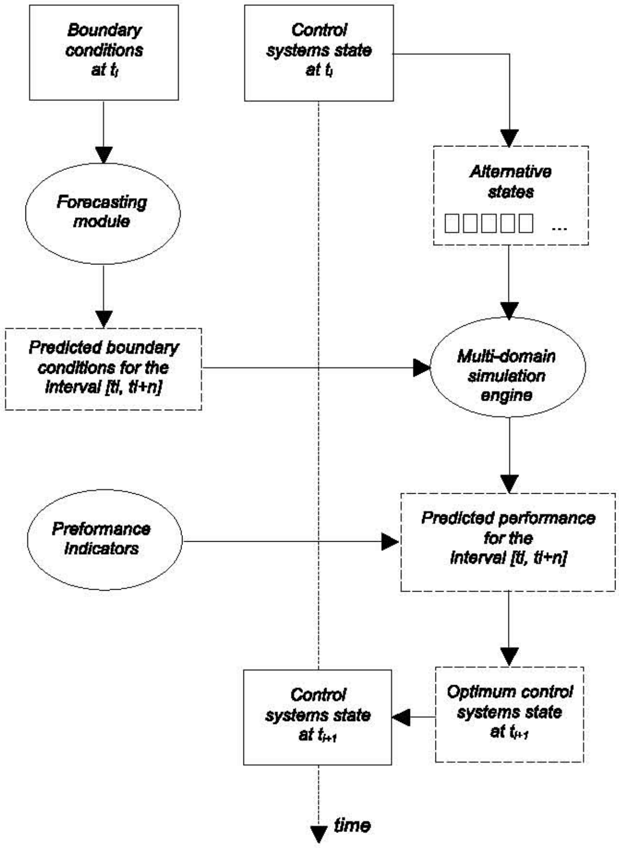

Figure 1. Illustration of the multi-domain simulation-assisted control method

2.2. Performance indicators

To guide the operation of the control system, a number of performance functions and indicators were defined and applied to evaluate the multi-domain simulation results. The overall performance indicator i (Equation 1) is the weighted sum of all individual indicators i_x. The value of each indicator and the sum of the weighting factors w_x is in the range of 0 to 1. Hence i must be in the same range. The ranking of the alternative control possibilities is done by maximum to minimum sorting.

$$i = \sum i_x \times w_x \qquad (1)$$

$i, i_x, w_x \in [0,1]$ and $\sum_x w_x = 1$

The calculation of each indicator is based on the simulated predictive trend of the related system parameter (e.g., room air temperature). For each parameter, the sum of deviations d_{period} is calculated for the future n time steps shown in Equation 2.

$$d_{period} = \sum_{k=t_i}^{t_i+n} d(k) \quad (2)$$

The calculation of each deviation depends on a fixed set point (Equation 3) or an acceptable parameter range as shown in Equation 4 and Figure 2. The general indicator i_x could be derived either linearly (Equation 5), or exponentially (Equation 6).

$$d(t) = \left| p(t) - p_{SP}(t) \right| \quad (3)$$

$$d(t) = \begin{cases} p_{\min} - p(t) & if \quad p(t) < p_{\min} \\ 0 & if \quad p_{\min} \le p(t) \le p_{\max} \\ p(t) - p_{\max} & if \quad p(t) > p_{\max} \end{cases} \quad (4)$$

$$i_x = \begin{cases} 1 - \dfrac{d_{period}}{d_{period\max}} & if \quad d_{period} < d_{period\max} \\ 0 & if \quad d_{period} \ge d_{period\max} \end{cases} \quad (5)$$

$$i_x = 1 - e^{-c.d_{period}} \quad (6)$$

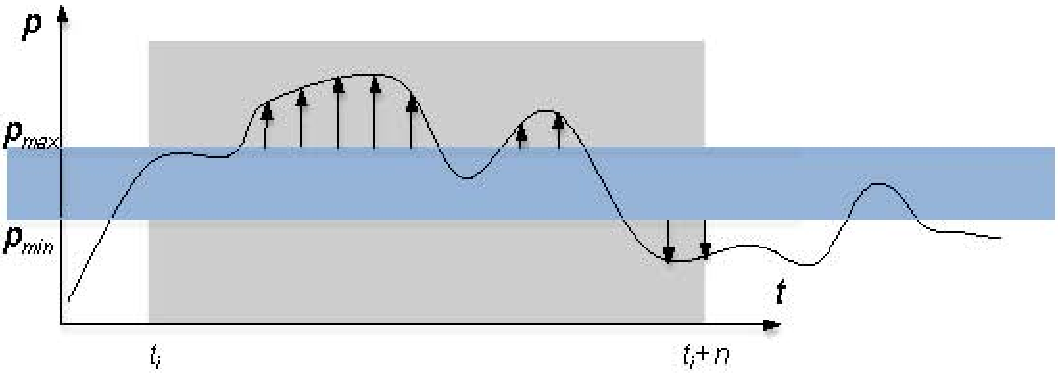

Figure 2. Deviation calculation for a general system parameter p

The principle calculation procedure for HVAC and lighting power use are expressed in equations 7 and 8 respectively.

$$i_{PHVAC} = \frac{1}{n}\sum_{t=t_i}^{t_i+n} 1 - \frac{P_{HVAC}(t)}{P_{HVAC_{max}}} \quad (7)$$

$$i_{PL} = \frac{1}{n}\sum_{t=t_i}^{t_i+n} 1 - \frac{P_{Lighting}(t)}{P_{Lighting_{max}}} \quad (8)$$

2.3. Generation of alternative control schedules

The predictive control method needs a set of alternative operation states in terms of the relevant device control schedules. These schedules have to be produced to run the multi-domain simulations. Using all possible combinations over the whole forecast interval would lead to an unmanageable number of possibilities. An approach using genetic algorithms (see Figure 3) provides a possibility to handle this challenge.

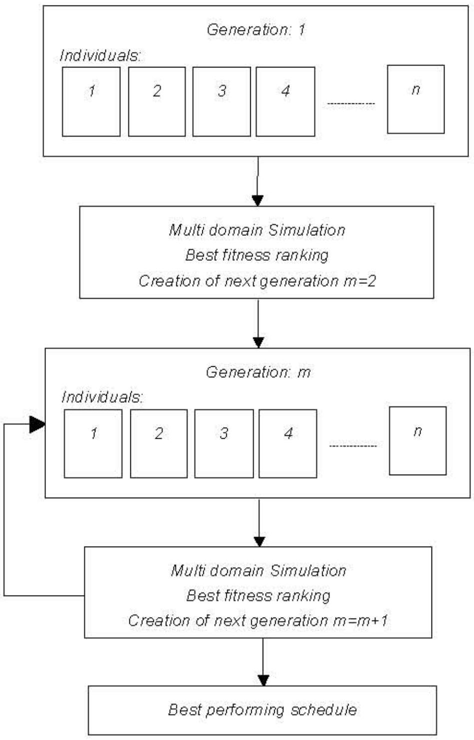

Figure 3. Illustration of the genetic generation of the desired operation schedules

Thereby, a number of default operation schedules were used together with randomized schedules as the initial setup. Needed state definitions and device attributes were stored in a predefined data structure to generate the schedules automatically. Based on the first generation simulation, the best-ranked schedules were selected to generate new child schedules in a random multipoint crossover reproduction process. For this purpose, the high-ranked schedules were crossed with themselves as well as with additional randomly selected schedules as parent elements. The selection of the fittest alternative (schedule) was done by the use of performance indicators (discussed before).

3. IMPLEMENTATION

Two office buildings in Austria were selected to implement and systematically test and evaluate the aforementioned approach. The first object (VUT) consists of three adjacent office rooms in an old office building of Vienna University of Technology. The second test facility (FIBAG) consists of two rooms (identical in layout but located on two adjacent floors) in an office building in Stallhofen, Styria. Note that the offices in VUT were actively used during the test period. This provided the opportunity to test the method's operation under realistic conditions. The corollary was, however, a few instances of user interference with the system's operation. In contrast, tests in FIBAG were conducted under unoccupied conditions.

3.1. VUT

Three occupied nearly identical south-oriented office spaces (R1, R2, and R3) were specifically targeted for our study (see Figure 4). The office R1, which has manually operated windows and internal venetian blinds, was kept as is and used as a reference. The other two offices were equipped with window actuators (for automated operation), as well as internal (R2) and external (R3) window shades. Additionally, PCM elements as well as a ceiling fan were installed in R3. All rooms were equipped with sensors for measuring indoor parameters such as air, surface, and globe temperature, relative humidity, occupancy, illuminance at the ceiling and at the workplace, air velocity, and carbon dioxide concentration (Figure 5). In addition, outdoor environmental data was collected (Figure 6) in front of the offices (air temperature, relative humidity, wind speed, and precipitation) and on the rooftop (global horizontal radiation, and diffuse horizontal radiation). Shade position and door/window status were also monitored. An overview of the deployed hardware equipment is provided in Table 1 and the hardware system schema is illustrated in Figure 7.

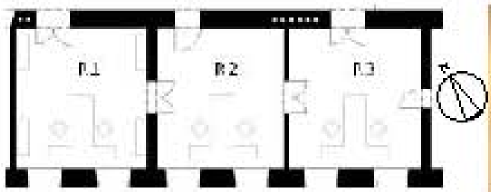

Figure 4. VUT - office layout

Figure 5. VUT – Internal climate sensors

Figure 6. VUT – Façade with climate sensors

Table 1. Summary of deployed hardware components

Hardware	Description
Indoor climate sensors	Compact indoor climate stations to measure air temperature, relative humidity, and velocity as well as carbon dioxide and illuminance at the workplace.
Outdoor climate sensors	Weather station for air temperature, relative humidity, precipitation, global irradiance, wind speed, and wind direction
User action and presence sensor	Presence: PIR - Sensor with adjustable threshold time; Door opening: magnetic contact sensors
Window automation	Two synchronized adjustable drives for each window to control the window opening position continuous.
Shading automation	Single drives with a special gear unit for height and angle positioning
Lighting control	The room controller can adjust dimming levels between 10 to 100% of the total lighting power
Backbone and communication network	IP base communication with access to building data points and data history

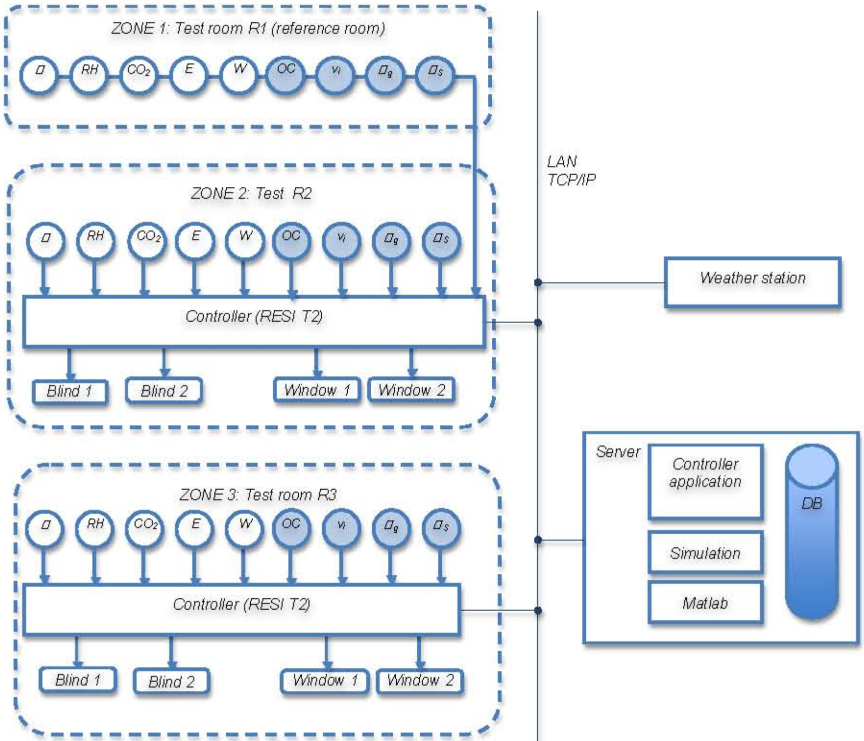

Figure 7. VUT - Hardware systems schema

3.2. FIBAG

A second implementation of the predictive control approach was done in a new office building in Styria, Austria (see Figure 8). For this purpose, two rooms in this office building were selected. The building structure with a concrete skeleton (ceilings and staircases) and the lightweight internal and external walls is typical for new office buildings in Austria. This circumstance, combined with the glass and aluminum façade, results in a reduced useable thermal storage mass and thus aggravates the impact of solar gains.

The two rooms are identical in terms of layout (Figure 9 and 10) and are located in the first and second floor on the northwest corner of the building. The offices were equipped with actuators for lighting, shading, and window operation. Indoor conditions in both rooms as well as the external climate were monitored with sensors for thermal and lighting parameters. One room was controlled with an implementation of the proposed predictive simulation-based control method. The second room was used as a reference.

Figure 8. FIBAG - Office building with two test rooms (marked)

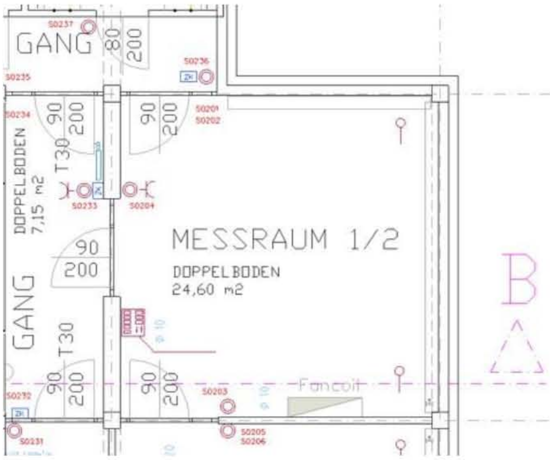

Figure 9. FIBAG - Test room layout

Figure 10. FIBAG - internal view of test room

3.3. Evaluation period

The developed control method was deployed in the operation of two test facilities during two months in summer 2010. However, parts of July were used for initial testing of the control setup. Thus full operational data is not available for all days in July. In August the system operated continuously. Hence, the present treatment focuses (with the exception of Figure 9), on August data. The control cycle was executed on a regular basis – once every hour. Figure 11 illustrates a typical outcome of such a cycle. The left side of the plot represents the history trends of the room air temperature (grey) and the outdoor air temperature (red). The predicted outside temperature is plotted on the right sight together with multiple simulation-based predictions of air temperature trends due to the virtual enactment of candidate control options. The best performing option is marked in black.

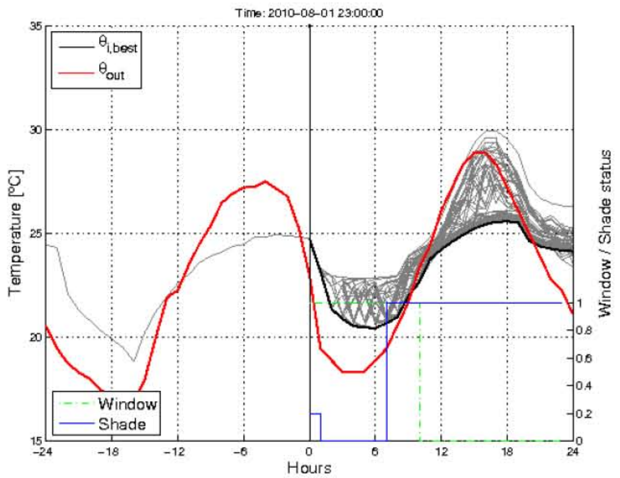

Figure 11. Indoor and outdoor (red) temperature history (left) and multiple predictions (right) with the best performing course (thick black) in the test room for a day in August 2010

To identify the preferable control option, two performance indicators (i) were used. One was related to the air temperature (θ_{air}) and the second related to mean interior surface temperatures of the room (θ_s). These two indicators were equally weighted (w_{air} , w_s).

$$i = i_{\theta_{air}} \cdot w_{\theta_{air}} + i_{\theta_s} \cdot w_{\theta_s} = \frac{1}{2} \cdot i_{\theta_{air}} + \frac{1}{2} \cdot i_{\theta_s} \qquad (1)$$

To derive the indicator values, a negative exponential formulation was used based on corresponding time-dependent aggregate deviations (Equation 10 and 11). In these equations, c represents a calibration factor.

$$i_{\theta_{air}} = 1 - e^{-c.d_{\theta_{air}}} \tag{2}$$

$$i_{\theta_s} = 1 - e^{-c.d_{\theta_s}} \tag{3}$$

In case of the storage temperature indicator, aggregated deviations are calculated as a sum of all discrete time deviations *m(t)* in the forecast interval (Equation 12). In case of air temperature (Equation 13), only the occupancy hours (08:00-17:00) are considered, as represented by *g(t)*. Figures 12 and 13 illustrate this circumstance.

$$d_{\theta_s} = \sum_{t=t_i}^{t_i+n} m_{\theta_s}(t) \tag{4}$$

$$d_{\theta_{air}} = \sum_{t=t_i}^{t_i+n} m_{\theta_{air}}(t) \times g(t). \tag{5}$$

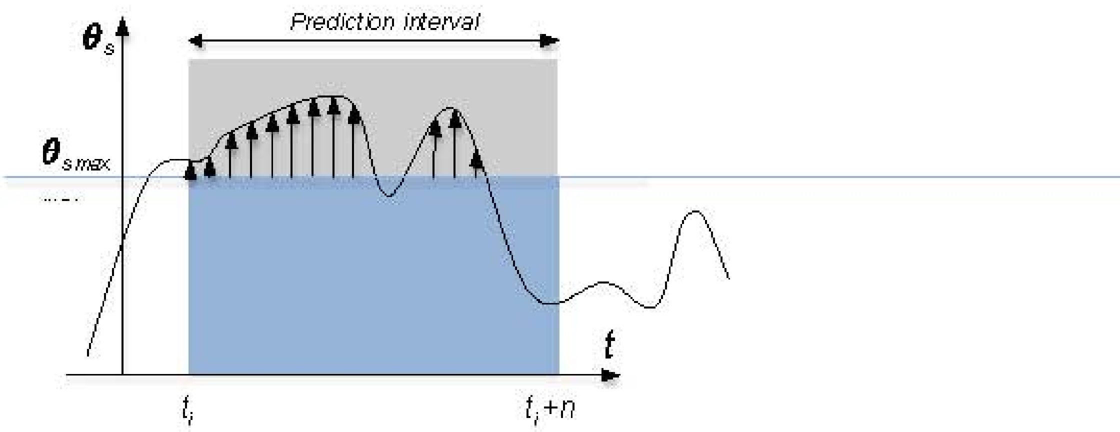

Figure 12. Deviation calculation for the surface temperature performance indicator

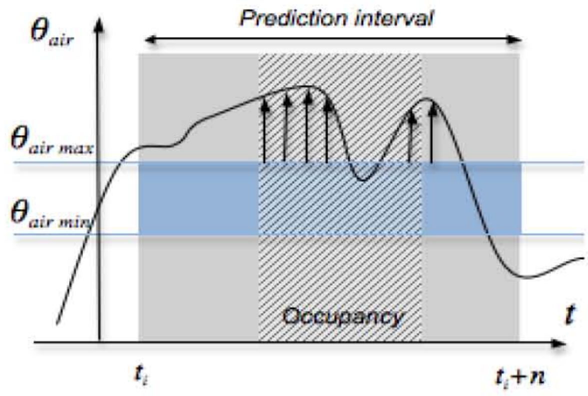

Figure 13. Deviation calculation for the air temperature performance indicator.

4. RESULTES

The test results point to the potential of the proposed predictive control: as compared to the reference rooms, the rooms with the predictive control systems demonstrated preferable indoor climate conditions

4.1. VUT

To illustrate the performance of the method, Figure 14 shows the indoor and outdoor air temperature trends for three successive days in July 2010. The better thermal performance of the controlled rooms is obvious. The peak temperature readings in R3 and R2 were 4 K and 2 K lower respectively compared to the reference room R1. To evaluate the system's performance in more detail, Predicted Mean Vote values (PMV) as well as mean overheating was calculated for August (during working hours, i.e. from 8:00 to 17:00). Note that, strictly speaking, PMV is not applicable to free-running buildings. Nonetheless, given its familiarity, it is used here to document the relative differences between the reference and controlled rooms. Figure 15 depicts the monthly mean PMVs and the mean overheating (computed for a reference overheating temperature of 26°C) for R1 (reference room), R2, and R3. As compared to the reference room, rooms R2 and R3 show better results. The difference between R1 and R3 is about 0.5 points in terms of PMV and 1.1 K in terms of mean overheating. The collected data was also processed in terms of psychometric charts (Figures 16 to 18). The (red) dots represent mean hourly values during working hours (08:00-17:00). The (green) polygons show the applicable thermal comfort zone according to the adaptive thermal comfort theory (Szokolay 2004). The psychometric charts display a similar trend. R3, as the best-equipped room, was 38% less outside the thermal comfort zone compared to R1. Likewise, R2 was about 24% less outside the thermal zone than R1.

In addition to such numeric comparisons, we also requested user feedbacks via questionnaires. In general, users in R2 and R3 generally had a better view of the thermal environment than in the reference room. Nighttime ventilation regime, added shading devices, and the – principally given – possibility to control the devices with the system's GUI was explicitly rated positive. The noise generated by the motorized actuators while opening or closing windows and blinds was commented on negatively. Moreover, users expressed the need for a more fine-tuned glare control.

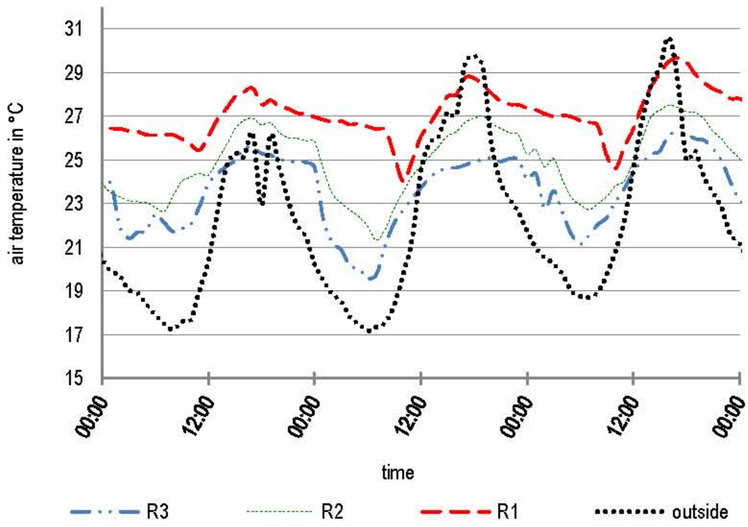

Figure 14. Typical air temperature trends in July 2010

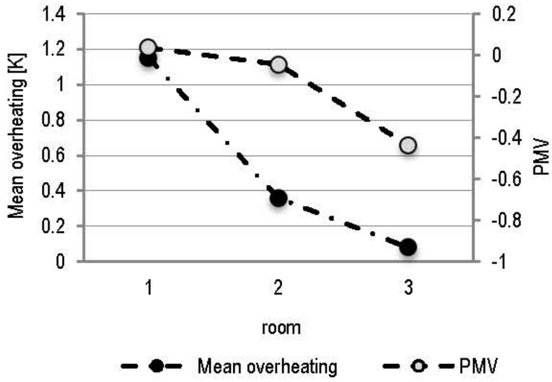

Figure 15. Mean overheating of indoor air and mean PMV values (VUT, August 2010)

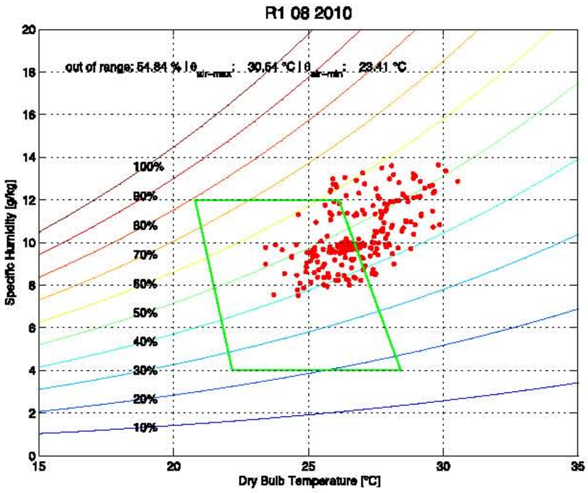

Figure 16. Measured temperature and humidity in R1 (VUT) during working hours, August 2010

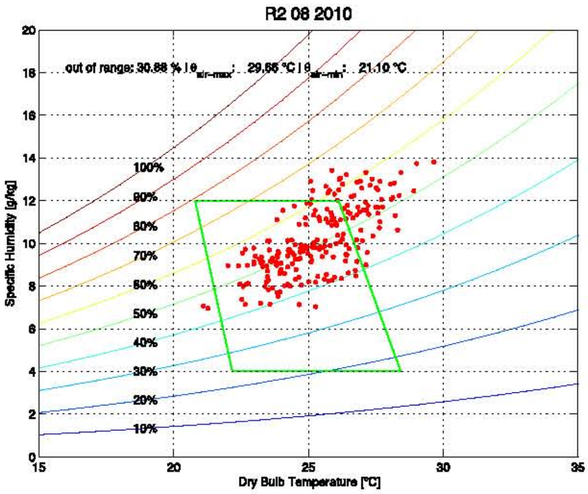

Figure 17. Measured temperature and humidity in R2 (VUT) during working hours, August 2010

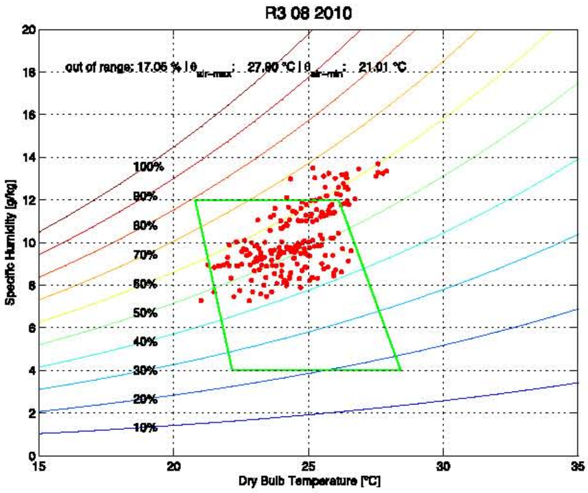

Figure 18. Measured temperature and humidity in R3 (VUT) during working hours, August 2010

4.2. FIBAG

Monthly mean PMV and overheating values for test spaces in FIBAG are shown in Figure 19. As compared to the reference room 2, room 1, which was operated via the simulation-based control method, provided better thermal conditions. Mean PMV amounts almost to zero (compared to 1 in room 2), whereas mean overheating is merely 0.5 K (compared to 2 K in the reference room).

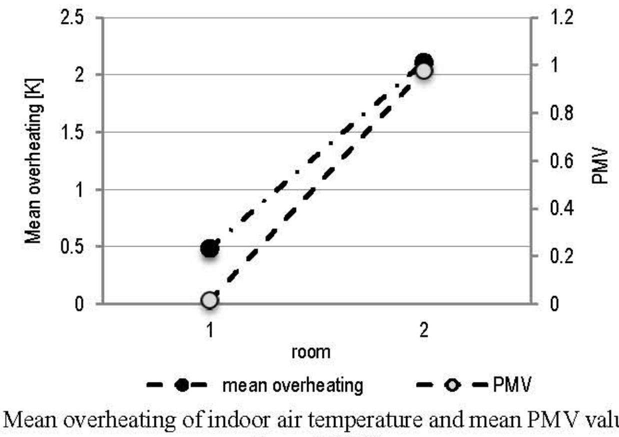

Figure 19. Mean overheating of indoor air temperature and mean PMV values (FIBAG, August 2010)

Psychometric charts (August 2010) display a similar trend (see Figures 20 and 21). As compared to the reference room 2, thermal conditions in room 1 were 35% longer in the thermal comfort zone (working hours).

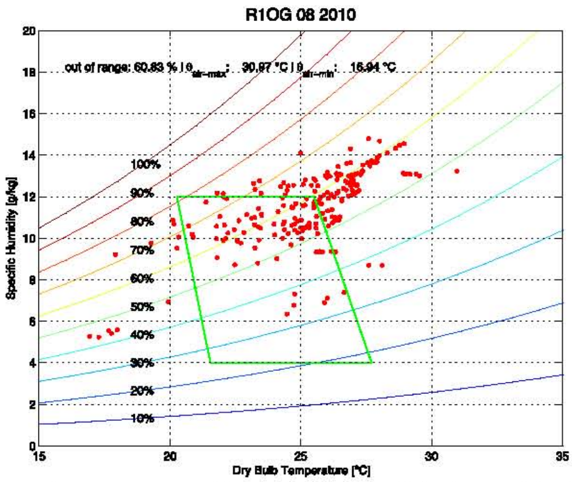

Figure 20. Measured temperature and humidity in room 1 during working hours (FIBAG, August 2010)

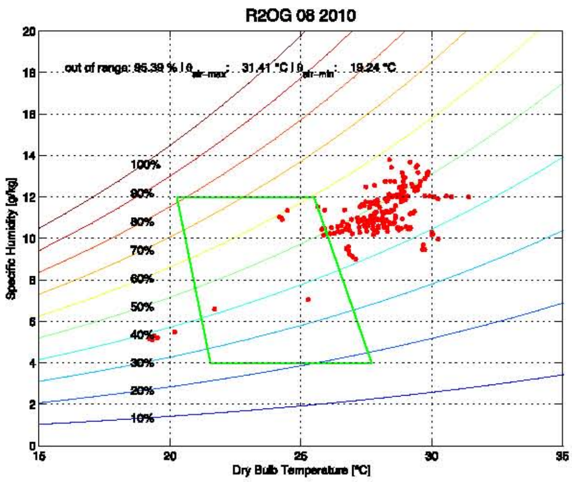

Figure 21. Measured temperature and humidity in room 2 during working hours (FIBAG, August 2010)

4.3. Weather prediction quality

The Quality of the integrated online weather forecasts was analyzed in terms of differences to the stored local monitored weather data. Generally speaking, forecast for air temperatures showed quite acceptable deviations in an overall one-degree range with some outliers around 2 to 4 degrees (Figure 22).

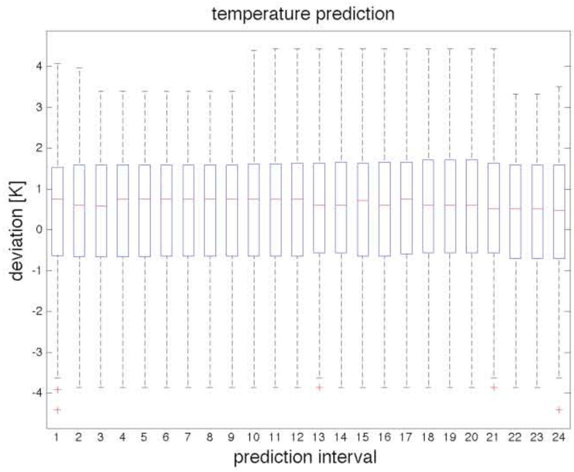

Figure 22. Temperature forecast deviation of 2010 data for 1 to 24 hour prediction

5. CONCLUSION

The research results illustrate the potential of the proposed predictive simulation-assisted approach to offer low-cost and energy-efficient indoor environmental control. Compared to the reference rooms, the rooms with the predictive control systems clearly demonstrated preferable indoor climate conditions. A number of measures would allow to further improve the performance of the system:

- The minimization of internal loads: The installed power of the electric devices (computers, artificial lights, etc.) should be minimized. Devices should be switched off (or hibernate) when not in use.
- The importance of informing the users: Users should be instructed regarding the proper operation of building systems. Moreover, the users should be given proper feedback about the implications of their actions and behavior.
- The accuracy of input parameters for the predictions: The quality of the weather forecast is critical. Especially the prediction of solar radiation needs improvement.

Nonetheless, the results and the experiences with the implementation show that the proposed approach can be generally realized in existing structures with a reasonable degree of investment.

ACKNOWLEDGEMENT

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& Play Façade" (Project-Nr: 815075) and the "Hans Höllwart Forschungszentrum für integrales Bauwesen AG".

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SESSION 2

15 November 2012 Thursday, 15.30-16.45

Topic: Environmentalist technologies and architecture

Chairperson: Prof. Dr. Gülser ÇELEBİ

Prof. Michele CHIUINI, Prof. Walter GRONDZIK, Prof. William Mark McGINLEY
Net-Zero Houses: Designing for the 2013 Solar Decathlon

PhD. Student Nasim SHAKOURI
The Role of Landscaping on Buildings Energy Efficiency

PhD. Student Mahshid MIKAEILI, Prof. Dr. Yalçın MEMLÜK
Badgir: Design with Nature, A Traditional Architectural and Climate Element in Hot Dry Region of Iran

Assist. Prof. Dr. Ayşe PEKRİOĞLU BALKIS, Instr. Mete MUTLU BALKIS
Sustainability of Earthen Construction in North Cyprus

PhD. Student Parisa ALİASHGARİ KHBAZZİ, Master Student Yeliz OLGUN, Prof. Dr. Murat Ertuğrul YAZGAN
Case Studies in the Planting of Structure Surfaces; Roof Gardens

NET-ZERO HOUSES: DESIGNING FOR THE 2013 SOLAR DECATHLON

MICHELE CHIUINI[1], WALTER GRONDZIK[2], MARK MCGINLEY[3]

ABSTRACT

Residential buildings contribute a significant percentage of total energy consumption in developed countries and about eleven percent in the USA. Among U.S. governmental initiatives related to solar energy application to residential design, the Solar Decathlon competition, organized by the U.S. Department of Energy, stands out as the most architecturally relevant.
Through the lens of a 2013 Solar Decathlon entry, this paper discusses the evolution of technologies and the changes in the architecture of the American single-family house when solar energy is used as a primary energy source. The design strategy of our 2013 Solar Decathlon team is to maximize the effectiveness of the PV array while keeping the costs low. The resulting net-zero house will also be significantly more affordable than the typical Solar Decathlon house, which is a fundamental condition if these houses are to have an impact in the housing market.

Keywords: Solar Decathlon, Solar houses, Net-zero houses, North American house

1. INTRODUCTION: FORM FOLLOWS PERFORMANCE

Building technology and environmental problems have been driving forces in shaping modern architecture worldwide. For over thirty years, technical experimentation and innovation in housing and house design have focused on decreasing the household energy consumption[1]. The relatively low cost of energy in the US has not encouraged major changes in house types and construction systems over the last few decades. However government programs[2] in conjunction with an increased public awareness of energy and environmental problems have encouraged a gradual evolution of the housing market, lowering the energy use for appliances, increasing the efficiency of HVAC systems, and improving the thermal performance of the housing envelope.

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Designers and builders have made many attempts during this time to introduce the use of solar energy into residential building design, in the form of passive systems, active hot water panels for space or domestic hot water heating, or PV panels for electricity production, with varying degrees of market success[3]. The growing pressures to reduce fossil fuel consumption and the uncertainties of nuclear power have contributed to a growth (Fig. 1) of photovoltaic (PV) system use in the U.S.[4].
The Solar Decathlon competition, sponsored by the U.S. Department of Energy, has addressed the issue of solar house design, construction and performance since 2002. Its relevance for this paper lies in the importance that this competition places on the combination of engineering innovation and architectural appeal. The homes created for this competition must be an integrated package that can be realistically marketed to the American public. This paper uses the Solar Decathlon as a vehicle to discuss the question of how the house typology and architectural vocabulary are affected by solar energy considerations. This question must be addressed in order to devise ways to integrate these design requirements into houses that can be realistically produced for the private market. The question is, therefore: how does the integration of solar energy systems impact the design of the American home? Are dramatic changes necessary, which may affect house form and even the layout of neighborhoods, or can technologies such as PV (with related energy-saving technologies) be integrated into the house types typically expected in the American market?

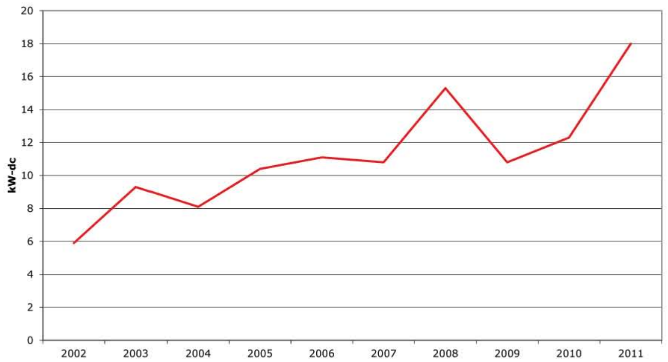

Figure 1. Average Capacity of Distributed Photovoltaic Installations (2002-2011). (*From IREC, Solar Market Trend Report 2011*)

Both approaches have to address the thermal efficiency of the building envelope and follow some basic rules for effective use of solar panels and solar energy in general. When using either design approach it is important to understand how solar energy is collected and used. The solar energy systems and the interaction of these systems with the rest of the building systems, especially the building envelope, will affect the architecture and the cost of the house. Establishing clear rules or guidelines that can be used by builders and designers can contribute to improved efficiency of the housing stock and to an increased use of solar energy with consequent reduction of fossil fuel consumption.

Figure 2. Purdue University 2011 Solar Decathlon house. Computer-generated rendering. *(Courtesy of the Purdue University Solar Decathlon team)*

In addition to guiding development of basic design criteria, the design question is relevant in relation to architectural theory. In this regard, it asks if, or to what extent, architectural design is driven by technologies, and more specifically what is the impact of a 21st century resource-conservation design focus. Will a house become an energy system supported by a dwelling, or a dwelling supported by an energy system? If we accept that resource conservation is a socio-cultural choice driven by economy and politics, then the resulting house typologies will consequently reflect the characteristics of a region or a country (its climate, materials, culture, energy constraints and opportunities, etc.). In this sense we can establish the characteristics of true regionalisms and even define the character of a national residential architecture[6].

2. AMERICAN SOLAR HOUSES AND ENERGY POLICY

Do solar houses look different from other houses? What do we mean by "solar house?" The simplest and most obvious features can be observed in modern solar house prototypes such as the 1939 MIT solar house using flat plate solar collectors, and a second MIT prototype (Fig. 3) built in 1959. The 1959 MIT home used the principles established by Keck and Keck in their 1940 Glenview, Illinois, "first American solar house," [7] and featured a south-facing greenhouse space that was capable of producing hot air on a sunny winter day. The technical design complexity with this type of solution relates to the ability of the system to circulate the warm air to the rest of the house and retain the heat so that the temperature would remain comfortable during the night. This requires good insulation and some thermal storage.

These prototypes represent a solar energy design approach called solar-mechanical, where some energy is used to circulate hot water or warm air, in combination with passive solar solutions (thermal storage in floor structures or walls, direct space heating through windows, natural ventilation and natural convection). The house has to have a long side facing south to support these types of heating systems, and there is a strong architectural difference in house form using roof solar collectors versus sunrooms. Sunrooms can be attached to the south side of the house, as in the

Glenview house, or dominate the entire house form, as in the Solar IV house. Many houses of this type were built in the 1960s and 1970s with a vertical sunroom forming an atrium in the center of the house, a solution used for the Living Environments Concept House built by General Electric (GE) in Massachusetts in 1989 as a laboratory (the primary goal was actually to test and showcase plastic products ranging from pipes to structural panels).

Figure 3. MIT Solar IV house, Lexington, Mass. (From *MIT Solar 7,* Massachusetts Institute of Technology)

Twenty years later GE went further with it Net Zero Energy Home Project (Fig. 4), featuring photovoltaic panels[8]. This project, started in 2009, aims at commercializing integrated home energy-saving systems by 2015. The systems include a 3kW to 4kW PV array and a small wind turbine on the roof, a Home Energy Manager monitoring energy consumption, a smart meter, a geothermal heat pump for heating and cooling, a heat pump water heater, and energy-efficient lighting. According to GE, a net-zero energy home would cost about 10 percent more by 2015. As discussed later, the cost today is still much higher than that.

Both active solar collectors and passive sunrooms have remained a rarity in the US housing market, due to the additional construction costs that cannot be recovered rapidly with savings in energy. Natural gas remains the most prevalent fuel for heating homes in the United States. Over 55 million homes (49 percent) use natural gas as the main fuel source for space heating. Electricity as the main heating source increased from 29 percent of homes in 2005 to 34 percent in 2009 while the use of fuel oil as the main heating source continued to decline. In 1993, more than 10 percent of homes were heated with fuel oil, but by 2009 this had declined to about six percent[9].

Figure 4. Net Zero Energy Home Project, 2009, General Electric (*Courtesy of General Electric*)

Another significant problem is that while solar passive systems can be effective in regions where the primary energy demand is for winter heating, they do not help in the many areas with hot and humid climates where there is a significant need for summer cooling. These areas, ranging from Texas up to the northern USA, represent a large percentage of the U.S. population. The solar energy solution in this case is to produce electricity with PV panels in order to power an air conditioning system. Modern PV arrays that can fit on the roof of a single-family house can supply much, in some cases all, of the energy demand of an American household.
How this can be accomplished is best illustrated by the houses built for the 2011 Solar Decathlon, which are required to have a net-zero energy balance, i.e. the output from the PV system must equal or exceed the total house energy consumption. Because residential energy demand is not synchronous with supply from a PV system (which varies depending on the season as well as the time of day), the system must be supported with storage batteries and/or connected to the grid via an appropriate meter. This allows the house to sell electricity to the grid when the PV output outstrips the demand, and vice versa.

3. THE ARCHITECTURE OF SOLAR DECATHLON HOUSES

The Solar Decathlon is a biannual competition for solar-powered homes sponsored by the U.S. Department of Energy (USDOE). The first Solar Decathlon was held in 2002 with fourteen teams (all from the U.S.). Subsequent competitions were held in 2005, 2007, 2009 and 2011. The first five competitions were conducted on the National Mall in Washington, DC.
Team Kentuckiana will be competing in the 2013 Solar Decathlon competition along with nineteen other teams—sixteen of the teams are from the US, two are from Canada, and two from Europe. The 2013 competition will be held at Orange

County Great Park in Irvine, CA. Entrants are selected by the USDOE following a competitive proposal process.

The Solar Decathlon is named for the ten contests that constitute the competition. Several of the contests (such as Architecture) are juried; and several (such as Energy Balance) are measured. The nature of the contests and the criteria for success have changed somewhat during the history of the Solar Decathlon.

Reducing the Solar Decathlon to its essence, a successful entry will demonstrate net-zero energy performance during the ten days of the active competition, will be architecturally appealing, will be judged appropriate for its defined target demographic, will not exceed a fixed construction budget, will comply with USDOE rules and regulations, and will do well in specific areas such as lighting, thermal comfort and hot water production. Each of the ten contests is worth 100 points, for a total of 1000 points. The design, construction and operational challenge for participating teams is to not fail in any contest, do pretty well in most contests, and excel in a few contests. This is a serious challenge for student-led teams—which is definitely a big part of the ongoing allure of the Solar Decathlon.

There are many aspects that go into the design, construction and operation of a high-performance building. Typically, if a project claims "greenness," it will exceed (often substantially) the prevailing minimum code requirements for energy efficiency and water efficiency; provide better-than-normal interior conditions; and use materials that are environmentally preferable. The Solar Decathlon competition does not demand green projects. It does, however, emphatically demand high-performance in the realm of energy. As stated on the Solar Decathlon web site:

> *"The U.S. Department of Energy Solar Decathlon challenges collegiate teams to design, build, and operate solar-powered houses that are cost-effective, energy-efficient, and attractive. The winner of the competition is the team that best blends affordability, consumer appeal, and design excellence with optimal energy production and maximum efficiency."*

The objective of optimal energy production and maximum efficiency is reiterated in the criteria for the Energy Balance contest of the competition:

> *"In the Energy Balance Contest, a team receives full points for producing at least as much energy as its house needs, thus achieving a net energy consumption of zero during contest week. This is accomplished by balancing production and consumption."*

The Solar Decathlon energy performance expectations hinge on a project that can function with net-zero energy for the duration of the competition in Irvine, California—and ideally on an annual basis on its home turf. As defined by the National Renewable Energy Laboratory (NREL) a [site] net-zero energy building "produces at least as much energy as it uses in a year, when accounted for at the site." It is also possible to define net-zero energy on the basis of source energy or energy costs.

The Solar Decathlon, like most current high-performance building projects, sets site energy as the target to be mitigated by on-site (solar) energy production. Equilibrium between energy used and energy produced is established by net metering during the Solar Decathlon competition. From a design perspective, the less energy-efficient a net-zero building the larger the required solar components—

and vice versa. Since solar components (solar thermal, PV) are typically more expensive than efficient systems, net-zero energy buildings usually aggressively push the envelope on the demand side of the supply/demand equation.
Studies conducted during the Solar Decathlon design process provide some answers to the question of how house architecture is affected by a net-zero energy objective. These houses typically use an array of roof-mounted PV panels to produce sufficient electricity to run a 1000 ft^2 (93 m^2) single-family house. We will call these systems solar-electric (able to produce electricity), to distinguish them from solar thermal (active or passive systems directly producing heat).
Clearly the design issues that have an impact on architectural language and house form are orientation, window location and size; shading devices, roof form (if using solar panels); and envelope integrity. Another order of consideration is the increased attention to internal loads, such as lighting and appliances.
The roof form is one of the first impacts of PV technology on architectural appearance. Due to transportation constraints related to the Solar Decathlon competition, an efficient solution is to have prefabricated housing modules with flat roofs, on which the PV arrays can be mounted on site. In the 2011 competition more than half of the houses had a flat roof, four had PVs on a low-pitch roof (below 15º) (Fig. 5) and the remaining four (such as the Purdue University house) had a steeper, more conventional North American pitch roof system. All houses avoided vertical PVs, such as the wall- mounted system adopted by Team Germany in 2009, due to the inefficiency and resulting cost impact of this configuration.

Figure 5. Computer-generated rendering of the Team Maryland house, an example of a low-pitch roof with PV panels. This house won first prize in the 2011 Solar Decathlon. *(Courtesy of the University of Maryland Solar Decathlon team)*

Optimal annual PV production will typically result from an array tilted to the site latitude—an engineering solution that may not mesh with architectural intentions.

Accepting reduced PV output to accommodate an architecturally preferred roof pitch is a common compromise.The integration of PV arrays with roof design depends first of all on the area of PV modules necessary to power the house. The PV array/floor area ratio is typically (and currently, with 14% efficiency PVs) around 0.77 for the highly-energy-efficient houses designed for the competition, meaning that a 1,000 ft^2 (93 m^2) single story house may require about 770 ft^2 (72 m^2) of PV, including the mounting and spacing of PV panels forming an array[10]. This ratio would of course change depending on the envelope thermal performance, climate and energy efficiency of the building systems and appliances, as well as on the ratio of the enclosed volume to envelope area. Furthermore, as the PV panel efficiency increases, a smaller roof area is required to provide the same kWh output. Some of the energy demand, for instance hot water, can also be offset by other systems, such as solar thermal and heat recovery devices, decreasing the area of the PV array.

4. THE DESIGN STRATEGY

The Team Kentuckiana prototype addresses the problem of post-disaster reconstruction, with a durable, permanent house that can be delivered and site-assembled very quickly. In this design scenario, natural disasters often damage infrastructure so severely that the ability to produce electricity with PV panels allows a replacement home to be placed quickly and operate for some time independently from the grid. Once the grid has been restored, the PV powered homes can serve as a distributed green power generator, increasing the power capacity of the community.

One design strategy to balance energy demand with production is to lower energy demand as far as possible. This is the strategy that the Passivhaus design approach takes[11]. In this approach, the heating demand of the home is reduced to the point where a traditional heating system is no longer required. Cooling demand may be reduced by ventilation and night cooling. This approach requires very efficient exterior envelopes, very efficient building systems, and generally requires significant changes in traditional architectural choices to ensure this energy demand is low enough.

An alternative design strategy is to maximize the efficiency of the PV array and of the house envelope, while keeping cost low with a balance of low cost arrays, reasonable levels of demand control, and avoiding the very expensive, high-efficiency technical solutions. This is the approach that Team Kentuckiana has taken in its design efforts for the 2013 Solar Decathlon.

Climatic conditions in Kentucky and southern Indiana require both heating and cooling. To support the high electricity loads demanded by active climate control, a PV array of about 650 ft^2 (about 60 m^2) on a roof pitch close to 30° is planned. This is a good tilt for the PV panels, since the latitude of Louisville, Kentucky (the heart of the design-focus region) is 38°. Figure 6 shows a design solution investigated for the Team Kentuckiana house. Although lower roof pitches could be accommodated, especially with angled PV arrays, rows of PV panels installed at steeper angles would have to be spaced to avoid overshadowing, making this solution less effective compared to a 30° roof. Furthermore, placing the panels directly on the roof reduces the connection costs for the arrays. During the preliminary design of the Team Kentuckiana house, a series of whole building energy analyses were conducted.

Figure 6. An early version of the Team Kentuckiana house, showing the integration of the PV array on the south-facing roof

In these analyses varying amounts of thermal insulation were used in the building envelope and the effects of these variations on yearly energy use were investigated. Fig. 7 shows the effect of increasing thermal resistance on annual energy use in Louisville, Kentucky. It can be seen from this figure that there is a steep reduction in energy use for increasing thermal resistance, up to a point. After this point, further increases in R-value have much less of an effect on annual energy use. Fig. 8 shows the yearly energy savings as a function of R for each condition. This analysis was then used to set design R values of 30 for the floor (raised above ground), 30 for the walls, and 60 for the roof/ceiling. It was not automatically assumed that super-insulated walls and roofs were needed to produce an energy-efficient design, and in fact little energy savings could be realized for higher insulation values.

A similar analysis was conducted to investigate the type and placement of windows in the building design. This analysis verified that larger windows with significant shading and low solar heat gain coefficients should be used on the southern exposures and windows should be limited on the north, east, and west faces. It was also determined that multi-paned, gas-filled window systems did not provide much better energy performance than a reasonably efficient double pane systems. Window size and location had a much bigger effect than performance characteristics.

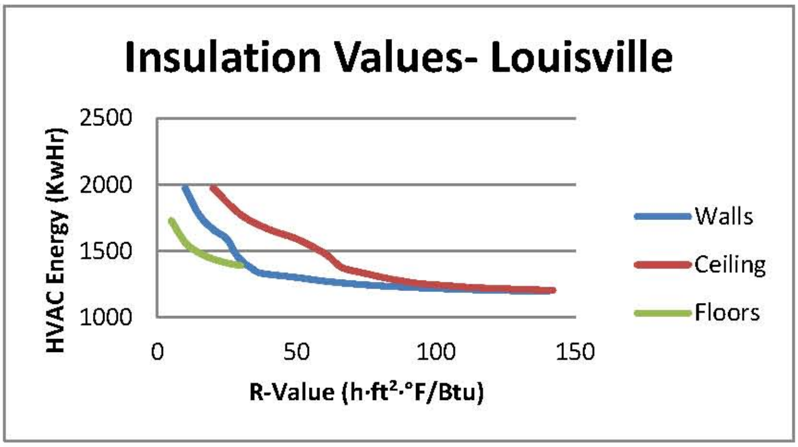

Figure 7. Total annual energy consumption vs. R-value in Louisville, KY

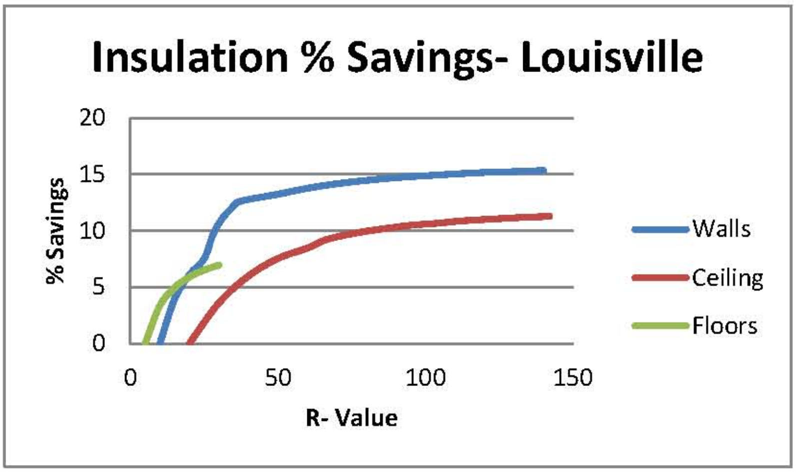

Figure 8. Percent annual energy savings vs. R-value in Louisville, KY

The design solution was informed by these analyses and incorporates passive heating and cooling strategies through the use of moderately high insulation values with an effective house form and careful window placement and sizing. The windows were also oriented to allow good cross ventilation. Natural ventilation will be most thermally effective in the early summer and fall months. This requires that the house plan extend east-west for the maximum permissible length. This orientation also makes this house type practical in typical urban neighborhoods, characterized by narrow E-W lots with streets on the east or west side. A variety of scenarios of post-disaster reconstruction of neighborhoods have been studied to evaluate the solar access conditions of a variety of housing layouts, as shown in Fig. 9.

Figure 9. An urban design study testing the density of housing development with roof-mounted PV arrays. The density can be considerably higher than the solution shown

5. CONCLUSIONS: THE FUTURE OF SOLAR-ELECTRIC HOUSES

One of the goals of the Solar Decathlon competition is to produce cost-effective net-zero energy homes. The cost of net-zero energy houses, as demonstrated in the 2011 Solar Decathlon, is still much higher than the cost of an ordinary house. With a target Solar Decathlon cost of \$ 250,000 and a nominal floor area of 1000 ft^2 (93 m^2) these net-zero houses (without site acquisition) cost around \$ 250 per ft^2 (\$ 2,688 per m^2)—compared to a national average cost of \$ 80 per ft^2 (\$ 860 per m^2)[12]. Since the 1970s, significant changes have already taken place in engineering American homes for improved energy efficiency, including advanced framing, new insulating systems such as structural insulated panels, and automated controls (from the 1989 Smart House to the 2009 GE Net Zero House). However, at the same time, residential "plug loads" have increased dramatically with the number and complexity of domestic appliances. In addition, the average house size has also increased. However, even with these inflationary influences, residential energy consumption has still been declining. Furthermore, heating systems increasingly use electricity-driven heat pumps, suggesting that more homes will be using only electrical energy sources, shifting the heating energy sources away from direct combustion.

From an environmental point of view, even the Solar Decathlon net-zero houses are far from ensuring zero-carbon emissions, particularly when transportation and land development are included. These houses may represent an intermediate step if energy costs were to escalate, while PV systems become cheaper and electric cars more common. In addition to the "smart grid," microgrids could also contribute to efficiencies and economies of house construction and energy distribution. This suggests that major changes could be driven not by the house becoming autonomous from the grid but instead more dependent on a compact infrastructure, with utilities shifting part of the energy production from large centralized plants to small local PV systems, perhaps integrated into commercial as well as residential buildings.

The Solar Decathlon houses may fail to provide a truly holistic solution, but are nevertheless a very useful experiment in the development of design methods and strategies that future generations of architects can apply to a variety of energy efficient building designs. The integrated design experience also allows both engineers and designers to more accurately assess how early design choices can impact the energy performance of a building. Rules of thumb often encourage, erroneously, the belief that "if a little is good a lot is much better." Being competitive in the Solar Decathlon completion demands the skillful integration of engineering and architectural solutions, something that is still woefully lacking in most building projects.

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THE ROLE OF LANDSCAPING ON BUILDINGS' ENERGY EFFICIENCY

NASIM SHAKOURI[1]

ABSTRACT

During the recent years, the number of buildings has been increased with the rapid growth of populations in cities, which cause proliferation in the total energy consumption. It also has negative impacts on the urban environment. Today, one of the challenges of buildings' design is to find some efficient solutions to reduce the energy consumption. For this purpose, different types of construction materials and methods have been applied.

Over the past few years, sustainable building design which is an energy and ecologically consciousness approach has gained significant importance in urban design. According to the goals of this term, structural materials are not sufficient enough uniquely. Therefore, new adaption strategies such as placing the vegetation directly on buildings (rooftop garden, green walls and etc.) have become more efficient.

In this study, the role of landscaping on energy efficiencies of the buildings has been evaluated. Various methods of integrating plants to the buildings have been analyzed in order to decrease the energy consumption. In addition, the methods have been compared with construction materials from different points of view: the energy consumption, the surface temperatures and energy fluxes out of buildings and their effects on environmental problems.

The results obtained from different studies indicate that landscaping has significant role on optimizing energy performance in buildings especially during utility peak demand period. Although, landscaping would require more time and cost initially in contrast with construction materials used in buildings. Within the scope of sustainable design in urban area, it is obvious that using the plants in buildings will have positive impacts resolving the environmental issues and energy saving comparing to non-vegetated buildings.

Key words: Energy, Green roof, Buildings' energy consumption, Sustainable architecture, Environmental problems.

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1. INTRODUCTION

Through the history of life, Human beings consume energy resources and damage the natural resources according to his needs. During the years, quest of energy and natural resources caused the development of new techniques on energy generation and change human lifestyle. Population growth, rapid urbanization, fast moving consumption of energy and natural resources caused anxiety about the future of human life. Therefore, sustainable use of energy and the earth's natural resources become vital to ensure the next generations life on the earth.

Nowadays, most of the people live in cities. Therefore, energy and natural resources consumption are high in urban areas. The relative share of buildings as a major elements of cities, in energy usage and environmental impact, as compared to other areas of human activities is undoubtedly significant. As a result, such positive and effective activities for environment and the consumption of energy in buildings are important. Sustainable architecture is a general term to achieve these two objectives. Towards the goals of sustainable architecture to obtain environmental quality, buildings must be constructed both to use less energy and have environmentally sensitive design. Existing structural materials are not sufficient enough to achieve these goals. Therefore, in recent years, using vegetable materials and new adaption strategies such as placing the vegetation directly on buildings or surround of the buildings have become more efficient than constructional applications.

In this study, the roles of landscaping and vegetative materials usage on energy efficiencies of the buildings has been evaluated by analyzing the various methods of integrating plants to or surround of the buildings. In addition, the methods have been compared with construction materials from different points of view: the energy consumption, the effects on surface temperatures and energy reflection out of buildings and their effects on environment.

2. ENERGY AND BUİLDİNGS

The concept of energy is consists of three parameters; generation, transmission and consumption. For a sustainable life style, increasing the generation of energy is not enough. The transmission and consumption parameters also have effective role on energy cycle.

Today, cities by definition are a focal point of energy consumption. Different researches indicate that most of the energy consumption of the cities belongs to the buildings. Due to the climate condition in different cities, energy consumption of buildings is varied. In addition, many other factors such as orientation, form, shape, depth, obstruction angle and etc. of buildings are effective on energy usage. Furthermore, construction materials used in buildings can be effective on the amount of the wasted energy. As a result, government policy makers and building professionals, including architects, building engineers, project managers and etc. play an important role enhancing the planning, design, construction, operation and maintenance of the building energy efficiency process in order to form a sustainable urban development.

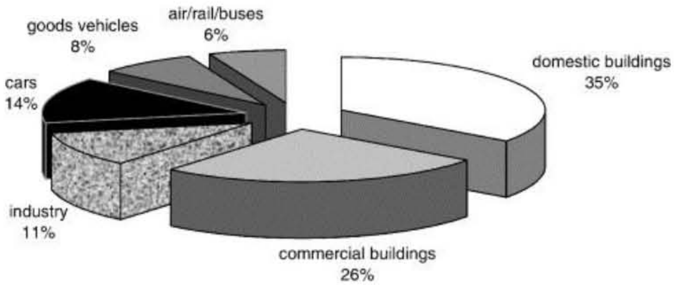

Figure 1. Energy use breakdown for London (Steemers 2003).

During the recent years, according to urban sustainable development objectives; reduction of energy consumption and environmental condition improvement in the cities, landscaping has gained importance. For this purpose, various methods and materials have been emerged. These methods and their materials for buildings' energy efficiency could be considered as two headings:

- Landscaping surround the buildings
- Landscaping directly on buildings

2.1. Landscaping surround the buildings

Landscaping surround the buildings could have positive effects on energy consumption as well as environmental problems. Different planting design next to the buildings can be effective on energy consumption over the year. Some examples are written as followings:

- Planting tree for the purpose of providing shade in summer. This can block the sun's warming rays and reduce energy consumption of buildings for cooling. Planting deciduous tree also can redirect sunlight into the house and decrease energy consumption of heating in winter (figure 2).

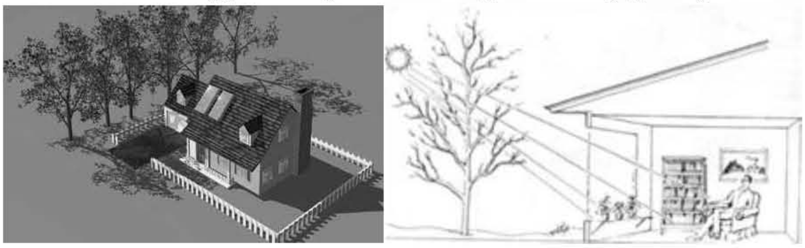

Figure 2. Planting tree for the purpose of reducing energy consumption in summer and winter

- Trees also can be used as wind break (figure 3). This method can prevent heat loss during the cold season. Trees and wall sheltering, where climbing plants are used as buildings wind break, can slow winds speed.

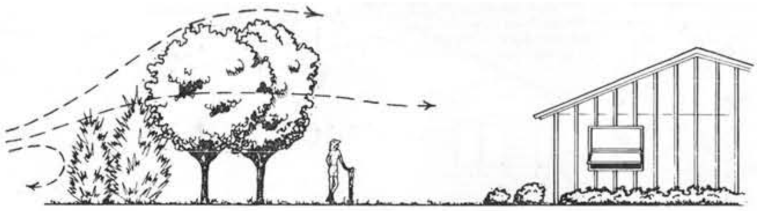

Figure 3. Planting trees as wind break

- Using pervious paving, high albedo paving, shade, and minimizing paved areas surround the buildings have a positive impact on microclimate as well as reducing the heat island in cities that reduce energy consumption indirectly.

Today, the lack of the open space in most of the cities is a problem for using plants surrounds the buildings. So this type of landscaping is only possible in places where land has suitable conditions for this usage.

2.2. Landscaping Directly on Buildings

Since 1980s a growing interest in environmental issues resulted in the vision to bring nature into the cities. For this purpose, various technologies and methods have been developed and different materials have been produced. Green roofs and green walls are some of these methods. Beside the environmental benefits, their positive effect on energy consumption and storm water management, urban heat island, noise pollution and etc. have been proved by several researches.

2.2.1 Green roof

Use of the concrete by the middle of the 17^{th} century allowed for the construction of green roof. Research of Dunnett and Kingsbury (2008) indicates that the 1868 World Exhibition in Paris was the emergence of modern green roofs. Today, the term "green roof" is generally used to represent an innovative established approach to urban design that uses living materials to make the urban environment more livable, efficient, and sustainable. Other common terms used to describe this approach are eco roofs, and vegetated roofs (Banting et al. 2005).
According to Frost (2008), green roof is a roof surface that contains a growing medium that can sustain a layer of plants. Green roofs typically include filter layer, drainage layer, and waterproofing layer.
The progress of green roof technology makes different kind of green roof system applicable. The most common systems can be categorized as below:

- Complete system
- Modular systems
- Precultivated vegetation blankets

2.2.2 Green walls

Building facades and exterior walls are usually under permanent environmental influences, such as sun and acid rain. These environmental influences cause damages and shorten the life of these elements. Green walls system can protect facades and offer many benefits like the green roof.

Vegetated facades are not new technology and can offer multiple benefits as a component of current urban design. According to Kohler (2008) research, in many European and some North American cities woody climbers were frequently used as a cover for simple facades in the 19th century. Incentive programs were developed in many cities of Germany, including supported tenant initiatives for planting and maintaining climbers in facades. However, Green walls and facades have not been developed widespread outside of Germany because they are not as well-known as green roofs.

Many researches have conducted on issues such as evaporative cooling effects of plants on green wall, improving urban life and biodiversity, positive effects on urban microclimate and buildings' ecological footprint. However, there is still a lack of implementation and evaluation of the effects of Green walls on energy consumption. Therefore, in this research for evaluation the positive effects of landscaping on energy consumption, green roof were focused and investigated.

3. THE EFFECTS OF LANDSCAPING ON BUILDINGS ENERGY CONSUMPTION

According to the research by USA National Energy Education Development project (2012), the residential and commercial sector- homes and buildings- consumes 41.2 percent of the energy used in the United States. The energy is used to heat, cool and light houses and buildings and to operate appliances and office machines. In addition, the research indicate that 54 percent of the average home's energy consumption is for heating and cooling rooms to keep living and working spaces in convenient temperature (USA National Energy Education Development project 2012).

Roofs are important determinants of building's energy flux and can represent up to 32 percent of the horizontal surface of built-up areas (Oberndorfer et al 2007). Buildings have changed the flow of energy matter through urban ecosystems that cause many environmental problems. Therefore, altering the surface properties of buildings can partially mitigate these problems. Green roof applications can reduce buildings' energy consumption and lessen several negative effects of buildings on local ecosystems.

During the summer, green roofs reduce heat flux through the roof by promoting evapotranspiration, shading the roof physically, utilizing the sun's energy in photosynthesis, and increasing the insulation and thermal mass beside lowering the energy demands of the building's cooling system (Figure 4) (Oberndorfer et al. 2007). The amount of saved energy is dependent on several factors. Among them are: the amount of roof insulation used; the height of the building; the climate and microclimate of the building; and the type and coverage of the green roof.

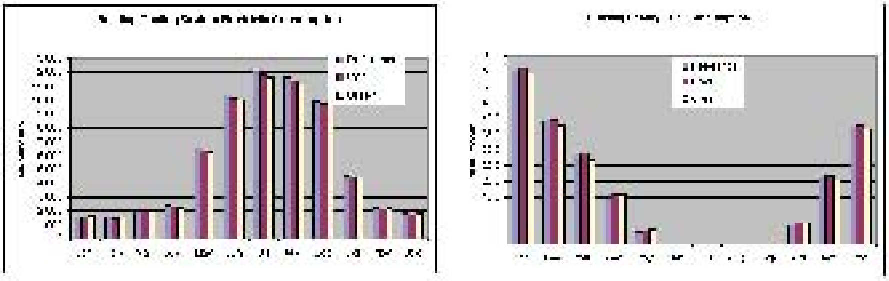

Figure 4 and 5. Energy Consumption of Model DDC Building ,Note: Coolroof is Energy Star® rated membrane or coating (Gruzen Samton Architects LLP et al., 2007).

The research of Wong and colleagues (2003) in Singapore indicates that the heat transfer through a green roof during a typical day was less than 10 percent of that of a reference roof. Green roofs prevent heat from moving through the roof in summer and heat flow out of the buildings in winter (figure 6,7).

A study in Madrid shows that a green roof reduces the cooling load on an eight-story residential building by 6 percent during the summer (Saiz et al. 2006). In a peak demand simulation, the cooling load was reduced by 10 percent for the entire building and by 25, 9, 2, and 1 percent for the four floors immediately below the green roof. For a typical residential house in Toronto, the cooling load during July was reduced by 25 percent for the building and by 60 percent for the floor below the green roof (Saiz et al. 2006).

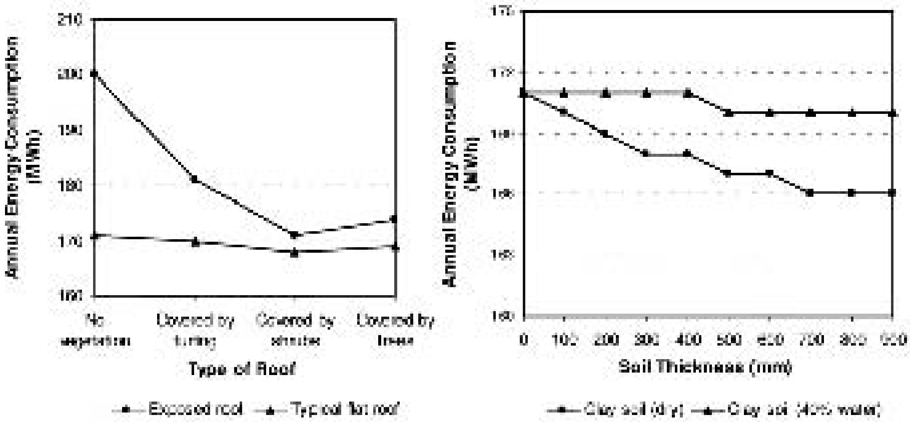

Figure 6 and 7. Comparison of annual energy consumption for different types of roofs for a five-story commercial building. Comparison of annual energy consumption for different soil thickness on a roof of five-story commercial building (Wong et al. 2002).

Landscaping would require more time and cost initially in contrast with construction materials used in buildings. But, they can payoff their costs thourgh the years by saving energy. Possman Cider Cooling and Storage Facility in Frankfurt, Germany yielded a 2-3 year payoff of their green roof system through the savings in heating, cooling costs and equipment costs. Consequently additional cooling towers had become unnecessary
(http://www.greenroofguide.co.uk/downloads/dev_guide_v3.pdf).

4. COMPARİSON OF CONSTRUCTİON MATERİALS AND PLANT MATERIALS IN BUILDING

In concept of sustainable architecture and urban design, buildings must be constructed both to use less energy and have environmentally conscious design. Using plant materials in building and green roof has significant role in reducing energy consumption of buildings as described in previous section. In addition their positive impact on environmental problems is indisputable. Because of the importance of these effects, few examples are given as follows:

- Storm water management

Since plants absorb rainwater, green roofs can help reducing storm water runoff. Impervious ground cover pavement, significantly impacts the flow of storm water over land which often resulting in flooding and erosion of stream banks. A study conducted for the city of Portland, Oregon found that if half of the buildings in the downtown area had green roofs (219 acres), approximately 66 million gallons of water would be retained annually. The study also represented that 17 million gallons of combined sewage overflows would be eliminated and storm water discharges would be reduced between 11 to 15 percent (Peck and Kuhn 2003).

- Reduce urban heat island effect

According to Dunnett and Kingsbury (2008), the construction materials of buildings and paved surfaces absorb and store solar energy during the day and radiated it back as heat energy during the night. The density of buildings and other hard surfaces in urban areas can dramatically increase the air temperature compared to surrounding rural areas. Plant materials that are used in green roof and green wall, apply this energy for the process of evapotranspiration decreasing the negative effect of heat island in cities. The Organization for Landscape and Urban Greenery Technology Development estimates that if half of the roofs located in Tokyo were planted with gardens, the hottest summer temperatures would fall by 1.5 ° F (Gruzen Samton Architects LLP et al., 2007).

- Decrease noise pollution

The hard surface of buildings and pavement tend to reflect rather than absorb sound. Research of Peck and Kuhn (2003), shows that the plants and substrates of green roofs absorb sound energy. Thus, reducing sound transmission into the building's interior. Kevin Burke of William McDonough and Partners note that the green roof of Gap Inc.'s Cherry office (located near a highway and flight path of San Francisco International Airport) reduces sound transmission nearly 50 decibels (Dunnett and Kingsbury 2008).

- Increased roof life

Green roofs protect roofing materials from extreme temperature fluctuations and damaging ultraviolet solar radiation. According to Peck and Kuhn (2003), evidence suggests that the life span of green roofs is at least twice that of conventional roofs. Less frequent roof maintenance and replacement, reduces waste and associated life cycle impacts. Green roof also improve the membrane longevity. According to Oberndorfer et al. (2007). Waterproofing membranes on conventional dark roofs deteriorate rapidly in ultraviolet (UV) light, which causes the membranes to become brittle. Such membranes are consequently more easily damaged by the expansion and contraction caused by widely fluctuating roof temperatures. By physically protecting against UV light and reducing temperature fluctuations, green roofs extend the life span of the roof's waterproofing membrane and improve building energy conservation. Research of Porsche and Köhler (2003), demonstrates that some green roofs in Berlin have lasted 90 years without any need for major repairs. İn an other resarch by Liu (2004) In Ottawa, Canada, an unvegetated reference roof reached temperatures higher than 70 degrees Celsius (°C) in summer, while the surface temperature of the green roof only reached 30°C.

- Increased performance of Photovoltaics

Comparing the typical concrete roof, vegetation reduces the temperature of the roof. According to research conducted in Berlin by Kohler, the reduction of temperature provieded by vegetable at the roof surface improves the performance of photovoltaic cells, which operate more efficiently at lower temperatures (Dunnett and Kingsbury 2008).

- Others

In addition to the advantages of using vegetable materials compared with structural materials mentioned above, vegetaded surface of buildings are especially important in urban areas in which much of the land area is consumed by buildings, pavement and other artificial surface cover. They are inherently more aesthetically appealing and can improve biodiversity in cities.

5. CONCLUSION

In line with the objectives of sustainable architecture in urban area, the advantages of landscaping over conventional flat and shallow pitched roofs and walls of buildings are considerable. As stated, many researches indicate that green roofs have a significant impact on the buildings energy consumption and improving the environmental problems. In addition, a green roof is inherently more pleasing than a typical membrane or bitumen roof offering substantial aesthetic benefits. The potential of green facades to improve urban microclimate and buildings' ecological footprint should be noted. It is true that the installation and maintenance cost of green roofs and walls are considirable. But, if vegetating roof and walls of buildings gain popularity and the technology of these methods also improves, the installation cost will decrease consequently.

As a result, with so many advantages, different methods of integrating plants to the buildings such as green roofs and green walls should be part of a comprehensive strategy toward achieving a sustainable and livable built environment .

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BADGIR: DESIGNE WITH NATURE, A TRADITIONAL ARCHITECTURAL AND CLIMATE ELEMENT IN HOT DRY REGION OF IRAN

MAHSHİD MİKAEİLİ[1]
YALÇIN MEMLÜK[2]

ABSTRACT

Performance and energy consumption in buildings are considered to be the most important factor in climate. Today energy consumption reduction requirement is purpose of climatic sensitivity depending on the use of natural resources and promoting comfort in life, healthy and sustainable living spaces, and sustainable building design. Nowadays sustainable design and construction strategies have great importance. Wind, as the source of renewable energy, is the vital factor in climate studies. Wind is the most significant factor used by architects in building design in order to natural ventilation. Badgir -Wind catcher or Wind tower- is a wind dependent and wind driven architectural element, as component of Eco Architecture is depending on natural, climatic phenomena and renewable energy sources. The operating system of badgir depends on the air convection and evaporation. The most important function of the Badgir is cooling the building interior with natural methods without consuming energy in hot, dry or humid areas. The most effective role of Badgir is the reduction of heat and adjustment of temperature of inner life spaces on the basis of comfort with the help of natural convection currents of clean air ventilation.

Keywords: Badgir, traditional architecture, climate responsive design, design strategies, Iran hot-dry region

1. INTRODUCTION

Performance and energy consumption in buildings are considered to be the most important factor in climate. Today energy consumption reduction requirement is purpose of climatic sensitivity depending on the use of natural resources and promoting comfort in life, healthy and sustainable living spaces, and sustainable building design. Nowadays sustainable design and construction strategies have great

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importance. According to some, sustainable methods as the driving force of past are exhibited a variety of different ways and sometimes these ways that are not possible at present. From Vitruvius until today, in spite of the developments in technology and materials observed, the type of problems, designing methods and the structure of measures taken have not changed. In addition, these developments have some negative effects since the emergence of modern methods causes the discharge of old ones. For these reasons, the process of creating a comprehensive approach is discussed. In other words, the climate-responsive selection of materials, design and construction techniques should be assessed jointly for the smooth operation of the final product throughout the service life. How the traditional architecture, topographic and climatic conditions in central and warm regions of Iran, and regional and cultural situation of people living there influence the sustainable design and construction strategies should be carefully reviewed. The main aim of this study is analyzing function of Badgir as component of Eco Architectural element in order to traditional house ventilation that depend on a renewable energy sources like wind works without consuming energy in hot, dry and humid regions of Iran.

2. TRADITIONAL BAGDIR

Wind, as the source of renewable energy, is the vital factors of climate studies. Wind is the most significant factor used by architects in building design with the purpose of creating a comfortable inner space in hot regions. In addition to its aesthetic and ornamental appearance for the building, the most important function of the presence of Badgir is cooling interior spaces of building with natural methods without consuming energy in hot, dry or humid areas. The most effective role of Badgir is the reduction of heat and adjustment of temperature of inner life spaces on the basis of comfort with the help of natural convection currents of clean air ventilation.

Badgir is a wind dependent and wind driven architectural element. “Bad” means wind and “Gir” means exposed in Persian Language (Wind Catcher). The widespread use of Badgir is observed in various forms due to climate-related reasons in different regions of Southern and Central Parts of Iran’s ancient architecture; the main structure in all forms depends on the air, the direction and the altitude of prevailing wind. Constant seasonal and daily winds are characteristic of Iran’s desert (Kavir) regions and therefore, badgirs are constructed in the direction of prevailing winds. The operating system of badgir depends on the air convection and evaporation. For this reason, the sides and upper parts of badgir are constructed open to let the air flow in. While the upper channel of badgir is constructed closed towards sky, the lower part of it in the building is constructed open. With the intention of steering the wind more effectively in the building, the inner of the badgir channal is divided into four, six, and eight sections with mud-brick in numerous forms. This process provides a more effective circulation of air in inner spaces (Fig. 1).

3. BADGIR FUNCTION

The method of operation of badgir is as follows: when the wind blows, air goes through the openings of badgir into the building, it creates a pressure at the back of doors and windows existing in building and this action allows the circulation of air. Generally, this type of pressure pattern constitutes in all badgirs: air goes in to the channel from the upper openings of badgir with the effect of a high pressure coefficient (positive) and goes out from the openings in the back of the doors, windows in the building with (negative) low pressure coefficient. The most effective cause of the air flow during the night time is the storage of cold air at walls of badgir channel, the low temperature of air and radiation of the heat to the sky (Fig. 2). The water resources are scarce and very limited in desert regions of Iran and in order to access the water, the water channel "Qanat" -traditional underground water channel- is constructed under the ground. In order to increase the function of badgir. Qanats are located underground, under the badgir channel inside the houses, meets the water needs of houses as well as cool the houses using the coldness of water with evaporation system (Fig. 3).
The air in badgir, running over the very cold water of reservoir and air, leaves its heat and cools down. A pond is built under badgir channel in the building without qanat and the pond water cools and moisturizes air which comes from channel. Badgir working in the evaporation system are usually built in very hot and dry regions. The function of badgir in Dolat Abad Pavilion sited inside the garden in Yazd city (17. century) is in this style. The Dolat Abad Badgir, which has roughly 34 m height (33.80 m) from earth level, is the world's highest badgir and 2/3 length of the badgir channel is out of the building. In front of the pavilion was built a large pool. Plants in the garden and water humid direct the air flow to badgir which has octagonal shape (Fig. 4 and 5).
Function of badgir in a windless environment: at the night times, badgirs get the cold air from outside of windows such as a ventilator, cold air warms up absorbing the heat of the building and the heat of walls of badgir and finally goes out from the upper openings badgir. At the day time, badgir channel function on the contrary of night time, in other words, the hot air of day time cools down absorbing the coldness of walls of badgir channel that preserved during the night and subsequently goes out from doors and windows. The amount of energy stored in badgir channel is limited since it has slight specific heat and mass. For these reasons, natural draft of air from outside of the building to inside which is called as "Chimney Effect" is likely only in the early hours of the day and without wind, badgirs have no significant function (Fig. 6).

3.1. Elements of Badgir

Elements of badgir are effective in its final formation. A badgir in order from downward to upward is formed from the following parts: 1- Pillar, channel or body (chimney), 2- Opening, 3-Blades, 4- Roof.

1. Pillar, channel or body (chimney):

The shape of the badgir's pillar is in the shape of cube, prism and its frame is square frame, rectangular, hexagonal, and octagonal. Wood is used with a view to increase the durability structure of the tall badgirs and a skeleton is designed in the structure. The function of it is same as the modern concrete building armature and it has been used with the aim of reinforcing the building. Head parts of the wood remains out of badgir structure and it is used as second skeleton for the future repair and maintenance of the badgir another time (Fig. 7).

2. Opening:

While openings are positioned at the head part of badgir, blades are located at the rear side of badgir. The common types of geometrical shapes of openings are elongated, vertical and horizontal, rectangular and squareb (Fig. 8).

3. Blades:

Blades are designed in several shapes depending on the plan of badgir. In a square plan, blades such as the shapes of X, H and are cruciform made of hexagonal and octagonal plan's diameters. Blades are grouped in two parts: main blades and side blades. Main blades which have the biggest role in the functioning of badgir are invisible from outside. The main blades which can start 1.5-2.2 m height earth level in badgir could reach up until the ceiling of badgir. In contrast, side blades which is positioned in the middle of the main blades has minor role, provide an aesthetic appearance beautifying the outer appearance of badgir. This issue is one of the characteristics of the Iran architecture. The facade and the structure of building are constructed jointly, not independently (Fig. 9).

4. Roof:

In order to strengthen the resistance of the badgir roof in case of severe storms, the roof is built in form of mound.

4. BADGIR FUNCTIONAL CATEGORIZATION

Functional categorization of badgirs, depending on wind direction, are made with respect to openings in different fronts. By way of direction of openings badgir are classified single, double, triple, and four-sided (Fig. 10).

1. The one-sided badgirs are built by the direction of mountains. In regions close Kavir severe seasonal sand storms occurs and Black Wind blow. In order to block the entrance of dust and sand, all directions that are against the wind are sealed off completely and by keeping open only one direction one-sided badgir is constructed. This type of badgir is built in cities like Meybod, Ardakan, Mahan and Bam. Badgirs are constructed in one sided and seaward in cities such as Bandar Abbas in the Persian Gulf coast and they direct humid breeze of the sea into the building.

2. Generally the water-reservoirs in Yazd have two sided badgirs. The number of this type badgirs are very limited. For example, the ratio of this sort of badgirs in the city of Yazd is only 5%.
3. This kind of badgirs are not so usual, but the badgir of the former military post in old Bam city (Ark-e-Bam) is being made in three sided (Fig. 11).
4. The most common types of badgirs are four sided ones and 96% of the water-reservoirs and houses in Yazd have four sided badgirs. This kind badgirs are made of both square and rectangular plans. The rectangular forms are made specially the big face is towards the appropriate wind.

Apart from these four types of badgirs, there are some exceptional types. For instance, the badgir of "Broojerdi House" built in Kashan in 1813 is one of these exceptions. It is the most perfect example of Iranian architecture as a house. The Badgir that was built in the form of a column adjacent to the hall of "Shah-Neshin" that has a roof closes with a very different dome. The dome was designed with functions of both to receive light and air as a badgir. The inner side surface of the dome is decorated with stucco and color (Fig. 12). The other exception is the one which is designed in pipe form in a house Sirjan city. This badgir inspired by the ship's pipes were built at the beginning of the 20th century (Fig.13).

4.1. Categories Based On Forms of Plans

At the time typology of badger is analyzed, the shape of pillar is seen to be built in the form of square, rectangle and a regular hexagonal, octagonal polygon and rarely in the shape of circle. Since square and octagonal types are able to receive winds blowing from several directions, they are suitable for the regions exposed to light winds from various paths. Rectangular forms are widely used since they increase the entry field of one way blowing wind in hot seasons. Badgirs are not only different in terms of their plan, but also blades located in badgir can vary in form (Fig. 14). They can be in the form of +, H, I, K and X. For instance, the blades of octagonal badgir of the pavilion constructed in the Dolat Abad Garden are in the cross form. Blades divide badgir channel in the small channels to increase air motion according to "Bernoly Effect". Bernoly Effect defines that air rate will be increased when air pass from narrow section. Such an arrangement provides more surface in contact with the flowing air, so that the air can interact thermally with the heat stored in the mass of these blades.

5. STURUCTURE

By means of wood hanks in a horizontal state in the mud bricks function the role of support in badgirs and also increases its resistance against lateral imposed forces (wind) in long heights. These hanks tie the structure to each other and two of wood bars ends are put out of structure to create trellis or ladder for constructing the upper of badgir or for doing later repairs. While the Shurune Wood is used in the desert regions like Yazd, in hot and humid regions like Bandar Lenghe in Persian Gulf coast, the Sandal Wood is used in the structure of bagirs wooden hanks (Fig. 15).

5.1. Material and Colour

One of the design features of Iranian architecture is the harmony of construction materials with regional and local climate, since it shows a good insulation performance with its own heat without consuming energy. General materials used in the structure are mud brick, wood and plaster. The type of wood used must be resistant against moisture, termite and decay. Badgirs in hot and dry regions such as Yazd are built either of brick or mud brick covered with clay and mud plaster (kah-gel). Mud plaster is mixture of soil, water and straw and it reflects the radiation of the sun. After the water evaporates from mud plaster, it leaves empty pit, causes that heat and cool cannot filtrate inners of the soil and mud brick or adobe. At the same time, the straw increases roughness of texture of mud plaster which in turn obstructs sun radiation.

In regions near to Persian Gulf such as the Port Lenghe (very hot and humid) plaster, lime plaster (sarooj) is used for coatings. These plasters are resistant to moisture and due to their white color they fully reflect the sun's rays.

5.2. Section

Since the function of badgir is to get prevailed wind and transfer it to internal spaces, its ratio of length to height and width to length would be of much importance. The ratio of length to width for Yazd badir's is 2 to 1, in Lenghe Port the ratio of length to width is 1 to 1. Channel cross-section of Yazd bagdirs reaches to two spaces: 1. Cellar of underground, 2. summer sitting hall in ground floor but; there is not underground in Lenghe port because of high altitude of water, badgir channel only, will continue until the ground floor.

5.3. Facade and Decorations

Generally, ornamental features are in two types in Iranian architecture and especially in badgirs. Firstly, ornaments are added on badgirs as merely aesthetic reasons. Secondly, the ornaments are on the facade of badgirs as a functional element. For instance in Yazd region's badgirs, stucco are used both ornamental as well as functional in various arches form on the badgirs openings. Each architect used a different type of arch consistent with his personal preference this type of ornamentation was accepted as his signature. However, the mud brick lines and arrays at the top of the badgir that reflects regional and local features of architect visually are simply ornaments of badgir facade (Fig. 16).

5.4. Badgir Floors

In most cases, badgirs are built in single floor. In very rare cases, with the intention of increasing the impact of the wind they can be made of two-floor. This kind of badgirs are constructed large, massive and, in places where the wind direction is locally variable. Only example of this kind two stories badgir in Iran is the one built in a house at Abargou city (Fig. 17).

6. BADGIR LOCATION IN BUILDING

The forms in which badgirs were set up at the roof of houses varied from region to region, even houses to houses at same region. The most important form is the residential form available in the Iran's desert regional architecture. Generally, residents are built in the form of courtyard called as "Daroungara" in Persian Language. In the courtyard form all of the openings are not in the direction of the outside of the building but they are toward courtyard and the reasons for that are to reduce the entrance of sun light to interiors in warm climate, intensify the degree of shadow, to create micro climate with pool made and plants growth and to ensure the privacy as a culture. The most important places in this system are hall (Shah-Neshin) and position of badger in the building. The main reasons of the differences are diverse location of badgir in the houses and on top of the roofs, spaced used in summer season and their connection form to courtyard. Therefore the locations of badgirs at buildings can be classified in to three groups (Fig. 18).

1. Badgir positioned behind the hall on the axis of symmetry. In this type badgir, the axis of symmetry, hall and courtyard extend together.
2. Badgir positioned at the corner of yard. In this type badgir connection to the hall is possible through the means of a space.
3. Badgir positioned on one of northern corner of a hall.

7. CONCLUSION

Iran's ancient architecture is implemented in hot and dry regions. Badgir (wind-catcher) is an intelligent application that proceeds of exploitation from the wind natural energy, and at last it makes possible the coldness comfort ability in hot regions. Traditional architecture in hot – arid and hot-humid climate of Iran, rely on renewable fuels, It use wind energy for cross ventilation and cooling in the summer. This method is the best example of contemporary architecture which leads the art of architecture to benefit from sustainable, clean and renewable energy sources. In this respect the importance of environmentally responsive architecture will arise.

Sustainable architecture necessities force us to re-think and synchronize traditional methods of construction and use of local-materials. Several propositions are given in this paper for architects and urban designers to consider how to relate energy efficient traditional design strategies and technologies to the design of contemporary architecture.

7.1. Figures

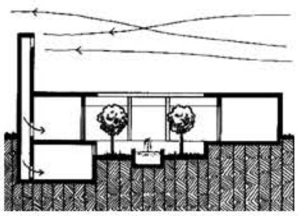

Figure 1. Badgir general function

Figure 2. Air convection in Badgir

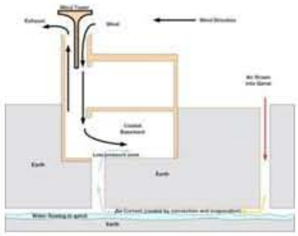

Figure 3. Evaporation system in badgir

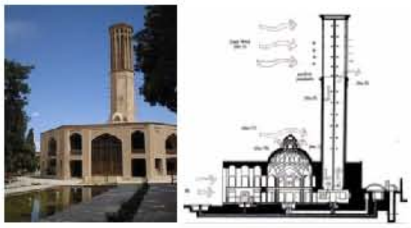

Figure 4 and 5. Dolat Abad Garden's badgir

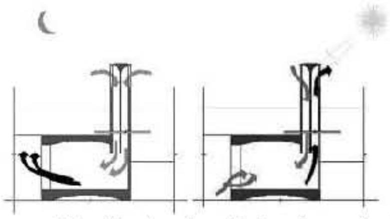

Figure 6. Badgir function during day and night

Figure 7. Outer skeleton of badgir

Figure 8. 3D model of badgir opening and blade

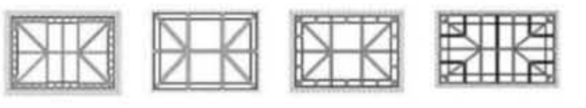

Figure 9. Badgir inner blades in horizontal section

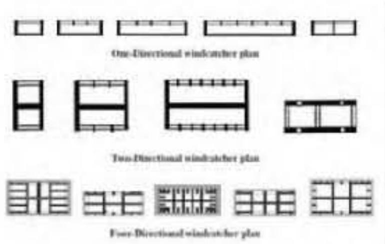

Figure 10. Typical plan of one, two and four sided badgirs

Figure 11. Ark-e-Bam three sided badgir

Figure 12. Broujerdi House badgirs

Figure 13. Sirjan Pipe badgir

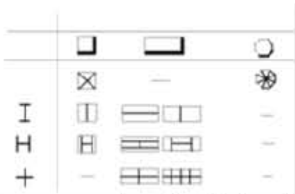

Figure 14. Categories of badgir based on plan

Figure 15. Wooden hank in badgir

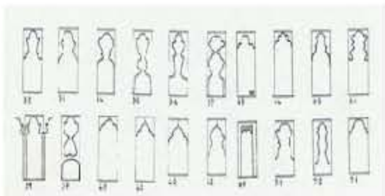

Figure 16. Opening details

Figure 17. Abargou, two stories badgir

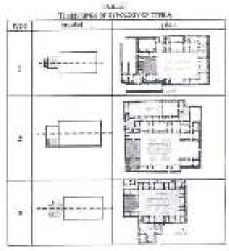

Figure 18. Badgir locations in building

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SUSTAINABILITY OF EARTHEN CONSTRUCTION IN NORTH CYPRUS

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METE MUTLU BALKIS

ABSTRACT

Sustainability depends on the maintenance of the natural world and natural resources. Built environment has the greatest impact on environment. Reducing energy consumption of construction and life cycle of the buildings will contribute to the sustainability. In this study, traditional structures of North Cyprus and their effective structures for environment protection have been analyzed. Traditional structures in Cyprus were built with natural materials such as stone and earth that creates healthy indoors, concerning the climatic conditions. Structures constructed with industrial materials no longer provide indoor comfort. Lots of energy is being used to provide indoor climate in today's buildings. A very large part of consumed energy in Cyprus is being used by residential sector. Earth is a natural building material made from sand, clay, and water. They may also be produced with some kind of fibrous or organic material (sticks, straw, dung) which is shaped into bricks using frames and dried in the sun. Earthen structures are extremely durable and account for some of the oldest extant buildings on the planet. Earth's strength and durability can be improved if needed. Dense forms of stabilized earthen construction have high thermal mass and able to store heat and provide long term energy savings for cooling in summer and heating in winter so, provide bioclimatic comfort for health with a suitable humidity and thereby balance indoor climate. Due to their high thermal comfort and being cultural characteristic properties of Cyprus, sustainability of Earthen structures are important. Earthen construction is not meeting with today's requirements because it has some disability such as low water resistance and low earthquake resistance. But these properties can be stabilized with gypsum. Revival of earthen construction will protect earthen architectural heritage.

Key words: Earthen construction, sustainability, indoor comfort

1. INTRODUCTION

Characterisation of earthen buildings involves definition of basic materials. Cultural and environmental conditions highlight the reuse of the earthen material today.

Nowadays the studies on earthen structure are among the most important subjects of sustainability that many researches are dealing with throughout the world. The rapid production of industrial materials is the threat for earthen constructions. In this study, earthen buildings around the world and Cyprus have been investigated. Labour, design and materials properties of earthen constructions have been defined. Advantages and disadvantages of earthen construction are also given in this study.

2. EARTHEN BUILDINGS IN HISTORY

Earthen building as an architectural technique has a very long history. Since towns were first built up, ten thousand years ago, Cyprus has used earth to build cities; residential buildings, palaces and temples. The earliest surviving remains had been found in the Güzelyurt. Earthen building has been used throughout all the world's ancient civilizations, from China to North Africa; from the eastern Mediterranean to America, in the mankind history [Ronald 2008] (Figures 1, 2, 3, 4). Taos Pueblo in New Mexico is the oldest inhabited settlement in USA since more than 1,000 years [Ronald 2008]. Earthen architecture has responded to the different climates with the knowledge, accumulated throughout the history.

Figure 1. USA, New Mexico – Taos Pueblo [Ronald 2008]

Figure 2. Egypt, New Gourna Mosque by Hassan Fathy [Ronald 2008]

Figure 3. Iran, Meiboud – Office of ICHO

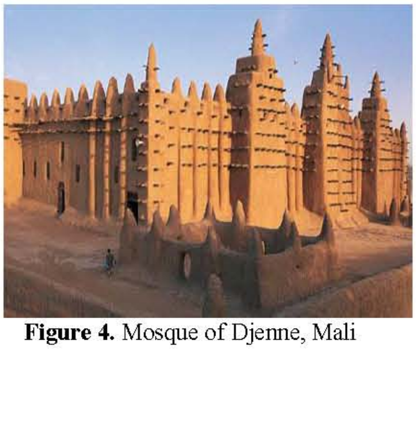

Figure 4. Mosque of Djenne, Mali

3. NEW EARTHEN BUILDINGS AROUND THE WORLD

Earthen materials are commonly used all around the world; 33% of world population live in earthen structures [Ronald 2008]. Today's curriculum of higher education does not cover earthen construction subjects and cities have been concreted with concrete building materials. Since the building physics and building biology is in the curriculum, earthen structures are also increasing in demand. Intellectual people in European countries are aware of healthy living prefer to use earthen structures. In the USA huge residential buildings constructed with earthen material are the legend of prosperity. Institutes or individuals from Italy, Germany (Dachverbant), Austria (Architect Martin Rauch), France (CRATerre), Switzerland (SIA) are exercising different construction techniques and also trying to keep earthen construction in the foreground. In France around 15% of the population lives in earth-walled houses [Ronald 2008, Minke 2006].

4. EARTHEN BUILDINGS IN CYPRUS

In Neolithic period (10 000 B.C), settlement is found on the slopes to avoid the cold north winds of winter. Their door faces are to south. Walls were made of adobe and mud bricks and earth mixed with hay under the sun. Adobe is a natural building materials made from sand, clay, water and some kind of fibrous or organic material such as sticks and straws. Stones outside and adobe inside are sometimes laid on top of each other. Exterior and interior sides of walls are plastered with whitish earth [Salihoğlu 2008]. Buildings with courtyard system begin in the Bronze Age. These buildings consist of two rooms which have doors opening to the courtyard facing south. The foundation of the residence is composed of natural rock and block walls. Walls are made of adobe and their interior side is plastered with mixture of sand and lime [Salihoğlu 2008]. Rural houses built during the Ottoman's period were continued until the recent times. Wind is the main factor that effects on the planning of houses. Courtyards are surrounded with walls to create a calmer and cleaner environment [Salihoğlu 2008]. Roofs have little inclination and covered with earth. The roof exposed to sun and external atmospheric events is insulated against heat by using thick layers of earth. Inclined roofs have been designed to allow the rain waters to flow into gutters at the end of the roof. Room heights were 4 m. This height allowed warm air to move up inside the building meanwhile achieving natural climatization at the lower levels in the space. Courtyard will benefit from the morning sunlight while it is protected from the afternoon sun shine [Salihoğlu 2008]. There are mainly two types of Cyprus houses. One is countryside and the other is urban side. In countryside generally houses are single story however, in urban areas they are more integrated. Typical countryside example is shown in Figure 5.

Figure 5. Alker (gypsum stabilized earthen) building in Büyükkonuk, North Cyprus [Özbekoğlu 2008]

The Chamber of Turkish Cypriot Architects' Building is given as an example for earthen houses in Lefkoşa (Figure 6). The building is on Zahra Street facing Ledra Palas, on the Venetian walls in Arabahmet district, Nicosia. The 100 year old building which is a good example of typical Ottoman Turkish Civil Architecture was built as a two floor masonry building with the ground floor walls out of stone, first floor walls out of adobe, and interior walls out of wooden framework. Being a natural material, the gypsum plaster allows the adobe, stone, and wood to breathe and enables them to have a long life [Aktaç 2008].

Figure 6. Typical Cyprus earthen building
(The Chamber of Turkish Cypriot Architects' Building, Lefkoşa)

5. ADVANTAGES OF EARTHEN BUILDINGS

5.1 Embodied Energy

The embodied energy of a material refers to the energy used to extract, process and refine it before use in product manufacture. The most important factor in reducing the impact of embodied energy is designing long life, durable and adaptable buildings [Işık and Tülbentçi 2008]. Earthen structures use locally available materials and they typically have low embodied energy because transportation cost decreases. Earthen structures are completely recyclable with minimal resource requirements. All over the world, the awareness of the embodied energy of materials and the global impacts of carbon dioxide emissions encourages the use of low-embodied energy materials. The use of earth for the built environment will continue to be a strong component in the future of humankind [Middendorf 2001].

5.2 Low Transportation Costs

Since earth exists all over the environment, there may be a very low cost for transportation of raw materials. It can be built by the homeowner. Environmental pollution will also be positively affected because lower transportation will cause lower energy consumption and environmental pollution [Middendorf 2001, Holtzhausen 2007].

5.3 Low Heat Transfer Value

Heat transfer is the movement or passing of heat from one point to another. Heat transfer value is the energy passed for unit time. This depends on the physical and chemical properties of materials. Denser materials have higher heat transfer. Light and porous materials cause low rate heat transfer. Heat transfer property of traditional earthen material provides indoor comfort. Since earthen walls exchange humidity they can be considered ideal for natural indoor comfort. Thermal comfort is experienced when the thermal processes within the human body are in balance i.e. when the body manages its thermal regulation with the minimum of effort and the heat dissipated from the body corresponds with the equilibrium loss of heat to the surrounding area [Neufert 2002]. Expected indoor temperature and-humidity should be 18-24^{0}C and 40-60%, respectively. For healthy living, there should not be too much temperature difference in indoors. Soil the best energy saving material stores thermal energy. After heating, walls give stored energy to the environment and balance the temperature. Because of its high isolation capacity, it protects the indoors from unwanted gain and loss. Therefore there will be no condensation on the surface of indoors. Lack of condensation prevents the wall from chemical and physical aging and there will not be any accumulation of micro-organisms [Middendorf 2001].

5.4 Thermal Comfort

Human thermal comfort is defined by ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) as the state of mind that expresses satisfaction with the surrounding environment [Ravikumar and Prakash 2001]. Thermal comfort is affected by heat conduction, convection, radiation, and evaporative heat loss [Ravikumar and Prakash 2001]. Thermal comfort is maintained when the heat generated by human metabolism is allowed to dissipate. Any heat gain or loss beyond this generates a discomfort. Lower heat transfer value of earthen walls provides temperature difference $\pm 2^0$C with outdoor temperature on the walls which does not create discomfort.

5.5 Renewable Material

Renewable is defined in Merriam-Webster as "capable of being replaced by natural, ecological cycles [Anne 2007]. A renewable material has economic and environmental value that can be replaced in the same amount. Soil is a renewable material for construction because it is a supply through the natural decomposition cycle or through composting and it is a non-toxic resource which can be readily recycled.

5.6 Low Fire Risk

The biggest threat of fire is to cause the collapse of building load bearing structures and result with harm to goods and human life. There are no flammable components in the earthen construction. Since fire turns earth into ceramic it increases its strength. Compared to other building materials, such as wood, earth houses feature efficient fire protection owing both to the use of concrete and the properties of the earth itself [Neufert 2002].

5.7 Workability

When the material has ability to be mixed, transported, poured, consolidated and finished easily and homogenously, it is classified as workable materials [Neufert 2002]. Earthen materials can be shaped by hand into attractively architectural forms: Because of its workability, rounded forms may be formed easily. It allows expression of personal creativity using traditional crafts and skills when produced by hand. Production by hand is labour intensive. For being workable, water amount should be high. Traditional production steps are shown in Figure 7 that also shows the labour intensive production.

Figure 7. Preparation of mud brick [Özbekoğlu 2008]

6. DISADVANTAGES OF EARTHEN BUILDINGS

Despite all the good qualities of traditional earthen constructions, the earth as construction material has some weaknesses. The disadvantages stated below are derived and mentioned from the experience of unstabilised earth construction.

6.1 Labour Intensive

Traditional earth building methods are extremely labour intensive. Adobe bricks are usually made by labour-intensive processes and adobe buildings require the hand placement of thousands of adobe bricks. Even with modern forms and pneumatic tampers, rammed earth construction also requires a considerable amount of labour [Minke 2006].

6.2 Design Limitations

Load bearing principles of earthen structures should be obtained from regulations and standards. General directorate of the earthquake disaster legislation (1997) defines some criteria on earthen structure design such as limitations of masonry structures, the wall height and wall width, window openings from the sides as a plan and window size depending on wall size. Earthen structures were excluded from the scope of earthquake regulations from this time beyond.

6.3 Durability

Durability is the quality of structures of continuing to be useful after an extended period of time and usage. Abrasion on earthen due to water affects its durability. Earthen materials gain its strength as drying. Therefore when it has contact with water it becomes more plastic and loses its strength.

6.4 Earthquake Response

Earthen structures are vulnerable to the effects of natural phenomena such as earthquakes, rain, and floods. Traditional earthen construction responds very poorly to earthquake ground shaking, suffering serious structural damage or collapse, and causing a dramatic loss of life and property. Seismic deficiencies of adobe construction are caused by due to their low strength. During strong earthquakes while 1/8 to 1/10 of the gravity acts as lateral forces on to the building, these structures develop high levels of seismic forces they are unable to resist, and therefore they fail abruptly [Blondet and Aguilar 2007]. Regulations are limitations in the earthquake resistance. Tensile strength of structures are so low that it can be ignored during earthquake. Earthen materials are ductile therefore they will have some plastic deformation under load before failure. Modern construction materials such as concrete, brick, aerated concrete are not ductile as much as earthen material. Earthen construction should be made according to earthquake safety standards [Yıldız and Gökdemir 2007]. It is a mistake to believe that earthen buildings are more sensitive to earthquakes than the other ones which are built with stones, bricks or concrete blocks. The important matter is always how well buildings are designed and built.

Traditional structures have been defined as old-fashioned. Earthen construction is not meeting with today's requirements because it has some disability such as low water resistance and low earthquake resistance. Earthen construction is labour intensive. Therefore the rapid production of industrial materials is a threat for earthen constructions. Water causes deterioration on earthen structures. Stabilization with gypsum and lime stabilization was used in Çatalhöyük in 9000 BC [Kafesçioğlu 1985]. Gypsum stabilization was developed since 1978 from Ruhi Kafesçioğlu at İstanbul Technical University [Kafesçioğlu 1985]. Buildings constructed with Alker since 1980 proved durability of earthen structures. This new composite material with lower shrinkage value is suitable to produce with the machines. In this manner, instead of labour intensive conventional production, new composite material has advantage for the construction sector.

7. CONCLUSION

Earth has been used as building material for thousands of years, and was discarded throughout the age of industrialization. In the last decay revival of earthen building techniques have been observed all over the world. The reason for this increase is the awareness in ecologically friendly construction and healthy houses. The growing dissatisfaction due to new buildings in the last century results from the increase of allergies and illness caused by indoor environment. Revitalization of earthen architecture in Cyprus can come true, if architects, constructors and craftsman had the knowledge and experience with the usage of earthen building products in new and historical buildings. Study on earth as construction materials and disseminate the knowledge can increase awareness and confidence on the technology. Gypsum stabilized soil has been determined for earthen construction revitalization. Gypsum stabilized soil, called Alker, has been studied in laboratory since 1978 and pilot buildings are in use since 1983. The advantages of alker are; low weight, low shrinkage, low heat transfer value, low energy consumption, less labour expenses and durability of the material. Characteristics of earthen construction in history and new earthen buildings around the world have been visualized to contribute to the awareness. Climate of Cyprus has been defined, as it has the greatest influence on to the architecture. Value of earthen building in Cyprus has been defined as: thermal indoor comfort in summer and winter seasons, indoor air quality, workability of the material, low embodied energy, easily available material, low fire risk, sound damping, etc. Most of the disadvantages, such as low durability, high labour demand, earthquake risk, low physical and mechanical properties are solved with the gypsum stabilization technology researches since 1978. Alker researches are summarised to be the base of the study.

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CASE STUDIES IN THE PLANTING OF STRUCTURE SURFACES; ROOF GARDENS

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ABSTRACT

Ever-growing high buildings cause also heating of the air as well as pollution by blocking the air circulation. Decreasing of the soil to be absorbed the rail as a result of concretion leads to fall more burdens on waste water systems of the cities, while increasing the use of water in the cities and industrial areas. Many cities have to struggle with floods due to selection of wrong location and inadequate infrastructure. Our environment, as a result of development of rapidly and irregular of especially our large cities, is covered with concrete and asphalt on a large scale. Use of many green roofs to be taken place in the urban centers as recreation and relaxation areas will be effective in the both economic and more livable formation of the urban environment. Having solved of structural problems in the facility of roof gardens in green structure surfaces in the large cities in terms of static causes giving more and more interest in this green surface type with each passing days. Roof gardens do not take place in only roofs of building where people live. It is possible to encounter with roof gardens in also various locations such as roofs of workplaces, on the buildings of industrial areas, underground car parks, hospital buildings or universities in the cities of the countries where this application is performed. Roof gardens are areas established for their environmental benefits nowadays, while roof gardens were an aesthetic object in previous years and this has generated the concept of "green roof". In today present situation, they are the type named as "ecological roofs" or "green roofs" and used for ecological purposes, as well as aesthetic purposes of the roof gardens. Green roof is a concept used for buildings to adapt to the environment living. In this study, general design principles related to planting with static properties of infrastructure were explained depending on these green types.

Key Words: Roof, Roof garden, Environment, Ecological roofs

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1. INTRODUCTION

High cost of lands and gradually increasing population in urban areas has led to multi-purpose utilization necessity of roofs. People have used roof gardens for both ecological and aesthetic purposes for centuries. These structures generate green environments for people in their surroundings for years. They are also used as a show off symbol and on occasion as a place protecting people from outer environmental conditions.

Roof gardens have become rather attractive during the last 50 years with the visual quality they provide owing to plantation and colorful ground covering designs, pools and fountains. City structure and life style changing during the years takes people away from the natural surroundings and leads to decreasing of green areas. Roof gardens are special green areas not only as a place realized with aesthetic thoughts and at the same time as special green areas contributing to urban ecology.

2. MATERIAL AND METHODS

Materials of the research include an explanation of the context of roof gardens and determination of infrastructure of roof garden concept and a systematic explanation of insulation and drainage, and information (plant material and structural elements) about the selection criteria of herbaceous and crown plants that are to be used for plantation purposes. Based on this purpose, text books, thesis studies, technical reports and papers, etc. about the application were examined. Applications about the plantation of roof gardens within the country and abroad and data such as visual materials, projects and sketches were included within the research content.

Primarily, similar samples realized domestically and internationally and roof garden designs and application studies realized by individual and special companies made up the methods. In this context, significance and functions of roof gardens were revealed primarily and materials, establishment techniques, plant species and utilization styles used in plantation of roof gardens were determined. In the second stage, proposals were developed according to the synthesis studies, theoretical and applied samples based on the revealed analytical studies.

3. GREEN ROOF SYSTEMS

When roof gardens, as urban greenery, are compared with other green areas, it is clear that there are significant differences in terms of both realization and healthy sustainability. Whereas existing areas are used in green areas other than roof gardens, an environment needs to be generated for roof gardens initially. Roof gardens are divided into intensive and extensive roof gardens in terms of function and benefiting properties. These categories are used in the explanation of different purposes, methods and different applications generally. Different ideas will reveal the type of method proper for the roof where the application will be made. Intensive roof gardens are flat roof arrangements, which require more than the growth

environment with intensive afford and excessive growth inputs such as grass, bushes, shrubs and small trees, and application of various nonliving materials (pavement, sitting elements and water surfaces, etc.) (Küçükerbaş 1991).
It is mandatory that isolation, filtering, drainage and watering systems must be perfect in intensive roof gardens, which have a thick growth environment (200mm or more). Main target of such type of roof gardens is to provide open areas, serving recreational activities for people (Johnston, et.al. 1993). Intensive roof gardens have a thick soil layer and watering and drainage systems and provide more proper growth conditions in comparison to extensive green roofs, and they have various advantages and disadvantages.

3.1 Advantages

- They provide growth of various vegetation on top of roofs.
- Soil and vegetation taking place in these gardens attribute to heat insulation of the buildings.
- Soil surfaces gained on structures provide new living environment for the fauna (birds, bees, butterflies, spiders, beetles, worms and ants, etc.) as well as for the plants.
- In addition to the functional benefits, they provide significant benefits for urban ecology and aesthetics. They have constructive effects for human health as well.
- They enable various utilization of roofs.

3.2 Disadvantages

- They generate excessive load on roofs.
- Utilization of watering and drainage systems requires extra financial burdens.
- They are highly costly.
- They require more complex systems and technical perfection (Johnston1 et. al.1993).

4. HISTORICAL DEVELOPMENT OF GREEN ROOFS

People have planted roof areas for various purposes ever since the B.C. periods until today. Although they are used in terms of environmental and economic purposes today, constructive approaches this roof system brings to social lives of people caused the planted roof areas to be used throughout history. People have used landscaping elements in higher elevations from Ziggurats until today, along with the sufficient opportunities, chances and financial resources necessary for the application of vegetated roof systems (Tokaç 2009). Investigations point out that roof garden concept goes back to hanging gardens of Babylon established in B.C. 6000 although they are not in today's context. Roof terraces and roof gardens started in the Near East countries, where flat roofs were built. Holly books before Christ include evidences about this type of roofs. The homeland of the gardens named 'hanging gardens' is Tigris and Euphrates basins, namely Mesopotamia (Kücükerbaş 1991).

Figure 1. Hanging gardens of Babylon (urbangardencasual 2012)

Following these preliminary applications, roof gardens or terraced garden applications are not encountered in early period civilizations and Anatolia until Roman period. Widely seen open place design was backyards in this period, which included prehistorically and Hellenic civilizations. When Roman period is reached (A.D. 1 century) roof garden applications are encountered in houses belonging to high level persons and civil architecture samples and especially in villa structures (for example Pompeii). Although Renaissance period garden designers were influenced by the past, they reflected the style of their period in their work (for instance Casime de Medici's Villa Careggi in Florence during the 1400s) (Johnston1 et al.1993).

Roof gardens or similar terraced garden applications are not seen in Turkish trite in Anatolia, Seljuk and Ottoman periods. 1867 Paris World Display was a significant milestone for roof garden design. In this display a constructor named Carl Rabite displayed a plaster cast of his house in Berlin which he thought for his house's roof in Berlin and he attracted great attention. French city planner Architect Le Corbusier, on the other hand, proposed that flat roofs of high buildings are used like gardens, and he contributed to the development of roof landscaping in terms of aesthetic and functional manners. Until 1960s, there was no roof garden sample comparable with the hanging gardens of Babylon in terms of dimension and size, Caiser Center roof garden was a mighty example overcoming this scale for the first time (Johnston1 et.al, 1993).

5. VEGETATION TYPES OF GREEN ROOF SYSTEM

There are two types of plantation in roof vegetation as 'intensive vegetation' and 'extensive vegetation' based on benefiting and function. Mixed vegetation manners according to the characteristics of the area can also be applied. These two major plantation techniques can be limited based on the criteria given below (Barış1 et al. 2003).

5.1. Extensively Planted Roof Systems

Plant varieties used in this roof system are endlessly varied. When infra systems are provided such as plant carrier layer and drainage layer, which are necessary for plant growth, all plant varieties can be selected from bush types to tree types. There was no limitation in the plants that were used and this lead to unlimited aesthetic alternatives. Depending on the plant type, thickness of the plant carrier layer, and in turn, load to be brought to the system must be taken into consideration. Generally, load to be brought to the roof carrier system per square meter is accepted to be at least 290kg in densely planted roof systems. Furthermore, construction, maintenance and repair costs are high due to the plant types used. They spread into larger areas in comparison to sporadically planted roof types within the buildings. Depending on the area they cover and plant types they include, they enable more living varieties to live. Utilization targets are to generate public areas that are open to mutual usage within the buildings (Banting et al. 2005).

5.2. Intensively Planted Roof Systems

In this type of roof planting, plants that are preferred do not require maintenance, and continue existence and grow on their own. Especially rocky area plants fitting to this definition renew themselves gradually and enable new species to grow, and thus plant flora become widespread. Since the plant species do not require excessive maintenance, establishment, maintenance and repair costs are lower in comparison to the densely planted roof system. Moreover, depending on the requirements of the plant varieties used, plant-carrier layer thickness is higher in comparison to the densely planted roof system. Generally, densely planted roof system thickness is accepted to be more than 20cm and rarely planted roof system thickness is accepted to be less than 20cm. Thus, it may be regarded that weight per square meter does not exceed 290 kilograms (Liu 2004).

6. BENEFITS OF GREEN ROOF SYSTEM

- Green roofs decrease annual flow volume and aid in rain water to reach administration targets
- Soil layers, and over the roof top, vegetation maintains building-interior heat in a medium level, and in addition, they insulate against hot and cold. As a result, energy amount required to heat and cool the building decreases and this in turn enable the building owner to save energy. Increasing

insulation decreases HVAC infrastructure requirements and thus building construction costs drop.

- Additional roof insulation protects the materials against ultraviolet rays, which ruin standard roof materials, and against excessive heat changes. It is estimated that green roofs increase roof life up to 20 years.
- Green roofs are designed to isolate building interior from outer noises as well; noise-insulating properties of the green roof infrastructure may make the surrounding areas less quite.
- Completely saturated green roofs may provide resistance against fires and may prevent the fires to spread nearby buildings.
- Green roofs cool and humidify the weather, and may diminish urban heat island effect.
- Green roofs improve air quality and aid in filtration of dust particles and other particles hanging in the air and help in preventing them
- Roof planting made in cities or environments away from cities provide a natural living environment for birds and butterflies.
- One of the benefits of extensive green roofs is that pedestrians have access to areas within an urban area.

7. STRUCTURAL CHARACTERISTICS OF GREEN ROOF SYSTEM

Certain characteristics are sought in the roof overlay, due to both structural properties of the roof and growth environment to be prepared for vegetation. Since all of these characteristics cannot be found in a single layer, an overlay method is applied as layers. In this overlaying, the layer is ranged as carrying layer, insulation layer (water, heat and steam blocking insulation layers), separation layer, filter layer, substrate and vegetation layer. Structural walls such as flooring, windows, wind blockers, pergolas, steps and pools, which are thought as materials other than the plant material in roof gardens, should be designed based on the carrying capacity of the roof carrier system. Very light material should be used in roof gardens and strong yet light materials should be selected such as light concrete and light aluminum (Barış et al. 2003).

7.1 Plant

Selection of the plants that are to be used in a planted roof varies according to the planted roof type that is to be used.

7.2 Plant Bearer Layer

Plant species used in different climate conditions for green roof systems are as follows;

7.2.1. Lichens

Brachytecium rutabulum
Bryum argenteum
Ceratodon purpurcus
Campothecium sericeum

7.2.2. Single year herbaceous

Anthemis tinctoria
Arabbiodpsis thaliana
Arenaria scrpyllifolia
Campanula rotundifolia
Cardamine hirsute
Centaurea seabiosa
Cerastium pumilum ssp pallens
Chrysanthemum sp
Daucus carota
Erigeron annuus
Galium verum
Hieracium pilosella
Holosteu umbeliatum
Medicago lupulina
Potentiall argentea
Senecio vernalis-vulgaris
Tragopogon dubius
Trifolium campestre
Tunica prolifera
Veronica arvensis
Vicia sativa

7.2.3. Perennial Herbaceous

Achillea nobilis
Anthemis tinctoria
Anthericurn liliago
Anthyllis vulneria
Arthemisia campestris
Aster linosyris
Cerastium holosteoides
Dictamnus albus
Dianthus deltoids
Epilobium angustifolium
Gallium album
Garanium sanguineum
Herniaria glabra
Inula conyza
Iris germanica
Linaria vulgaris
Linum perenne
Lychnis viscaria
Ononis repens
Plantago lanceolata
Rumex acetosella
Senecio erucifolius
Solidago gigantean
Taraxacum officinale
Trifolium pretense
Veronica serpyllifolia

7.2.4. Grass

Agrostis tenuis
Avenella flexuosa
Bromus mollis, B. sterilis
Festuca rubra, F. ovina, F. tenuifolia
Melica ciliate
Phleum phleoides
Poa bulbosa, P.pratensis
Stipa capillata, S. pennata
Vulpia myurus

7.2.5. Alliaceous, tubercular and rhizome plants

Allium
Tulipa sp.
Schoenoprasum
Muscari sp.

7.2.6. Succulents

Sempervivum tectorum
Sempervivum ruthenicum
Scmpervivum marmoreum
Sempervivum caucasicum

Sedum ruperstre	*Sedum acre*
Sedum album	*Sedum cauticolum*
Sedum reflexum	*Sedum kamtschatikum*
Sedum sexangulare	*Sedum spurium*
Sedum ewersii	*Sedum floriferum*

7.2.7. Short Ligneous

Calluna vulgaris	*Genistra linetoria*
Cylisus scoparius	*Helianthemum mummularium*

(Mansuroğlu 1998)

7.3. Filter Layer

Today, geotextiles that are not braded are preferred as a material in the filter layer. Non-braded geotextiles are made of regularly or irregularly stacked fibers of various lengths. These fibers may form an overlay brought together with various mechanical, chemical or heat effects. Or they may be protected naturally and produced due to the structural characteristics of the tree itself used as a raw material.

7.4. Drainage Layer

It is necessary that a drainage layer and drainage system is used for storing water requirement of plants and taking away the excess water from the buildings. In case excess water coming to the roof is not stored, plants cannot meet their water requirement when they need water and this leads to their death. If excess water is not drained away from the buildings, this leads to an excess load in the building carrier system, and water accumulating on the surface may also harm the plant layer (Toydemir, 2002).

7.5. Root Retaining Layer

The purpose of the root retaining layer is to prevent water reaching to the layers and materials as a water insulating layer first of all, and thus preventing plant root harming and losing their function. Root retaining layer may be generated in two ways. In the first method, a protective layer is used for this requirement, similar to other layers. In the second method, root-retaining characteristics are gained with the aid of various chemicals on roof-carrier layover or on concrete surfaces like stems (Toydemir, 2002).

7.6. Water Isolation Layer

Water isolation materials are used for the roof system sub layers and inner environment not to be harmed by rainwater. Water isolation material makes the roof system impermeable to water. Furthermore, a slope shaft can be used to collect the water accumulating on the roof, and a rainwater removal system can be used to take away the collected water.

7.7. Roof Carrier System Component

The function of the roof carrier system is to transfer the vertical loads in the roof to the building carrier system safely (Toydemir 2002).

Figure 2. Green Roof System Constructions (greenspec.co.uk 2012)

8. CONCLUSION

There is a rapidly increasing need for roof gardens today due to rapidly increasing population and gradually decreasing green areas in large cities. Roof gardens balance surface flows, and regulate heat balances in the buildings and regulate excessive temperatures or other extreme climatic conditions generated by hard surfaces in cities. Roof gardens create green areas similar to natural areas in towns owing to their ecological and creative functions, and they have a vital role in the increase of green areas per person. However, roof gardens never take the place of a forest or any ecosystem in the nature. Green areas diminish in parallel to increased structuring today, and it is approved that green areas are won back by establishing roof gardens in buildings, which are actually supposed to be green areas. Roof gardens, which play an accessory role in the establishment of green area integrity in cities, have a significant role in people's lives owing to their economic and creative functions.

It may not be always possible to include a garden, which is to be established in the roof, ever since the design stage. It is possible to vegetate the area with plant containers of various dimensions and materials instead of a garden integrated with the structure in such type of roofs. Roofs planted this way do not bring excessive loads to the roof, and at the same time, they provide aesthetic and ecological benefits same as the roof gardens. It is necessary to allow more space to such special gardens, completing the urban greenery and reducing problems, in order to diminish traffic noises and air pollution in modern urban life today. It is inevitable that city planners, architects and landscaping architects operate in coordination in this respect.

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SESSION 3

15 November 2012 Thursday, 17.00-18.00

Topic: Architecture and technology relationship in social and cultural context

Chairperson: Prof. Dr. T. Nur ÇAĞLAR

Assist. Prof. Dr. Yasemin INCE GÜNEY, Assist. Prof. Dr. Isaac LERNER
Technology and Architectural Education: A Conceptual Framework

Instr. Dr. Nihan CANBAKAL ATAOĞLU
New Formations in Circulation Areas and Technology

Instr. Dr. Bilgehan YILMAZ ÇAKMAK, Prof. Dr. Kerim ÇINAR
Vernacular Settlements in Cultural Continuity Context

Instr. Dr. Jaroslaw BAKOWSKI
Updating a Hospital Building. A Task for Innovation Design

TECHNOLOGY AND ARCHITECTURAL EDUCATION: A CONCEPTUAL FRAMEWORK

YASEMIN INCE GUNEY[1], ISAAC LERNER[2]

ABSTRACT

The development of materials and technologies available for construction always had affected architecture and architectural education either directly or indirectly. Furthermore, these new developments cannot be thought apart from the changes in the socio cultural and economic structure of the societies. It was both the availability of the pozzolana during the Roman period that lead to construction of imposing structures but also it was the Roman culture that created a need for the construction of these structures. During the modern era it took some time for the architects of the time to accept and use the new technologies and materials available as representatives of the new age. It required not only the availability of these new materials and technologies but also acceptance of them by the society.
During the contemporary period, the development of material and construction technologies coupled with developments in software engineering are providing the means to create the language of new architecture, while at the same time altering the experiential dimension of architecture. Today, architecture and more significantly architectural education are facing a new challenge that needs to be solved: the emphasis on the surreal over the real experience of spaces. In this paper, the interrelations of material and technological developments and architecture is examined in a historical perspective hoping to bring forth some of the critical dimensions related to the discipline of architecture and architectural education. The aim is to highlight the positive and negative opportunities that are presented with contemporary material and technological developments for architecture in general and architectural education in particular.

Keywords: Technological developments, new materials, architectural education

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1. INTRODUCTION

Architecture is a profession that defines spaces to suit certain required functions. As available means are used to define spaces, architecture is directly affected by the materials and technologies available at the time. Architectural education cannot be thought apart from this relationship between architecture and technology. During the long human history the interplay of development of materials and technologies and architectural education had different characteristics, sometimes one lead to another at other times there is a conflict that needs to be solved before they can start working together. During the Roman period for example, the use of pozzolana in Roman cement gave way to unprecedented successes in the construction of imposing structures for public use. Another example is after the industrial revolution when architects were resisting to the use of steel and glass and it took some time for them to reconcile with the use of these materials and to consider technology as the "cultural manifestation of modern man".

The contemporary period is facing a similar challenge since the development of material and construction technologies coupled with developments in software engineering. On the one hand these developments are providing the means to create the language of contemporary architecture, while at the same time altering the experiential dimension of architecture both in real life as in architectural education because of the emphasis on the surreal over the real experience of spaces.

In this paper, the interrelations of material and technological development and architecture in general and architectural education in particular is examined in a historical perspective in four distinct periods: Before the Modern era including Ancient period and Middle Ages where practice was the key to architecture while architectural education at first involved trial and error problem solving out of which the apprenticeship and guild system was born; Modern period starting with Renaissance well into twentieth century when the academies and universities emphasized theory over practice even though there were some efforts towards the end to unite the two as in Bauhaus example; and lastly, contemporary Post Modern period where the information age and globalization has a toll on everything and where the separation between architectural education and technological developments is at the highest. In doing so, the paper hopes to bring forth some of the critical dimensions related to the discipline of architecture in general and architectural education in particular in relation to technology and materials available over the course of the history. The aim is to evaluate and highlight the positive and negative opportunities that are presented with contemporary material and technological developments for architecture in general and architectural education in particular.

2. HISTORICAL EVALUATION

2.1. Before the Modern Era

One can easily assume that the first design education began during the prehistoric times right after there were skills to learn. The first step in learning involves trial and error problem solving even among animals. It can be assumed that the first humans also used trial and error to built their shelters. After much experimenting with the materials available to them, they were able to develop a mechanism that hold the pieces together to form their houses. The ones that succeeded were imitated later by others to avoid the failures inherent in trial and error approach. As the complexity of the processes increased the learners needed to be thought with more explicit directions. This can be considered as the start of the apprenticeship system in craft teaching. In this system, a novice who wishes to learn the craft becomes a helping hand for the experienced master in creation of the work. The student first observes the master at work learning the details of the craft and when he tries to conduct the skill he gets corrected by his master to do the work right. In this pragmatic education the theory is not a major component, only the practice needs to be in accordance with the rules of the craft. (Kostof 1977)

During the Ancient period though, when the architects aimed for the timeless forms of the buildings then they had to use precise methods to achieve these true forms. Thus the students of architecture should had to be educated to learn these essential rules of design. As a result, these essential knowledge of the design, the theory of architecture had to be thought as well. The design education now involved not only the teachings of the practice of construction but also this theoretical part as well, which later became the trade secret for the guilds to be handed down from master to disciple. By the time Vitruvius wrote his book on architecture, he emphasized the importance of being educated both on the knowledge of universal principles as well as on practical training. He warned architects, "the child of practice and theory," to have a thorough knowledge of both to "sooner attain their object and carry authority with them." (Morgan 1914) It was also during the Roman period that the workers came together as informal and voluntary organizations for the first time and called themselves as guilds or collegia (Gertner, p.85). They not only thought the young designers the theoretical part of design, the objectively true divinely inspired forms, but also the practice of how to construct the buildings.

The apprenticeship system that emphasized crafts continued all throughout the medieval period. The guilds uniting the workers in the same trade started to become more organized especially towards the eleventh century to pursue common interests such as securing raw materials, combating foreign trade, and controlling and regulating the craft itself via educating the young workers. The guild members also socially became more connected to each other as they started to work and even worship together. Their social ties were reflected with their rule to provide financial security for their widows (Gertner, p. 85). A student of architecture, first learned a building craft such as carpentry or masonry or both, and worked alongside the builders on actual projects. The trade secrets such as how to generate plans and elevations through geometrical manipulations or important construction details were thought to apprentice architect by his master and through his membership to the guild. After seven years of education with a master, both on the practice as well as on the theory of architecture, the student became a journeyman for three years travelling across Europe observing and sketching notable buildings while also working at different sites to gain experience. After settling down, the student presents a masterpiece of work to the guild to prove his competence. Only after he is

found qualified by the guild that the student became a master on his right and started to get commissions as well as apprentices of his own. (Kruft 1994)
It was also towards the end of the medieval period that the first universities emerged. With the rise of the city life, revival of trade and renewed interest in learning in the eleventh and twelfth centuries, the schools that were attached to monasteries for education in arts and sciences were not able to meet the new need for trained lawyers, doctors, secretaries and logicians. (Gelernter 1995) The first universities that were established by the end of the twelfth century took their formal curriculum from the cathedral schools and their institutional structure from the guilds. These universities aim was not to develop new knowledge or students creativity, they were to transmit to students the pre-established divine truths by carefully studying authoritative texts. The student in a university similar to one in a guild studied with a master for four years to hone his ability to reason through argument learning standard texts. After passing an examination he received a Bachelor's certificate similar to journeyman's certificate in the craft guilds. After further study, he took exams for Master's and Doctor's certificate. Only those with Doctor's certificate were then hired in universities as a fellow master entitling him to teach. Until further development of the universities, the design education in the guilds were able unite the theory and practice of architecture and both was considered as necessary for an architect to be. (Kostof 1977)

2.2. Modern Era

Modern period starting with Renaissance well into twentieth century can be summarized as a time when theory is emphasized over practice especially for the discipline of architecture. The most rudimentary element of the modern era is its attention to the individual stressing the development of his personality and character in such a way that he would be able to understand the world and reason for himself. It was the Renaissance men who for the first time in human history would develop an awareness of consciousness. It was also during the Renaissance period that the first time we see an increasing interest in personal fame. (Kruft 1994)
The emphasis on personality and character also had an effect on design education during the Renaissance. The old guilds that thought the young students the pre-established secrets of the trade, both existing bodies of knowledge and skills necessary, were not suitable in this era where the individual was to reason why certain things are done and in what other possible ways it could be done. The individual could no longer rely upon the established knowledge of the world, he needed to question to find the common structure behind all human knowledge. In the pre-modern era, the guilds explained how to do a particular task, while the new educational system needed to explain why they were done in that specific way. Moreover, in the guilds the masters had to be exceptional in their practice while in the new system the teacher was to understand the underlying principles of the craft even if he had little practical skill. The distinction between the practical craftsman and theoretical scholar was increasingly felt. (Gelernter 1995)
With more value given to theory over practice, the architects of the period were always theorists as well searching for the true knowledge of art and architecture. One of the earliest architectural theorists, Leon Battista Alberti for example, aimed

to explain the source of artistic and architectural ideas in such a way that it would be as objective as possible. According to Alberti, the source of all true forms lie in the underlying structure of the nature itself, which is to be found in a set of proportional ratios. Alberti wrote treatises on painting as well as architecture to set out these rules. Similarly, other theorists of the period also stressed the importance of the absolute rules for design and many wrote treatises such as Serlio's, "Works on Architecture" and Palladio's "Four Book on Architecture".

Since Renaissance what is important is that, as Leonardo Da Vinci suggested, practice ought always to be built on sound theory. As he argued, a painter should be guided by the "science of painting which included the principles of perspective and proportions as well as the most accurate ways of portraying light, shadow, human gestures and even human emotions" (Gelernter 1995 p. 114) In his workshop Leonardo would have the young painter first learn these principles of art before he could step into the workshop. His idea was the first step in the academic art education.

Academies were invention by Renaissance humanists who admired Plato's Academy, informal school, consisting of a community of scholars committed to the pursuit of knowledge. Soon after their establishment these academies challenged and ultimately won from the guilds the right to educate the young in art and architecture. The first of these academies, Accedemia Platonica established by Marsilio Ficino around 1470s, were similarly little more than informal social gatherings (Gelernter 1995). In 1563, the first official art academy, the Academia del Disegno, were established in Florance by Cosimo de' Medici with Vasari's influence. The students continued to work in the shops of their masters but in addition three visiting scholar from the Academy visited them regularly and criticized their work according to the academy's principles. They also got supplementary courses on theoretical subject such as geometry, anatomy and perspective. In other words, they got their practical training in the workshops and theoretical training in the lectures given in the academia. Later academies tried to bring the theory and practice even more closer to each other by bringing the masters and students in the workshops of the academy itself. This is the academic method of design education that continues even today, even though challenged at times. (Kostof 1977)

By 1670s, following the epistemological shift from Rationalism to Empiricism in sciences, a debate began in French Academies questioning the rationality versus subjectivity in art and architecture. By the first half of the eighteenth century, artistic theory emphasized the priority of sensory appearance over rationality creating the well known "Quarelle des Anciens et des Modernes". Similiarly in architecture, Claude Perrault liberated the true sources of form either from God or nature that were always rational and put it on the custom and culture, which was subjective to the rules of the societies. After Perrault, the creation of the rules to follow was up to human agency thus instead of reason a definitive authority should be agreed upon. This new perspective put the academies in a difficult position questioning their very existence that was based on the teachings of the timeless universal principles of art and architecture. In the following decades many such principles were to be discussed including the importance of function as well as materials and technology available. (Gelernter 1995)

During the Enlightenment, for example, although on the one hand we see academies were trying to continue the neoclassical tradition insisting on the universal timeless principles of art and architecture, there are now other perspectives that equally voice their concerns for the source of true form for designers. Carlo Lodoli for example, who himself was not an architect but a monk, suggested for the first time that function and nature of materials to provide the guiding principles for architects (Gelernter, 1995). It was also during the Enlightenment period that a new conception of history was born as well; one that rejects the continuous and progressive understanding of western history but rather sees history as a series of separate compartments where each compartment is as valuable and valid as the other. This new conception of history led to the creation of the idea of style for the first time that architects would be able to then choose freely as they deemed appropriate for their creation. For example, Piranesi argues for the superior quality of Roman forms, while Winckelmann championed the Greeks and Kent the Palladian Classism, yet others who value the emotional over rational the Gothic style.(Kruft 1994)
While these new ideas of Enlightenment were spreading among architectural theorists, new technological developments and new materials were due on their way after the Industrial Revolution. The way of life was changing in every way for everybody starting with the everyday objects changing from hand-made to mass produced standardized ones. The architects were reluctant to recognize these changes. They were busy with the discussions of which style was more appropriate for new functional buildings. In terms of the architectural education, the academies that were constantly increasing in number continued their predecessors with students working as apprentices in their master's workshops while attending the academy to learn the general principles behind practice. It was during the nineteenth century that the Ecole des Beaux-Arts in Paris would alter for the first time the traditional arrangement of academies. Ecole des Beaux-Arts, founded after the French Revolution as part of a general movement to establish and reorganize academies, combined the schools of Painting and Sculpture, Ecole Speciale de la Peinture et de la Sculpture, and Architecture, Ecole Speciale de l'Architecture, under one heading (Kruft 1994). This joint school treated architecture as one of the fine arts stressing the aesthetic aspects of architecture over practical matters of construction. At first, the Beaux-Arts continued the tradition of student working in the workshops of their masters in addition to taking lectures at the academy. Soon, this arrangement was changed and atelier system was initiated. The students no longer had to work in the workshops as masters now separated their workshops and instead worked with students in the ateliers on make-believe design projects. For the first time in western history, students could complete their professional education without ever stepping into a real architectural office. Still, the masters in these ateliers should have to be practicing architects, the weak link left between theory and practice for architectural education. The Beaux-Arts become the model for the following school of architecture around the world, such as for MIT that offered the first formal architectural education in 1865 in North America. (Kostof 1977)
Even though Ecole des Beaux-Art, emphasized the aesthetic aspects of architecture, it was also towards the end of the nineteenth century, that the style with which the buildings were clothed was dismissed and instead convenience and economy were

emphasized as the two essential requirement that good architecture should satisfy. It was Jean Nicholas Durand, the professor of architecture at Ecole Polytechnique in Paris, who suggested that objective principles of architecture should be considered as general abstract concepts which lie behind all good style, which are the qualities of symmetry, regularity and simplicity. In other words, as Ecole des Beaux-Arts focused on the aesthetic principles of Classical architecture Ecole Polytechnique focused on the economical and functional requirements defining Classism broadly as rational, geometric planning. (Kruft 1994)
Towards the end of the nineteenth century, there were also some romantic rebellion against these developments after industrial revolution. Following Ruskin and Pugin's ideas and headed by William Morris, Arts and Crafts movement argued for a return to medieval craft practices where the form of the products were derived from the inherent qualities of the materials used from a clear expression of constructional realities. The designers also saw design as a matter of personal artistic expression deriving from inner sense of taste free from universal principles. The Arts and Crafts artists even established informal versions of medieval craft guilds as they believed a complete return to the way of medieval life needed to moral goodness that the industrial society lost. (Gelernter 1995)
Since it was not possible to compete with the demands of the industrial society, the romantic rebellion of Arts and Crafts movement was not able to continue for long though its ideas was influential for Art-Nuevo approach and later on for Bauhaus educational systems. Founded by Walter Gropius in 1919, Bauhaus was considered as a watershed offering a modern vision of design and education appropriate for the new century. It called for a searching for the source of art and architecture in considering material and function in a craftly way. To reunite art and craft, Bauhaus educational system took the model of medieval craft guilds where students were trained to design and execute in one continuous system where master and apprentice were united in the workshops. Soon though he needed to add the instructional education in the classrooms for training in conceptual design, the abstract characteristics of form defined as "language of vision" by Moholy-Nagy, or well known as basic design principles of point, line, plane, rhythm, balance, proportion etc. Bauhaus method that includes avoiding preconceptions, teaching basic design principles, and emphasizing creativity that seeks new expression for a new age still provides the foundation for design education in today's architectural schools. (Gelernter 1995)

2.3. Post Modern Era

At the end of the Modern Era, it was clear that something was not quite right in architecture as there were major social problems arising because of the way we have designed the built environment. There were some reactions to these problems in the form of new styles from expressionism to post modern eclecticism to post modern classicism, post modern structuralism and deconstructivism. Yet, what distinguish this era from the Modern is not these different styles, but it is the insistence on considering the discipline of architecture not only as a profession but also as a rigorous empirical science. The new architectural research agenda established with the aim to create a body of scientific knowledge about how people use and are affected by buildings, and also to create a rigorous method to apply this knowledge produced into design problems. The scientific approach to architecture also affected architectural education as some schools soon started to reorganize their curriculum to incorporate this new approach to architecture. In 1960s, the Bartlett School of Architecture at the University College London replaced the Beaux-Arts method with a rigorous education in the basic sciences related to architecture, including courses such as anatomy, physiology, psychology of the senses and some physics. The school was to teach the theory alone and the architectural offices would later show students how to apply those theories into practice. Soon University of California at Berkeley followed the same steps, which later on continued to spread across US and Europe. (Kruft 1994)

Another major distinguishing aspect of Post Modern Era is related to its being the information age; a period that is characterized by the ability of individuals to transfer information freely, and to have instant access to information that would have been difficult or impossible to find previously. The idea is linked to the concept of a digital age or digital revolution, and carries the ramifications of a shift from traditional industry that the industrial revolution brought through industrialization, to an economy based on the manipulation of information, i.e., an information society. The Information Age developed with computer advances, with the advent of the personal computer in the late 1970s to the internet's reaching a critical mass in the early 1990s. The following decades the public adopted this technology in their daily life. Fast evolution of technology in daily life and in educational system allowed rapid global communications and networking to shape modern society.

The digital age also affected architecture with the introduction of Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) technologies. A CAD program produces at first a digital file consisting of a sequence of numbers which later on could be converted to print outs or even three-dimensional printouts via other machines, applications and interfaces which might be digitally controlled as well. Early in history of CAD, it was realized that although the computer screen is two-dimensional, all three-dimensional forms visualized using CAD programs may exist in a computational 3D space right from the start. Thus, a coherent object designed on a computer screen could be automatically measured and built informationally and even computer can fabricate the same object using CAM via a suitable 3D printer (Carpo 2011). A continous design and production process is made possible with 3D printing, 3D scanning and reverse modeling. Furthermore, one or more designers could interact with the 2D visualizations and 3d representations even printouts of the same object and all the revisions could be incorporated into the same master file of the project. Carpo (2011) considers this process as similar to artisanal hand-making with the only exception that in digital production chain the primary object of design being an informational model. Furthermore, by bridging the gap between design and production reduces the inherent limits of notational regimes of 2D architectural project drawings such as straight lines, right angles, squares and circles and some limited variations on similar elementary Euclidean themes (Carpo 2011).

CAD CAM applications are not just recording tools for scripting final set of design instructions; they are responsive tools for designing as well as making at the same time. Designers using the potentials of digital technologies, though a handful for now, working on informational models or even interactive avatars of the objects themselves using these technologies as mechanical utensils like hammers and chisels (Carpo 2011). Prior to introduction of these digital technologies it would have been exceedingly difficult to represent and produce objects that are possible to design and manufacture today. Thus, to consider these digital technologies similar to traditional notational vectors such as blueprints of construction drawings is being ignorant of the potentials that are presented to designers today. It is important to recognize the changes in digital technologies and incorporate them in architectural education as well. In the fall of 1992, Columbia University's Graduate School of Architecture, Planning and Preservation inaugurated its seminal "paperless studio". However, this is not a common thread in architectural education yet.

3. DISCUSSION

In the earlier section, the interrelations of material and technological developments and architecture is examined in a historical perspective hoping to bring forth some of the critical dimensions related to the discipline of architecture and architectural education. It was mentioned that during the Middle Ages the language of design was based to a greater extend on the essential qualities of materials and technology available, thus the student of architecture was to be thought both the universal guiding principles as well as the materials and technology that is used. The Middle Ages joined the designer and builder in the same person, while Renaissance had set design apart from construction and the designer apart from the builder. The Renaissance architect who was separated from the builders intellectually produced project documents hand-drafted as precisely as needed before they were shipped to the distant sites where they would be used.

The common thread in the Modern Era was that, the first priority in architectural creation had never been the materials and technology available. The topic of discussion was always based on what principles to follow to reach the true forms. During the Renaissance, it was the universal principles that was agreed upon for centuries and architectural education was based on teaching of these rules in academies. During the Enlightenment period, with the new understanding of history as separate compartments, the idea of style was born for the first time only to focus the discussion on which period's style to be considered for the true forms. It was only towards the end of the Modern Era that the importance of new materials and technologies for the creation of forms was recognized to be important. It was also for the first time that technology and materials available was considered the most significant aspect of architectural creation as it was the "cultural manifestation of modern man".

The distinct characteristics of Post Modern Era is a the importance of considering architectural discipline as a rigorous science on the one hand and the introduction of digital technologies, CAD CAM possibilities on the other. The new developments in digital technologies are enabling collaborative, information–based decision making a possibility in design process. It is important and yet not fully understood yet that the new digital design tools could serve to make something that was not possible before because of many geometrical notational limitations deeply ingrained in the history of architectural design.

4. CONCLUSION

Built architecture depends on the production of material objects such as bricks, nails, iron beams, etc. Therefore history of architecture cannot be thought separate from the production process. Architectural design on the other hand can be considered as a informational operation specifying how the pieces of the built architecture need to come together. The processes of design uses a range of cultural and media technologies available at any given time. At first the architectural models were used for centuries to record, transmit and imitate architectural design ideas. The architect was not only the designer but also the builder before the Modern era and thus always his existence were required on the construction site. During the Renaissance period, Alberti's new geometrical definition of architectural project drawings consisting of a set of notational tools to be materially executed by builders, supported the intellectual separation of designers and builders. Alberti's claim that architects should be designers not makers and Brunelleschi's legendary struggle for recognition as the sole designer and master of a major building programme also reflects this separation between designer and builder.
Architects were so involved with the problem of style that architecture was not developing hand in hand with the developments during the industrial revolution. Throughout the nineteenth century, most architects were either ignorant or reacted against the new technological developments of industrial mass production. It was the pioneers of modern architecture that for the first time recognized that mechanical production was changing the world and they had to come to terms with it. They recognized that they should invent new forms that would measure for the new tools available.
Similarly, one can argue that today most architects are also ignoring or denying that today's machines are no longer same as the mechanical production which modern architects celebrated a century ago. It is important to recognize the possibilities presented with the advent of new digital technologies both for architecture as well as for architectural education. While CAD CAM technologies are rising up in challenge, most of the architectural schools do require the students hand-draw their projects until the end of their second year of education. Most of these new digital technologies are not existing in many of the architectural schools and there is constant discussions among the professors about the necessity of digitally producing architectural projects for the students. The problem needs to be recognized together with its underpinnings: The sooner the acceptance of this new technologies the sooner the language of today's architecture could flourish.

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NEW FORMATIONS IN CIRCULATION AREAS AND TECHNOLOGY

NIHAN CANBAKAL ATAOĞLU

ABSTRACT

In the post-modern period, in today's architecture, spectacular and dramatic changes are observed in the formation of buildings and the organization of interior space. Even though these dramatic changes draw attention in the forms of structures at first glance, when interior space organizations and circulation areas are analyzed, radical changes are identified in design strategies, scale, geometry, perception, and size of circulation spaces. Circulation spaces of today, which take form around large and complex atriums, are designed with ramps, bridges, transparent elevators, stairs, escalators, and take shape with expressions of speed and dynamism which reflect spirit of the age. These new, exciting, interesting, surprising and dynamic circulation areas, which offer experiences very different from ordinary circulation areas designed with the traditional and conventional concept, take nourishment from computer technologies, new materials, new structures and new technologies.

Key words : Spatial circulation design, Spatial scenarios, Technology

1. INTRODUCTION

Architects, particularly in their post-1980 designs, have been striving to design interior spaces which are not easily perceived with orthographic means such as plan and section. This search and differentiation has made itself felt especially in circulation areas. In these structures, space is not formed within only one perspective but it consists of several perspectives by combining a lot of spaces, one on the top of another and based on different scenarios.

2. NEW FORMATIONS IN CIRCULATION AREAS

New space organization in circulation areas produces new spatial experiences with the formation alternatives stated below:

- Spherical and amorphous forms
- Making borders obscure

- Irregular openings on cross sections
- Irregular geometric floor plans
- Striking colours and textures
- Visual illusions designed on mirror surfaces.
- New materials, new structures and their facilities
- Changing circulation elements formations (stairs, escalators, elevators, ramps, bridges)

2.1. Spherical and amorphous forms

In today's post-modern architecture, with the development of new materials, new technologies and carrier systems, huge buildings are constructed which cover large spaces under one roof after large spans are passed. Particularly, in post-1980 structures, it is observed that interior space is designed with surprises and perspectives changing within different architectural scenario fantasies. Spatial scenarios in circulation areas, surprising formations in the same place create exciting formal organisations in the space. Modular forms and fragmented modular forms or amorphous forms in interior space create new and original designs in circulation areas which take shape under a big roof. (Figure 1)



Figure 1. Seikei Üniversity Library, Shigeru Ban, Tokyo, 2006; Carl Icahn Laboratuary, Rafael Vinoly, New Jersey, 2003; Doğuş Automotive, Kocacıklıoğlu Arcitecture, İstanbul , 2008

2.2. Making borders obscure

Circulation areas conventionally consist of halls, corridors, courts and atriums that intersect each other with right-angled surfaces. Unlike this conventional formation, spaces in circulation areas where corners disappear and borders become vague create alternative and original formations. (Figure 2)

Figure 2. Pierres Vives, Zaha Hadid, France, 2012; New Kyoto Town House, ALPHAville, Kyoto, 2011; Villa NM, UN Studio, New York 2007

2.3. Irregular openings on cross sections

It is possible to say that in usual conventional structures, in which traditional construction techniques are used, floor plans that form the section are piled up one on the top of another as smooth spans repeating each other. A formation created by irregular spans is observed in sections of a lot of structures which attract attention with their form and contribution to architecture. Today's technology, carrier systems, new materials, and steel technology ,that makes large spans possible, enable the formation of structure sections of these unusual designs with irregular spans.

For example, Rem Koolhaas's Berlin Netherlands embassy is a cubic mass. In this simple cubic structure, an interesting spiral structure is designed in which the ceiling suddenly turns into the floor and height of sections varies on every floor.

As another example; circulation is the main theme in Montessori College design. In the college, forming visual connections between various areas is one of the design principles. In order to enable social interaction between the users of the structure, staircases and bridges connecting different platforms are placed in a position that establishes visual relations in the section (Hertzberger, 2003). (Figure 3)

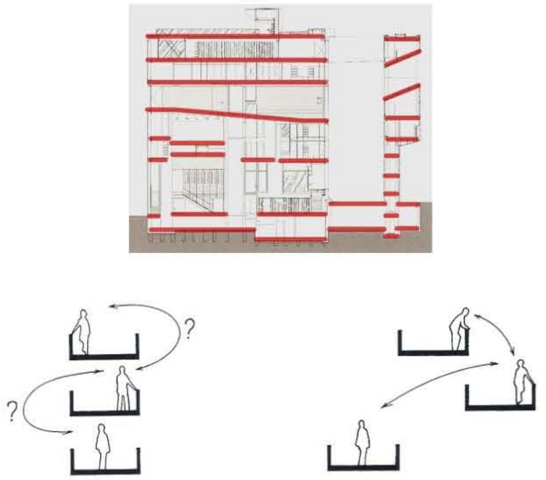

Figure 3. Embassy of the Netherlands, Rem Koolhaas, Berlin, 2003; Montessori College, Herman Hertzberger, Amsterdam, 1999

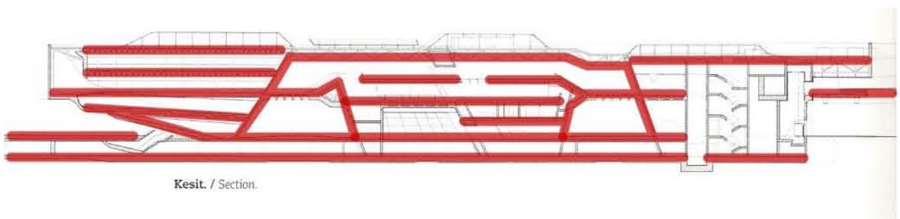

Figure 4. Phaeno Science Center, Zaha Hadid, Germany, 2000-2005

Phaeno Science Center, described as the transformation of feelings of exploration and curiosity into a concrete object, has an unusual volume and is based on a structural logic. During the planning, floors were not piled up one on the top another or empty halls were not formed by passing through large spans from one end to the other. In the structure, volumes were formed with conic structures stretching both inwards and outwards (Hadid, 2005). (Figure 4)

2.4. Irregular geometric floor plans

Today, it attracts attention that circulation area geometry of structures which stand out with their original circulation solutions are planned in undefined geometric forms with analyses on the plan plane.

In both of the structures given as examples, circulation areas are designed to be specific public places where social activities are carried out rather than being ordinary areas connecting units to each other in a functional way. Circulation areas holding this quality are designed in a random manner aimed at increasing visual relations rather than in a predetermined form. This dynamism is supported with irregular geometric floor plans.

Architecture and Art Building, designed by Roto Architects, contains a canyon-like social area between two rectangular blocks. All social activities are performed in this area, which can be seen from everywhere and every floor. This versatile place is a place of intense learning and teaching. Fluent interior spaces focus students on cooperation and encouragement and create countless areas for social change and dialogue in educational development (Pope, 2006). It is remarkable that the building with these features has a circulation area that is random and undefined geometric. (Figure 5)

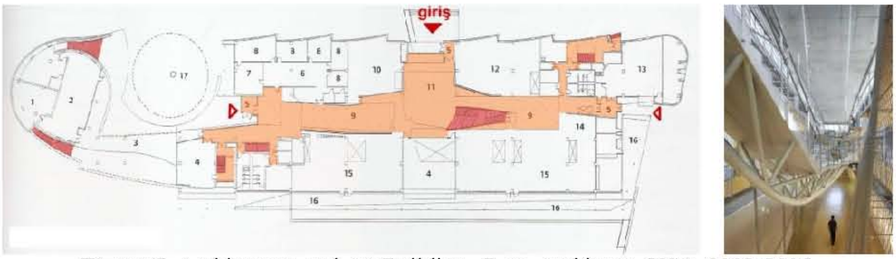

Figure 5. Architecture and Art Building , Roto Architects, USA, 2003-2005

Iowa University School of Art and Art History contains outlines formed by organizing spaces instead of real and traditional volumes. The main horizontal passages surrounded by glass walls display ongoing studies in various places while creating gathering places. The central part from which one can watch the ongoing studies is described as a social condenser (Holl, 2007). The staircases in the building which outstand with a different shape is described as a forum and located in the central part which is described as a social condenser. Formless geometries are used in the architecture, settlement of space and the combination of linear lines of the School of Art and Art History. (Figure 6)

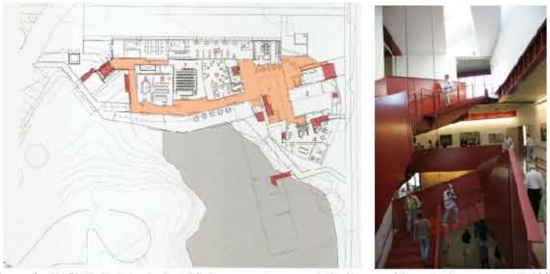

Figure 6. School Of Art & Art History, Iowa Univercity, Steven Holl, USA, 2006

2.5. Striking colours and textures

Colour is used in architecture to emphasize the character of a building, draw attention to its form and material and to make its parts explicit (Rasmussen, 1994). Colour can be effectively used as a determiner of the borders of the space and an organizer and orientator of circulation areas by emphasizing the form. Surfaces with

different textures display a feature of determining circulation by pointing out that the function changes and with their feature of defining borders.
In today's buildings, strikingness of circulation areas and staircases are powerfully emphasized with the dramatic colour tones and different textures. (Figure 7)

Figure 7. Library and Media Center, Herzog & De Meuron, Cottbus, Germany, 2006; Red Town Office, Taranta Creations; Hago Dental Office, Estudio Arquitectura

2.6. Visual illusions designed on mirror surfaces.

The start of using glass in interior and exterior spaces makes it possible to create transparent spaces. While glass material creates feelings of infinity and transparency in spaces, mirror adds depth to the space. Using mirror and glass as coating material on the ceiling and wall surfaces in circulation areas, atriums and staircases create designs in which it is not clear where the stairs start and which floor they reach, and in which form-floor relation is lost. With this formation, a brand-new interior space that misleads and confuses perceptions is created. (Figure 8)

Figure 8. Conservatorium Hotel, Piero Lissoni, Amsterdam, Netherlands; Festival Walk, Retail, Office, Arquitectonica, Hong Kong, 2003; Akademie, Behnisch and Partner, Berlin, 2005; Prosecutor's Office, Architects Of İnvention, Tbilisi

2.7. New materials, new structures and their facilities

Developments in construction materials, diversity of new materials, new structures and their possibilities diversify the designs of circulation areas and circulation elements. Development of reinforced concrete, steel and computer technology enables to pass large spans and create curvilinear forms. The circulation areas in

Frank Gehry's titanium-coated organic-formed Bilbao Guggenheim Museum offer an unusual geometry and experience.
In addition to the new materials such as plexy materials, titanium, aluminium composite materials and acrylic, traditional materials attract attention with their new uses. For example, wood is baked and its strength is increased thus glued, stratified wood suitable for curvilinear forms can be obtained. Strength of glass, a fragile material, is increased and also used as a structural material. natural Stones are treated with laser technology and staircases are designed in sculpture esthetics. (Figure 9)

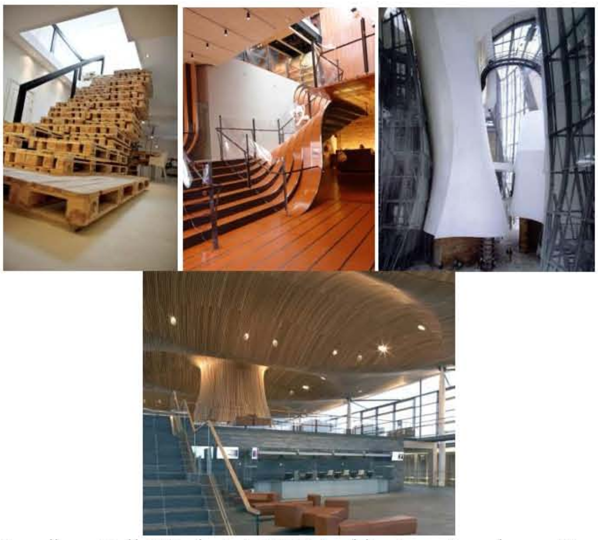

Figure 9. Brandbase Pallet Project, MOST Architecture; Lonchamp Store, Thomas Heathervick, Soho; Gugenheim Bilbao Museum, Frank Gehry, Spain, 1991-1997; National Assembly for Wales, Richard Rogers Partnership, England, 1998-2005.

2.8. Changing circulation elements formations (stairs, escalators, elevators, ramps, bridges)

While circulation elements were ornamented with decorative elements in pre-modern periods, today staircases, escalators, elevators, ramps and bridges have a surprising richness with their form, structure and material. Designers' search for originality, innovation and excitement create solutions specific to the building in which characteristic circulation, staircases and ramps form the focus. (Figure 10)

Figure 10. Didden Village, MVRVD, Rotterdam, 2007; Stairs, Gabriella Gustafson and Mattias Stahlbom; Music Theatre, UN Studio, Graz 1998-2008; City Hall, Norman Foster and Ken Shuttleworth, London, 2002; Parisian Apartment, MAAJ Architectes, Paris, 2010

3. CONCLUSION

As a result, circulation areas, which have undergone changes and breaking points on an evolutionary line, have turned into exciting, interesting and surprising fantasy areas in today's interior space in Post-modern buildings. It is possible to say that factors such as designers' search for originality, excitement and innovation, employers' demand for difference, deconstructivist discourses, contribution of computer technologies to the design process, convenience of production provided by modern construction material and technology are the causes of the new and different formation in circulation areas.

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VERNACULAR SETTLEMENTS IN CULTURAL CONTINUITY CONTEXT

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KERİM ÇINAR[2]

ABSTRACT

Analysing vernacular settlements, in contex of reservation of cultural heritage and transferring local identity to future generations, are coming into prominence day by day. In this respect, Anatolia has rich sources in global literatüre ,especially in residental design. Vernacular settlements in Middle Anatolia, are the best examples of the cultural herritage in terms of spatial organization and configuration characteristics. According to syntax of spaces and functional hiyerarshy, analysing the spatial structure of rural dwellings is very important Because these analyses helps us to explain and understand traditional space culture and effection of life style to spatial form. Konya as a research area, has significiant examples of residental culture in different geographies which consists of several topographic and climatic properties. By analysing rural dwellings in vernacular settlements, it is determined that, they are differentiated plain and mount dwellings according to life styles and environmental factors. It caused metamorphosis in spatial organization and functional structure by the reflection of user requirements. With the support of technological methods, analysing traditional spaces with modern techniques, is qualified as a "innovative movement". In this study a mathematical method called "space syntax" is used in proving the relation of spatial organization and social life. By using this technological method, some findings about functional structure and spatial connection occured. These findings are used to understand the relation of socio-cultural life and spatial configuration.
As a conclusion, it is determined that the trails of culture can be seen in usage and syntax of spaces. The relation of social life and spatial configuration is provided as objective criterion with the help of technological method. And it is predicted as a innovative method in recent house designs.

Key Words: Morphological Analysis, Space Syntax, Spatial Alteration Vernacular Settlements

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1. INTRODUCTION

For centuries Konya has been placed between most important settlement places of Anatolia, has been a reference city by its social and cultural properties. For centuries it shows regular improvement and evolution pattern which is expanded by radial axes from the center to city fringes. Although ımprovement and expansion problem is one of the branch of urban planning, it has been in interest of architecture because of its effects on residental design and planning of residential areas.
Economical, political and social improvements caused city improvement and starting migration from rural to city. By migration, residental areas formed on city fringes, families which are keep up with improvement and being urban, move on to city centers. This progress effected city form and has been a guidance factor to decide city improvement direction. In this changing and mutation progress some of residential areas which are migrated from rural to city, are urbanized or leisurely disappeared, some of them currently live in residential areas try to keep their properties in improving city form. In this progress rural residences which are one of the main source of our traditional culture, being urbanized by loosing their properties or changed.
Alteration is a situation of re-interpretion, which provides continuity of cultural identity and contains every value updating, which are transferred from past according to date requirements. In this sense, residences are basic elements of not only cultural continuity but also alterations which happens on this continuity.
Spaces and residences; living with the community and reflective arragements of cultural alterations. Alteration on spatial scale can be evaluated by experiential qualities rather than geometric integrity of space. Provider of continuity of alteration is, occured by expriences of residences and its integrated environment with livings more than the residences physical definitions (Morley and Robbins 1997).
According to this alteration concept, the spatial features of plain settlements in Konya region and the alteration of spatial organization in migration process in cultural continuity contex is tried to determined.

2. METHODOLOGY

In this study, the comparative spatial analysis of rural houses in the fringes of the city, Space Syntax method was used. Method is one of the analysis methods that included in morphological analysis techniques. Space syntax method can be called as a schematic presentation, which defines the changes in behavior, social relations and cultural differences.
Method is also used to investigate, predict, and evaluate the effects of various design alternatives. Nowadays, it is used to measure the intelligibility of the user or designer's perspective with the building's design styles (Edgü ve Ünlü, 2003).
The most important feature of Space Syntax is, being a numerical technique which has capable of analyzing the abstract characteristics of space as a concrete characteristic. These have a critical role in the formation of knowledge based on the experiences which can be named as a reflection of space in human mind.

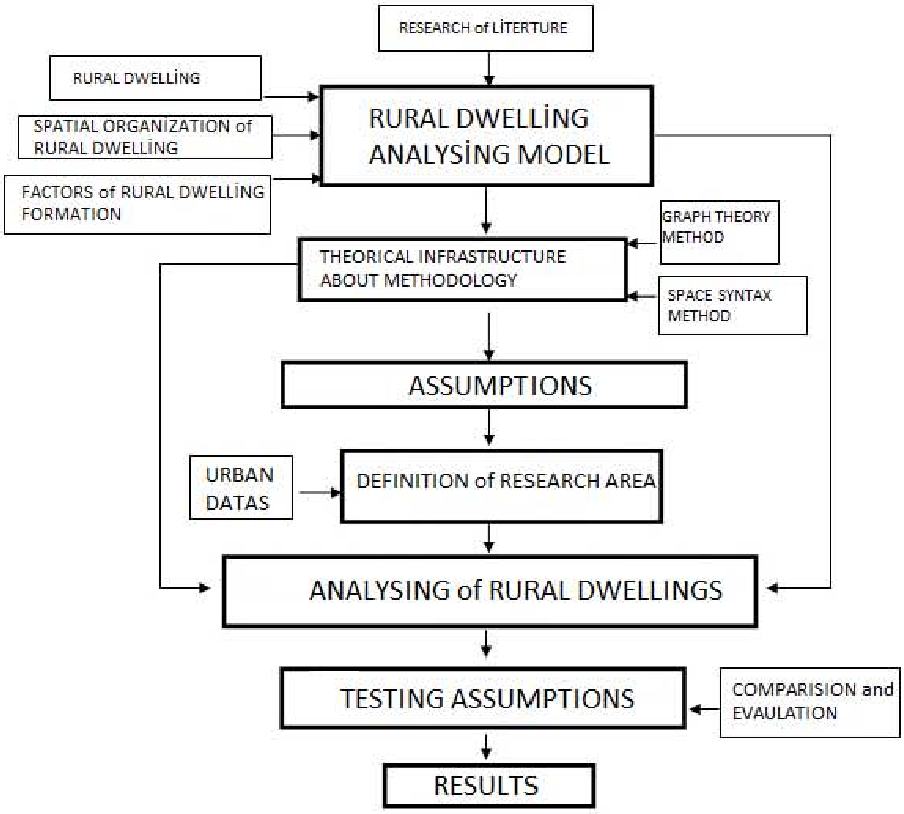
The general idea of this method is that, by separating the parts of place that these are "the starting point of human experience", and bringing these pieces into maps or graphs to allow them to make quantitative analysis on (Hillier ve Hanson, 1984).
There are some specific concepts in space syntax methodology. Explanation of these concepts is important to interpret the results of analysis correctly and to understand the logic of the method.
3 key concepts within the scope of the study will be considered for the interpretation of analyzes. These are connectivity value, visual integration value and visual mean depth.

a) Connectivity
A measure of the number of directly connected adjacent spaces. A local distance that measures the number of steps away from each line. (Hillier ve Hanson, 1984). This local criteria is the most basic knowledge about understanding space

b) Visual Integration
The most important criterion to predict the movement of a movement along the line,is the value of spatial integration. Integration as a global benchmark is the avarage depth of the space to other spaces within the system. The relationship between the integration value and connectivity value is intelligibility or readability. If connected spaces are also integrated spaces, it means strong and intelligent spatial relation. In this case, all the components that make up the system itself is readable (Hillier ve Hanson, 1984).

c) Visual Mean Depth
One of the most important relations in syntax method is the concept of spatial depth. Depth occurs when there is more than one crossing space to reach a space. If there is a low value to be reached in the deflection space, the depth is "shallow", if there is a high value, the depth is"deep". The important subject in this case is, showing as a value of the relation of each space with other spaces. This refers to the mean value of the whole, and allows for comparison with other systems (Hillier, 1984). In obtaining the findings the following flow chart related to the method is as follows (Table 1)

Table 1. Flow chart abaout the methodology of study (Yılmaz Çakmak 2011)



3. FIELD WORK

Anatolia is a rich area in local characteristics and rural settlements. For this reason, studies on rural settlements are increasing every day. The basic approach to the tradition of human environment is based on; the human, as well as in all its activities, is affected by geographical conditions in construction of his house. However the settlements built by communities living in natural environments shows important differences. At least, even if it prooves not only natural conditions in forming houses and settlements, but it also exposes the importance of culture.
Generally rural settlement can be defined as; intelligent settlements affected by environmental components (geographic and cultural), differentiate by living styles and extensive kinship relations (Çınar 1990, Aydın 2008). Plain and mountain settlements features are comparatively as follows (Table 2)

Table 2. General characteristics of plain and mountain settlements (Çınar, 1990; Kantar, 1998; Tunçdilek, 1967; Öymen Gür, 2000)

PLAIN SETTLEMENTS	MOUNTAIN SETTLEMENTS
• Dry farming is done	• Irrigated farming is done
• They have flat land structure in terms of topography. They are seen in plains and level areas.	• They have rough land structure in terms of topography. They are seen in the hillsides and slopes of a mountain.
• The accommodation action, food, cleaning and other areas of other actions are separated.	• All the actions are nested.
• The dwelling groups are together and in attached order.	• The dwelling groups are spread over the field in a manner that they are separated from each other at certain intervals.
• Social relations are high.	• Social relations are disconnected.
• Commonly seen in the Central Anatolia, Southeastern Anatolia and Eastern Anatolia Regions.	• Commonly seen in Black Sea Region. It is also seen in the hillside settlements in other regions.
• The facility and network installation is easy.	• The facility and network installation is difficult.
• The construction material is generally adobe for walls, stone for basement and the soil cover on wooden beam for roofs.	• The construction material is stone or wood for walls, stone for basement and wood for roofs.

3.1. Research Area, Location and Characteristics

The research area subject is Plain rural settlements, in Middle Anatolian Reigion, that can be seen concreatively in geographical and cultural features. In this context, the selected research area is settlements where migrating groups migrated and settled from plain villages to city fringes.

The research area is an area on the north-south axis of Konya city centre, where almost 100.000 people live and which is comprised of 10 districts. The demographical feature of the region is that it is comprised of families migrating from surrounding towns and villages with the industrialization period in Turkey (post-1960). Fetih Street forms the eastern external border of the research area. As the urban change and transformation keep on, rural areas are changed into urban settlements and the local dwellings are disappearing.

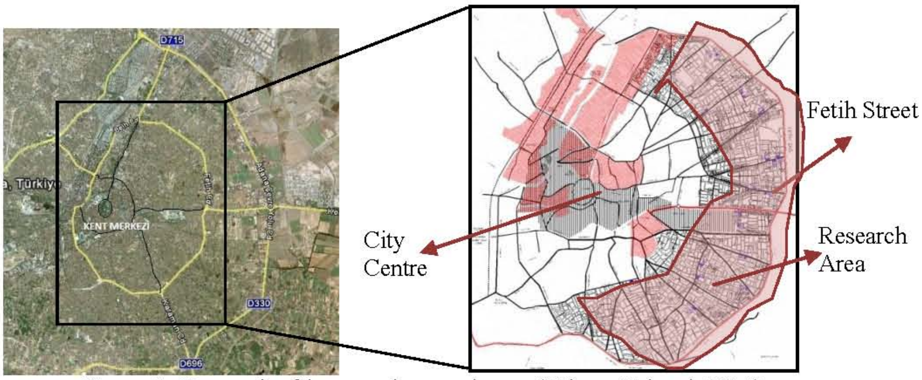


Figure 1. Konya city fringes and research area (Yılmaz Çakmak 2011)

Movement to city is usually at the Access road route. The classification of Konya, according to accession route is as follows;
1.Group(plain settlements), Kulu, Cihanbeyli, Altınekin, Sarayönü, Kadınhanı, Çeltik, Yunak, Akşehir, Doğanhisar, Tuzlukçu, Ilgın, Hüyük, Derbent, Beyşehir
2.Group(mountain settlements), Derebucak, Seydişehir, Yalıhüyük, Ahırlı, Bozkır, Hadim, Taşkent, Akören, Güneysınır, Çumra, Karapınar, Ereğli, Halkapınar, Emirgazi.

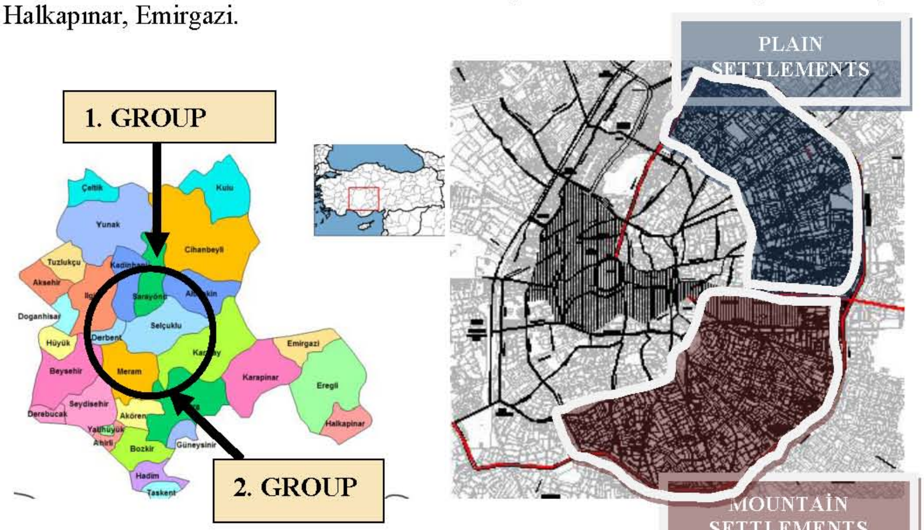


Figure 2. The approach to Konya from surrounding districts and plain and mount settlements. (Yılmaz Çakmak 2011)

4. FINDINGS and EVALUATION

Selected 20 dwelling which is settled by families that migrate from village to urban areas have been analyzed and compared according to the characteristics of plain and mountain settlements. The dwellings have been analyzed and classified as (branched or complex) according to functional features, (compact or sectional) according to connectivity and (integrated, connected and mean depth) according to syntactic analysis. These analysis figured out by a mathematical software named UCL Depthmap.

Table 3: Syntactic analysis of 20 houses in city fringes (Yılmaz Çakmak 2011)

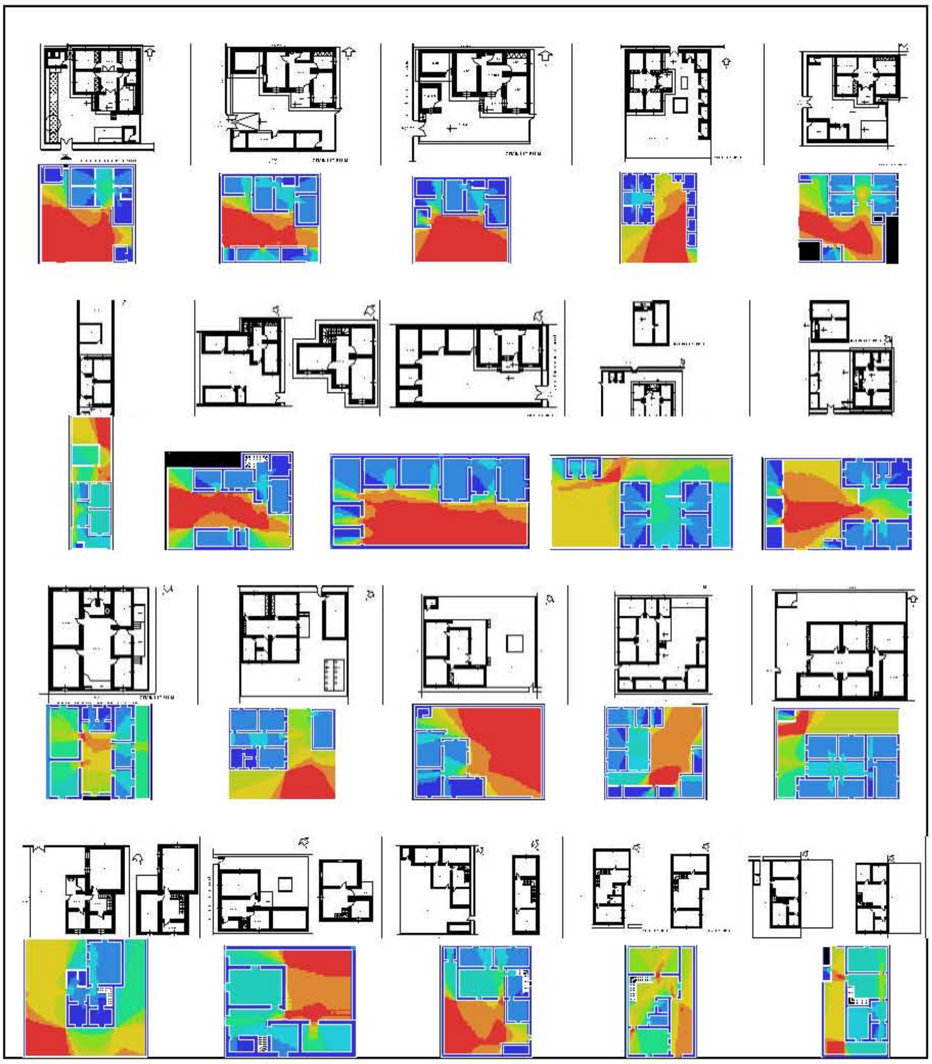


Table 4: The comparision of plain and mountain dwellings as functional structure and syntactic values*

URBAN	Functional structure analysis values		Syntactic analysis		
	Beta Branched/Complex	Gamma Compact/ Sectional	Connectivity	Integration	MeanDepth
PLAIN	0.909	0.180	1019	10.039	2.112
MOUNT	0.917	0,158	858	8.014	2.254

* Functional structure and syntactic values of dwellings are calculated with the avarage values of 20 dwellings.

Table 5. The comparision of plain and mountain dwellings as functional structure and spatial relation

	SPATIAL FEATURES	FUNCTIONAL STRUCTURE	SPATIAL RELATION	SPATIAL DEPTH
PLAIN	Form of the rooms are rectangle,symetric and	*Intelligible, (β plain=0.536)	*Strong (Bağl=1019)	*low spatial depth (d=2.112)
	There are lots of functional auxilary space	*Disconnected and sectional (G plain=0.197)	*High integration, movable and intensive spatial usage.(Entg=10.039)	
	Generally has only ground floor. Adobe material			
MOUNT	The form of rooms and courtyard is sectional asymetric and narrow	*Complex and not intelligible (β mount=0.884)	*Weak and disconnected (Con.=858)	*High spatial depth (d=2.254)
	There is little auxilary space	*Compact and connected (G mount=0.23).	*Low integration, reduction of movement and intensiveness (Entg=8.014)	
	Generally has 2 floor Stone and wood material.			

The space organization and functional structure of rural dwellings appear as a result of the influences of geography, social relations and life style in rural areas. This formation gives birth to a structural culture which has been shaped in years. When this structural culture which is differentiated as plain and mountain settlements and the settlement areas of those who migrated from rural areas to cities in city fringes, it is concluded that the geography, social relations and life style changed in time and this change affected the space culture as well.

In the cultural infrastructure which constitutes the rural area culture, the functional structure has not changed with the migration from rural areas to cities, there were some important changes in space uses, the relationships of spaces with each other and space depths. This change was highlighted being supported by space syntax method and graph method as numerical data.

Rural dwellings are the ones which are suitable for natural environment and field structure and which pay attention to all geographical and cultural values with their constructions considering climate data and fed by cultural values. The rural dwellings which are shaped by their own life styles shows a structure which ranges from one region to another and even from one village to another in the same region within the cultural richness of the Anatolian society. The rural dwellings which are a whole with their agricultural activities, social relations, natural architectures, and their houses and attachments are effective in the formation of natural environment and space culture. Therefore, the analysis of rural dwellings which are still trying to protect their special structure in the city fringes; however which are trying to accommodate to the city is of great importance. The important data obtained from these dwellings are that they transferred the traces of cultural identity to urban life in the process of migration from rural areas to cities and they protect their identities without ruining the backbone of the rural dwellings while making the spatial organizations in terms of adaptation to urban order.

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UPDATING A HOSPITAL BUILDING. A TASK FOR INNOVATION DESIGN

JAROSLAW BAKOWSKI[1]

ABSTRACT

Refurbishment of a hospital, especially located in a historical building, is a task that goes far beyond a standard framework of architectural practice. A concept of modularity in the architecture of the late nineteenth and early twentieth century was only just to happen, building system installations and technical equipment appeared as the simplest solutions. Inscribing complex functional solutions into such a space is an interesting design challenge. Besides of classical architectural design problems, there are several factors that should be considered – ongoing changes in functioning of the health-care system, growing social needs and expectations, expanding possibilities of implementation, both in terms of medicine or medical technology and hospital environment.

What is sometimes referred to as an innovation in health-care architecture is under constant change and development. It happens the changes are introduced by leaps and bounds, thanks to breakthroughs in medicine or as a result of constant progress in medical technologies. These changes and their impact on architectural design can be a fascinating subject itself. Construction of a hospital from a scratch, taking into account the possible development of knowledge, is a complex and complicated task. It becomes even more complicated when we deal with a hospital located in a historic building.

Entering a building on a list of heritage or historical objects does not rule out completely the possibility of its expansion, adaptation or modernization for purposes related to health care. The need for functioning health-care facility in the existing place, albeit at the expense of far-reaching changes in its historical fabric, is the supreme value – at least the location in an urban system that's something that cannot be ignored. A hospital complex formed in this way will retain all its existing advantages and will provide adequate space meeting the requirements of modern medicine.

Key words: hospital architecture, innovation hospital, hospital modernization

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1. INTRODUCTION – A SHORT HISTORY OF KWIDZYN HOSPITAL

Figure 1. The earliest known photograph of the hospital building – probably 1900s.
Photo courtesy: dr Justyna Liguz

History of county hospital in Kwidzyn (Pomorskie voivodship, Poland) dates back to the late nineteenth and early twentieth century (then Marienwerder, Westpreußen, Germany). It was built on a suburbia of town as a three-storey, detached building, with fully recognized local building tradition – a massive and ornamental brickwork, dominant sloping and tiled roof, with modest but still strong details.

Unfortunately, with loss of documents relating to hospital's early years during the turmoil of World War II, the very few is known about its founding, functioning, layout and medical profile. The only note describes its location in the southern part of town, just opposite the catholic cemetery (a city park nowadays) and gives the number of available 150 beds in the early 1930s and in 1937 increased to 200 beds.

In the 1930s the county-city hospital had two parts: main building at Rospitzer St. (now Gen. Jozef Haller St.) and a private part (now Jozef Pilsudski St.). The 1937 renovation and expansion merged these two parts of the hospital. Hospital operated on first and second floor of the main building as the two major female and male wards. There was no distinction among medical specialities, besides short-stay patients (so-called "weekend patients"), children and newborns; only infectious diseases were treated in a separate building.

It should be noted that the development of a new wing of the hospital did not take place by simple duplicating the existing spatial solutions – architectural character of newly constructed pavilions was quite different: block size, elevation divisions (and perhaps therefore a functional internal divisions) suggest that it was a modern and contemporary solution, with influences of then European architectural movements. One might even say – it was an innovative hospital modernization.

Figure 2. The 1930s modernization and extension. Photo courtesy: dr Justyna Liguz

The World War II was gracious to the hospital, as there was no damage. At the end of May 1945, the hospital welcomed its first civil patients, and at the end of this year it was renovated. In December, in order to obtain greater financial capacity, it was transformed from the city to the county hospital.
Starting with the 1990s there has been ongoing process of converting an ownership of the hospital (as many in Poland), from public to private one. Innovative for those times, a form of servicing in which the hospital was able to provide efficient and effective management, as well as public access to health-care system. Despite of these assumptions, the common inability to provide fully accessible solutions led to a break-through: the initial idea to build a brand new hospital in a nearby village had been abandoned. So, in 2007, the local authorities decided to upgrade and modernize the existing hospital complex.

2. DESIGN SOLUTIONS

2.1. Initial design assumptions

In 2008 the project team led by professor Andrzej Kohnke proposed a project of hospital modernization and expansion. The basic idea was to prepare the facility to serve the county of 80 thousands inhabitants, to optimize a profile of medical services and provide proper spatial solutions and to adapt the hospital building to current requirements of health-care regulations. While the first assumption requires no comment, the other two need some explanation.

Figure 3. Inner courtyard, contemporary view

When speaking of optimization I mean these tasks:

- Correction of bed wards capacities (after analysis of county disease statistics) – verifying its capacities and planning spaces for more specialized wards.
- Ensuring adequate solutions for advanced medical procedures, i.e. by designing new operating theatre (OT, 1st floor, marked with "F" on Fig. 6), intensive care unit (ICU, 1st floor, marked with "H" on Fig. 6), laboratory (ground floor, marked with "D" on Fig. 5) and delivery (2nd floor, marked with "G" on Fig. 7); these departments have been placed in the new wing of the hospital.
- Improving intra-hospital communication – existing hospital complex consists of several buildings, constructed on different ground levels, with different floor heights thus a simple connection is impossible. To solve this problem there is a central communication hub, with a system of ramps, staircases and lifts, connecting every part of the hospital. The hub, adjacent to inner courtyard, acts as a main vertical axis, guiding people with their flow through the building.

Figure 4. New hospital lay-out as designed, ground floor; key: A – communication, B – technics, magazines, C – pharmacy, D – laboratory, E – emergency department, K – outpatient; green dashed line – first building, red dashed line – 1930s extension, blue dashed line – 1970s and 1980s extension

2.2. Detailed solutions

As mentioned above, the detailed functional programme has been prepared after analysis of the county disease structure, with several recommendations given by the hospital's authorities. The existing functional structure has been preserved – there are five basic bed wards (distinguished because of their medical specialties, including ICU) with a more developed system of specialized nurse units. At now, there are 178 beds in the hospital, compared to 213 beds in the new layout.

Figure 5. New hospital lay-out as designed, 1st floor; key: A – communication, B – magazines, F – operating theatre, H – intensive care unit, I – observation unit, J – administration, L – radiology; green dashed line – first building, red dashed line – 1930s extension, blue dashed line – 1970s and 1980s extension

Thus the structure of hospital bed wards has been set as follows:

- Internal medicine 60-bed ward including cardiology and neurology, organized as 3 nurse units (number of beds has been slightly decreased from 64). Total area of the ward is 972 sq. m.
- Surgical and orthopaedic 58-bed ward, with 2 nurse units and an intensive care and observation unit. There is no change with a capacity of the ward; its area is now 992 sq. m.
- Obstetrics and gynaecological ward with 20-bed obstetrics nurse unit (with a rooming-in system), neonatology 28-bed nurse unit and gynaecology 12-bed

nurse unit. It is the most changed and redesigned ward – the whole its structure has been reorganized; it has been directly connected to enlarged and modified delivery. Total area of the ward is 997 sq. m (excluding the delivery).

- Children 24-bed ward with 2 nurse units with area 545 sq. m.
- Anaesthesiology and intensive care unit 5-bed ward with total area 207 sq. m. Additionally, there is 6-bed observation unit at the existing hospital emergency department.

Diagnostic and procedures departments of the hospital are as follows:

- Out-patient clinic with 10 consulting rooms (for internal, surgical and social medicine, gynaecology, pneumology, oncology) supported by 5 treatment rooms), with total area 360 sq. m.
- Laboratory (excluding bacteriological laboratory, area 180 sq. m), operating theatre (area 406 sq. m), delivery (area 259 sq. m), cardiology diagnostics (area 60 sq. m), endoscopy (area 97 sq. m). Because of the close location to other facilities there is no need for planning a rehabilitation department.

There are no changes in the ED layout, as it has been rebuilt recently, as well as the radiology. Despite of some minor errors in layout of these departments the decision has been adopted, as intra-hospital connections have been sufficient. The ED is directly (vertically) connected to the ICU, which is adjacent to the operating theatre; both have direct access to cardiac diagnostics. In terms of medical procedures it is the optimal solution, as a path of the ED or ICU patient is reduced to minimum.

3. HOSPITAL INNOVATIONS

Innovation, understood as an implementation of the widespread and common use of new solutions and ideas, plays a special role in medicine. Continuous improvement of living standards and consequently improvement of society's health is the very basic task of the modern civil state. Building an efficient and modern (i.e. applying the most advanced science and technology) health-care system requires cooperation of many participants, with a wide range of expertise. Collaboration of physicians, architects, biotechnology engineers, health-care management professionals and many others is crucial when planning network of health-care facilities. Results of such cooperation could be turned into a high quality health-care environment. From this point of view creating a modern hospital can be seen both as an architectural innovation, to build the environment (defined as a medical workplace and patient care environment) absorbing the new solutions and as structural innovation.
One of the conditions for proper planning and design of such a solution is to prepare a spatial frame which ensures the functioning of the health-care building in a long time period, resistant to changes over time. There are several items allowing such flexibility – hospital's internal structure meant as a system of its construction and installation elements, and its open functional lay-out. Obviously, no one can predict developments of medical technologies, nor forms of hospital organizations, but the accepted framework for architectural and functional solutions depends on how far

the building will be ready and open to changes and innovations – it can be assumed that the primary task for innovative hospital design is to determine appropriate functional, spatial and technical solutions.

The article attempts to define the conditions and architectural ways of implementing innovative hospital model. The main considerations are of architectural (functional and compositional solutions) and technical (construction and installation) nature. Although undoubtedly of great importance, urban factors or management of health-care system stay out of the scope of this discussion.

3.1 Construction and installation system

As long as progress in medicine is closely associated with advances in technologies, the ease of their introduction is the essence of innovative solutions in hospitals. This means not there are only financing and management issues, it is also a matter of flexible functional layout based on appropriate construction and installation grid – as the continuous implementation of further elements increases the complexity of the system and so complicated. Adoption of appropriate design solutions is a key element in achieving an efficient hospital building. These elements include:

- Construction and installation module or grid, closely associated with functional layout. The grid can be considered as a basis for the planning of hospital units.
- Distribution of installation systems (water supply, plumbing, ventilation and air-conditioning, medical gases, wiring system, communication, etc.) as a central or a distributed system, through installation shafts, technical floors or combination of both systems.

The adoption of relevant construction modules is the first step in resolving technical issues. Another is the adoption of energy-saving solutions – the larger the building (with functional complexity, extensive technical equipment, huge numbers of users), the greater demand for energy, the greater amount of wastes, etc. Consequently, the greater the demand, the more complex the installation system and more space is required for such distribution. Proper recognition of these issues and the introduction of appropriate technical solution lead to an innovative design.

3.2 Spatial layout of a hospital

The history of the development of hospital architecture gives us a picture of the current and dominant trends in the design of a hospital. It is worth noting there are always innovative solutions, and it is a matter of time when we would verify them. In Western Europe, starting with a monastic hall building, through pavilion hospital to present-day health-care complex, all these were considered then as innovative.

The fundamentals of hospital planning and designing (and most of the building types as a matter of fact) have been already thoroughly discussed and described. As mentioned above, the functional layout set by a construction grid is the basic tool for coordinating function and construction. A multi-span layout dominates at diagnostic or treatment departments, while a two- or three-span layout prevails at bed wards (as often seen in historic hospitals). The first one allows obtaining a functional block with two or more internal corridors, but at the cost of lack of illumination of some of

the rooms. In return, we can be confident that we will properly solve the complex functional dependencies, with the correct connections to other hospital departments, with good zoning and access control – but for the price of readability of the space and dehumanization, establishing an anonymous space, posing difficulties in spatial orientation. The second one works well in a set of small, low complex assemblies or as a basis for single-use department. This system leads to establishing radial layout with separate functional blocks and an extensive inner communication network. Of course, there are a lot of possible combinations; a "tower" is one of them – with an inner corridor system reduced to minimum thanks to use of vertical communication. When there are one or two extensive ground floors with diagnostic and treatment departments, set in a multi-span grid, with a vertical block of hospitalization wards based on a two- or three-span grid, we have got a regular modern hospital building. Of course, this does not mean that these are the only possible solutions and in such configurations. Theoretically, adopted grid can take any form, from the simplest, rectangular, to a grid based on other geometric figures, the completely free form.
Issues related to the design of functional layouts can be grouped in such categories:

- Layouts of bed wards, providing both the isolation and privacy for patients as well as easy access to treatment and diagnostic departments and the correct relationship with the outdoor recreation areas and easy access of visitors.
- Functional optimization of treatment and diagnostic departments, with a special role of implementing new technological solutions.
- System of intra-hospital communication, interior public spaces, green areas and inner courtyards as elements of way-finding.

3.3 Hospital architecture

Issues described in the literature as "innovative" are not the hospital architecture specialities – any action leading to build and implement energy-efficient or pro-ecological facility, using the local tradition, should be regarded as legitimate and worthy of promotion. The problem arises when we ask ourselves the question: what architecture can be regarded as innovative in relation to the exclusive category of health-care facilities? Apart from issues arising from medical technology (which from the facilities' user point of view need not be obvious), these issues can be reduced to the following assumptions:

- Social expectations of high quality hospital architecture and environment: the pursuit of "individualization" of space by creating high standard bed wards with single- or double-bed rooms, the use of human scale in architectural solutions, strong focus on creating space for a "well-being", implementing local and traditional construction solutions.
- Humanization of hospital procedures by creating a friendly space to the patient or by the introduction of green zones, building architecture in contact with water, adequate use of colour, placing the interior decorative elements.
- Ease of orientation by creating a communication axis running through and connecting the hospital public spaces (atriums, courtyards) with the use of natural lighting (skylights, corridors running along the inner courtyards).

Figure 6. Views of the hospital, as designed

The above solutions may lead to the creation of human-scale hospital architecture and environment. The hospital interior, besides its purely medical or technological status, can play a therapeutic value, spatial harmony leads to the humanization of technology and patient well-being.

4. CONCLUSION

The creation of an extensive, comprehensive health-care system requires not only the political, social or organizational will, not only the relevant medical, technical, economical knowledge, it requires above all a huge financial effort. In conditions of economic deficiency or even failure, it is impossible to set up a proper system of complementary elements. One can argue that such a full and available for all system can never arise, in any economic and social conditions. One of the critical factors is the rapid depreciation of a hospital building – its infrastructure, medical equipment, or even medical knowledge. Period of several years, devoted to planning, design and

implementation of a hospital investment means that the primary functional or organizational assumptions may change at the time of hospital opening.
Implementation of innovative solutions should be preceded by determining the strategy of health-care system and defining tasks for each of its elements. Quality and quantity of elements of the system depends on local conditions, especially on access to other health-care facilities (meant as a time factor, it is assumed that access to a county hospital emergency department should take no longer than 15 minutes). In polish conditions, with a system of universal health insurance, the State take on the role of coordinator, managing the development of network of:

- Hospitals with various degree of specialization, with particular emphasis on the role of academic hospitals as centres of highly specialized medical services and county hospitals as primary care, creating thus a network of public hospitals.
- Specialty hospitals as a medium level of medical care, both public and private, intended to serve as regional centres.
- One-day hospitals based on the full diagnosis and therapy, but without any hospitalization department, supported by rehabilitation facility.
- Automated hospitals, designed for innovation in fields of robotics, automation and telemedicine, preferably as university hospitals.
- Mobile hospitals as part of a system of rapid response to mass threats, for example in case of a disaster (based on field military hospitals).

The basic role in the system should play the network of public county and university hospitals; it is the only way to comply with the constitutional provision of universal access to the health-care. Such a network should be the basis and starting point in creating new supporting solutions. Without ensuring that basic infrastructure every effort to build innovative solutions could be seen only as novelties or curiosities, not as a real innovation. Considering all of these issues, the county hospital in Kwidzyn can fulfil its role as a medium size, primary element of the health-care system and to meet this role it requires a thorough expansion of the facility, with a total reorganization of the way it operates.
Objectives achieved in the outlined design solutions can be divided into several categories, according to the previously discussed issues:

- Structural and functional system: The structure of the historic building has been preserved and features that do not require flexibility (susceptibility to transformation) are entered into it without any major changes. This applies mainly to administration and bed wards (with minor adjustments to meet high standards). These functions are indicated in Fig. 4 and 5 with dashed lines. Complete transfer of diagnostic and treatment departments to newly designed wing and connecting their functional system to the construction module allow future flexibility. This applies especially to the laboratory (D on Fig. 4), central sterilization (B on Fig. 4), operating suite (F on Fig. 5) and delivery room (not show, the top floor). Thus solutions for the further development of the hospital have been separated and leaving the historic building with traditional hospitalization wards.

- Intra-hospital communication: Expansion of the hospital by adding more items to the already complicated system may result in the creation of functional arrangement far beyond the scale of human perception. Using a construction and support module as a design module helps to organize hospital layout and to make it possible to obtain a relatively simple functional system. Central communication with a vertical core allows creating of radial corridors system. This solution reduces to minimum access to patient care areas in all hospital departments (marked with A or light-gray colour in Fig. 4 and 5). Despite the extent of the hospital layout all functions related to direct patient services are grouped around this communication core. Additionally, spreading corridors open up to three internal courtyards; in one of them there is left nearly 100-year-old tree. It emphasizes the natural landscape of the courtyard, but also it is a part of orientation.
- Building architecture: Extension of the historical building is always controversial. The basic question always refers to the scale of intervention into the existing fabric of the building; how much new action preserves the original layout or how changes it. In the case of the hospital in Kwidzyn the function as an aim has prevailed. Analyses of the potential ways to achieve this goal without significant interference with the historical building have led to the conclusion that it is a difficult task, if at all feasible. The scale of the original building (Fig. 1) does not fit in the requirements of modern medicine, although it is possible to maintain hospitalization functions. On the other hand in the modern hospital bed wards stay in the minority. It has been therefore decided to refer to the architecture of the inter-war expansion (Fig. 2). Retaining the scale and height of the original building it has led to a result in which historical background for takes its part in a contemporary solution (Fig. 6).

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SESSION 4

16 November 2012 Friday, 09.30-10.30

Topic:Architecture and technology relationship in social and cultural context.

Chairperson: Dr. Emilia van EGMOND

Yasamin CHEGINI, Assoc. Prof. Dr. Uğur Ulas DAĞLI
Effects of Media (Urban) Screen On Built Environment in Public Space

Dr. Ali Kemal ARKUN
Change and Transformation of Cultural Landscape Components: A Case Study of Ulus Historic City Centre, Ankara

Res. Assist. Onurcan ÇAKIR, Assoc. Prof. Dr. Mustafa Emre İLAL
An Investigation of User Attitudes Towards Public Spaces Without Backround Music

Res. Assist. Aslı Çekmiş GÖRGÜLÜ, Res. Assist. İlgi HACIHASANOĞLU
A New Spatial Experience of Art Via Technology

EFFECTS OF MEDIA (URBAN) SCREEN ON BUILT ENVIRONMENT IN PUBLIC SPACE

YASAMIN CHEGINI, UĞUR ULAS DAĞLI [1]

ABSTRACT

Urban screens ask for urban language in new way of designing public space. Media screen is not only a technological challenge, but they change our perception and experience of our daily used architectural environment. The focus of study is on changing citizens' perception of architecture and public space in a digital age by using media screens in the city. The view of local environment was changing with this kind of elements. Urban screens could play an important role in the perception of locality and neighborhoods. By connecting an urban screen to web (internet), the culture of local people might change in to wider view. These kinds of elements can be utilized with cultural content and create the local identity in this global age. However, nowadays urban screens, mostly use in a context of commercial information and a kind of communication medium.

Digital technology bring us many aspects in our life , for example in public space we can see plasma screens exposed in shop, LED screen in squares , information display in billboard about transportation , large scale urban screen for advertisement and media façade on buildings. This kind of exposing information to pedestrian could do with many tools; one of them is used urban screen in public space.

This subject studied, based on the case study (Kyrenia, North Cyprus and Istanbul, Turkey) and support with theoretical approach and the projects about the examining this type of screening in public space that did these before in New York and Tokyo. During the recent years, media have applied more and more from private and semi-public spaces into public city space. This study examines the relevance of urban screens and public space. The wider context including related aspects of users' perception in a public space, and interrogated about media content and effects of these content to citizens mind, relation between advertisement and local culture in public space. Urban screens already combined aspects of lighting and graphics in the built environment, in this study the questions given in the questionnaires are focused on citizens and specific characters' of the locations. These locations have small media surfaces compared to previous media screens and media façades, which are studied in Times Square and Tokyo. The groundwork on Times Square is mainly

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discussing the dialogue between geometrical structures and image, information and ornament and their affects on the changing of the function of the architectural surface.

Key words: Media urban screen, Public space, Advertisement in cityscape, Today citizen's perception

1. INTRODUCTION

The role of media screening in our perception and experience of contemporary urban environment needs to be examined in a matter of public space. In this approach, the gap of research in this area can be clarified better by some questions such as:
Is it possible for citizens to handle all the public messages (like news, commercial, and...) and the contents they are exposed?
Are citizens satisfied and pleased with existed these big screens and advertisements in their environment?
How the public spaces have been potential for that much advertisement and media screens?
In this approach, we should consider the shift in culture in the transition to a media culture in psychological subject as much as its technological matter. Today, use of media screens in public space influence architecture in a way of transforming from form of buildings to perceive these as an image. The research problem and gap of this topic could be expressed in these questions: How, when and in what specific locations in urban landscapes, screens can affect people's perception and experience? In addition, it can be argued which the media screens are gradually starting to dominate the visual cityscapes even more than we would like to admit and see them everywhere. Moreover, how urban culture changes with this sort of media?
A focus point of this study is on changing current citizen's perception of public space by using media screens in the city in contemporary built environments. The research has been restricted to the perception of pedestrian from public space in a matter of screening.
The sentence of "the cityscape – our picture of the city – is rapidly becoming a city of picture."(Kolhonen 2005) Reflects that screen world, in a future might be argue in an approach of visual and technological pollution of urban space.
Future cities might be efficiently covered with advertisements and screen billboards.
The main difference between the traditional perceptions of the city elements is that the city includes the permanent elements like buildings, streets and squares, however at the present time advertisement, urban screen and large-scale posters have a temporary character and cityscape can have a temporary character too.
"The great obsession of nineteen century was, as we know, history: with its themes of development and the suspension of crisis and cycle, with its preponderance of dead man and the menacing glaciations of the world…the present epoch will perhaps be above all the epoch of space. We are in epoch of simultaneity: we are in the epoch of juxtaposition, the epoch of the near and far, image and movement, of the side-by-side, of the dispersed." (Manovich 2006)

This research is based on the examined and observed public space in two case studies. To support the related issues in a theoretical section, define public spaces and architectural discourse with emphasis in media façade projects.
It is possible to divide the main topic in to two main divisions; first one is the technological and the second is the philosophical section.
"Paul Virillio see the new developing "pervasive architecture style" of screens covering high-rise facades as electronic Gothic. He refers to the narrative of Gothic church windows, which were aimed to affect people's moral behavior. Immersion and its effects on the audience will be increased by the "perfect" incorporation of screens in the architecture of the urban landscape." (Struppek 2006)In mentioned research area where the use of electronic images in architecture has been discussed, we can turn to Robert Venturi in his book, "learning from Los Vegas" as well. His approach in this book could be "an electronic display is not optional addition but the very centre of architecture in the information age." (Foucault 1967), the media screen can bring the daily news in outdoor public space. In the metropolis city, most of the citizens do not have enough time to watch the news in the TV. They spend their time in transit and traffic .Urban screens can exhibit the information that we need as daily news like newspapers headline, Weather, air pollution, money exchange rate and advertisement.
In addition, connected screens could serve as an exchange platform between the inhabitants of various cities. "Hole in Space (1980), one of the early projects of this rather connected the people walking past the Lincoln Center for the performing arts in New York City with people in Broadway Department Store in Century City (LA) thought a life-size television image." (Struppek 2006)
This research is divided two main type of data collection. The first is a case study that is carried on in two specific locations: First one is in Turkey, Istanbul, Cevahir Shopping Center and the second is in North Cyprus, Kyrenia, Old Square near the Harbor. I collected information by a questionnaire, focused on pedestrian and local citizens; the study in the first part is base on the answers to the question that arranged in a questionnaire, that almost about the effects and attraction of the urban screen for people and their ideas about the risks of installation this kind of screening in future. By focus on public space, we front too much quality of space according to our situation in space like in driving space in a street or transport space in railway, airports or in shopping center and commercial spaces. By development of technologies, the new kind of space was produced to communicate in digital age.
The second section the (theoretical issues) focused on U.S.A, New York, Times Square and Japan, Tokyo, Shibuya District. This part talks about the universal visual culture in a metropolis city like New York and Tokyo.

2. CASE STUDY

Both two case study were examined according to the how screening can impact on people in public space, but the differences between the Kyrenia urban screen and Istanbul, Cevahir screen façade are: in Kyrenia the screen is located in a corner of square quite away from center of crowed. Nevertheless, in Istanbul the screen façade location is exactly in a center of crowed and near the entrance of the shopping center, and the scale of the screens are different from each other.

2.1. North Cyprus, Kyrenia, Old Square near the Harbor

"Kyrenia (Greek: Κερύνεια, Kerýneia; Turkish: Girne) is a town on the northern coast of Cyprus, noted for its historic harbor and castle. The center node of the town is the old harbor, the harbor is currently use largely for pleasure craft, and the buildings are now mostly all restaurants, with outdoor tables along the water. The harbor is particularly busy during the summer season, which is when it is greeted with mass loads of tourists. The castle at the east end of the old harbor is a very spectacular site and within its walls, there is a twelfth century chapel showing reused late Roman capitals. The main features of the exterior of the castle are the huge round towers built by the Venetians in 1540 ADs." (URL 10) With explanation about the character of the town, it is acceptable to say that Kyrenia is mostly famous for tourist attraction. In the location of the study (old square) most pedestrians is the tourist, but I focus on local people that they work there or come to square for chatting with their friends or to read newspapers. This square mostly used as a public space for local people. I questioned about their occupation and age in both locations of study in Kyrenia and in Istanbul. The age average of people that filled the questionnaires is, around 70% less than 30 Years old and around 30% more than 30. The occupation: such as student, police officer, architect, theatre actor, cooker, taxi driver, banker, Manager and mostly university students. Moreover, people who filled the questionnaires were randomly select. The questionnaires filled on 11 Dec 2008 in Kyrenia. The questionnaire was prepared in English and Turkish. The questionnaires included age, location, occupation and nine questions. Quantity of people who filled the questionnaires here (Kyrenia) were seventeen.

2.2. Turkey, Istanbul, Cevahir Shopping Center

"Istanbul (Turkish: İstanbul; historically, Byzantium and later Constantinople and Stamboul) is the largest city of Turkey and the third largest city in the world. The population of the metropolis more than tripled during the 25 years between 1980 and 2005. Roughly, 70% of all Istanbul population lives in the European section and around 30% in the Asian section. Istanbul is a very famous city due to the historical monuments but nowadays many modern buildings, constructed in Istanbul. One of the most popular shopping centers in Istanbul is Cevahir Mall (2005) which is the largest shopping centre in Europe." (URL 11)In Cevahir shopping center, two different façade views exist. First one in day and the second one at night, I examined the night view of the screen façade.


Figure 1. Cevahir Center (Photo: URL1)
Figure 2. Cevahir Center (Photo: URL 1)

The questionnaires filled on 20 Nov 2008 in Istanbul. In both case study data collection method is the questionnaire and observation. Thirty people answered the questionnaires.


Figure 3. Cevahir Shopping Center (entrance), (Photo: author, 2008)
Figure 4. Kyrenia, Old Square (Photo: author, 2008)

The next step for analyze and comparing the answers in questionnaire is making a bar chart for each question in both locations. For making the bar chart, calculation method is like this: how many people had the positive opinion about this screen? The results are exhibits in percentage. For example, in this question, is this large screen attractive for you? First and second columns show the Kyrenia result, third and fourth columns show the Istanbul result for this question. (Fig.5) Afterwards for evaluation of this bar chart prepare another bar chart (Fig.6) as a comparing two results:

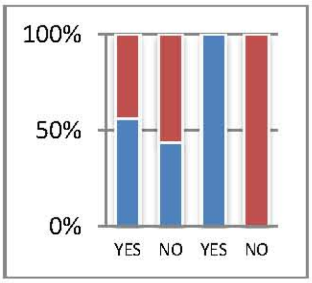

Figure 5.

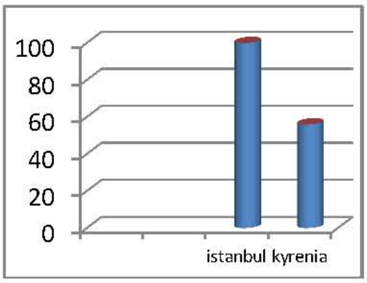

Figure 6.

If we compare the outcomes of Kyrenia and Istanbul about the first question, we can see: 100% in ISTANBUL and 56% in KYRINIA are interested in this media screen.(Fig.6)
In a next question, Does media screen create a new form of architecture or simply apply for aim of Advertisements? (Fig.7) Bar charts indicate around 70% of people conceived that used of urban screen in a city, mostly for advertising purposes in these locations. Nevertheless, in an issue of study in this topic (nature of urban screens), they should be place to usage in a creative way as a modern way of architecture representation. In question: Did you get information from this screen? (Is it useful in built environment in public space?) (Fig.8)
First column displays the percentage of positive answers in Kyrenia and the second one display the positive answers in Istanbul.

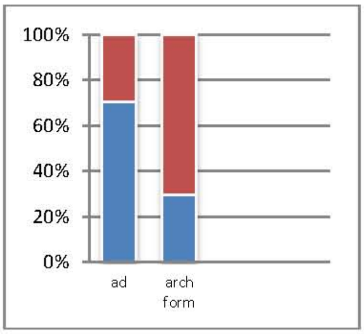

Figure 7.

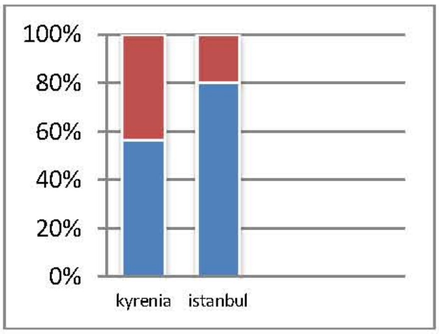

Figure 8.

In this step of research in these locations the questionnaire has got, a little modification according to nature of public space, for example in Kyrinia referred to an old square, Which one do you prefer to see every day? Square with this screen or without the screen. (Fig.9) and In Istanbul, the same question changed for Building common façade or Media Screen façade.(Fig.10)

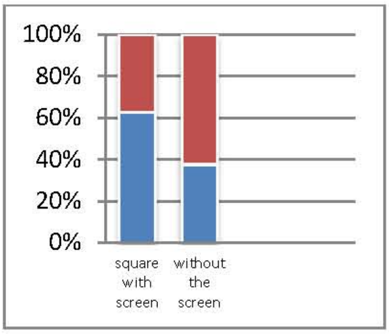

Figure 9.

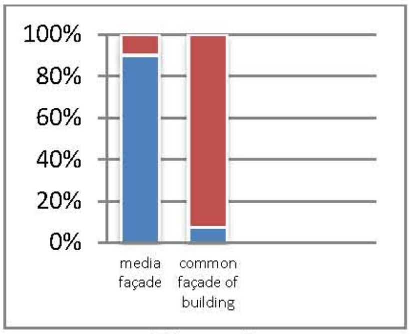

Figure 10.

Then, continued the process up to end of nine questions in the questionnaire form. At the end of this evaluation in all questions, the people in Istanbul are more satisfied with utilize urban screening in the city than people in Kyrenia. In few questions, both results are very close to each other. For example, in a question: Are these advertisement effects on you to buy these brands? In both columns, the positive opinions are around 45% in both locations. (Fig.11) In the chart in Figure 12, the question is about the how media screens can effects on the senses of citizens, or their feelings about modern face of public spaces in city.

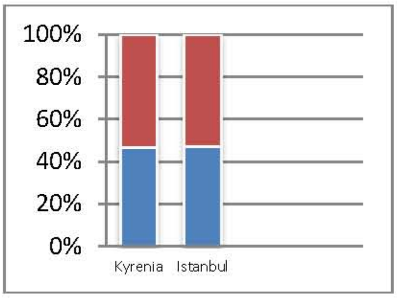

Figure 11.

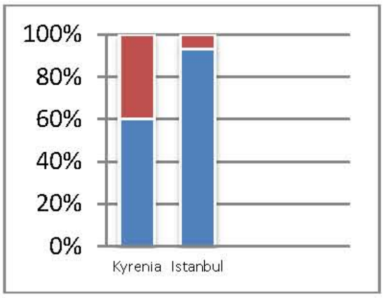

Figure 12.

Has media screen become our modern urban monuments? (Modern symbol in built environment), (Fig.13) The last chart (Fig.14) for evaluation is overall for nine questions in case of agreement of utilize urban screen in public space the chart shows result in Istanbul 92% and in Kyrenia 57%.

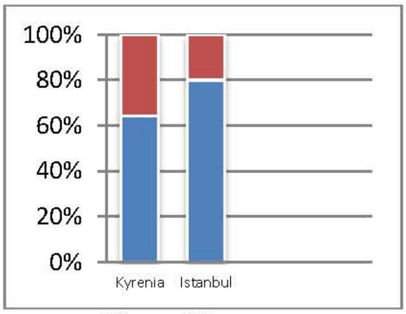

Figure 13.

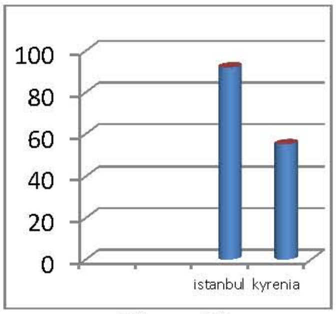

Figure 14.

3. SCREEN WORLD

"Public space is the city's medium for communication with itself, with the new and unknown, with the history and with the contradictions and conflicts that arise from all items. Public space is urban planning's moderator in a city of free players." (Slaatta 2003) "Urban Screens are defined as various kinds of dynamic displays in urban space that are used in consideration of a well balanced, sustainable urban society – screens that support the idea of public space as space for creation and exchange of culture. Their digital and networked nature makes these screening

platforms an experimental visualization zone on the threshold of virtual and urban public space." (Struppek 2006)

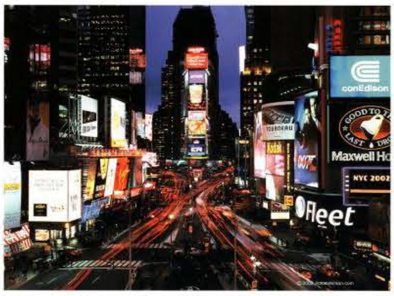

Figure 15. Times Square, New York, view of LED boards (Photo: URL2)
Figure 16. Beijing, China, Three creative LED screen (Photo: URL 3)

Although historically built environments usually covered with decoration, texts and images, the phenomenon of the dynamic multimedia information in these environments is new. "Large-scale screens in urban settings suggest new possibilities and challenges for city authorities and regulators, architects, advertisers and broadcasters as well as for cultural creators and producers. Urban screens establish new sites for the negotiation between commercial, public and cultural interests." (Auerbach 2006) In this approach of combination of architecture and media design, we can say that buildings are turning into becoming media infrastructure.

3.1. Times Square: (New York)

The study for Times Square is not purely in a matter of screening, but it takes in to consideration so many different approaches, Social, technological, cultural and urban context issues. New York City has several generations of urban planning and architecture with Art Nouveau, Gothic Revival, Art deco and at last modernism.

Figure 17. Times Square (1880), (Photo: URL 4)
Figure 18. Times Square, New York (Photo: URL 5)

Nowadays Times Square is looked like the world of electronics urban screens and neon signs. Turn to the book learning from Los Vegas by Venturi, which he argued the dissolve architecture structure in a world of screening and sign, the Times Square is a live symbol of this.

In an urban fabric of Times Square (as a symbol of Americans culture) dynamic and moving images in screens, sense of interruption between past and future, somehow change the sense of this square as a public space in to virtual and fantasy. The character of the space is more related to contemporary consumer culture. Screening, in an urban architecture of Times Square is main feature. "New urban guidelines are to be big, bold, high-tech and imaginative." (Maradia 2002-2003)The architecture of Times Square looks ordinary but the affects of the urban screen, advertisement billboard and commercial messages make a new way of communication. The critical question about Times Square that was opened the door in much research area is, how will the urban subjects receive and experience the new site of postmodern culture and how the architectural elements in a public space used as kinds of messenger of the companies messages.

3.2. Shibuya District:(Tokyo)

City advertisement that uses any kinds of tools for representation in a cityscape is mainly for people on the move. The position of advertisement and screening information in a public space directly related to the movement of the people.

In Japan today, especially in Tokyo, the non- places (the people that always move from one place to another) have become an important setting for this metropolis city. The attraction of urban screen in a correct position shows us that the people in this space have no chance to look away.

Figure 19. Shibuya District (Photo: URL 6)
Figure 20. Tokyo Street (Photo: URL 7)

The design of these screens always incorporated in to the surrounding environment in a way that seems natural for observers.This is an important feature of media facades in Tokyo. Another critical point in this area, in a installing of this media façade is the display and the building should merge, if the designer want to have a natural view of this kind of façade. It is up to creativity of designer and architect to be fined a professional way for this merging process. In Tokyo views of the urban screen, there is another item exist. That one is in Japanes version of the urban screen, utilized of these screens for non-commercial purposes as art, education or entertainment.


Figure 21. Tokyo Sreet (Photo:URL 7)
Figure 22. View of Tokyo (Photo: URL 8)

Furthermore, has a main role to represent Japan in all around the world. They are famous for using technology and high-tech equipment in many fields of their life. New research in a subject of screening in Japan nowadays, is inventing unusual media screens. Extensive use of an urban screen in Japan today, might be related to hold an ancient methodology that they used in Zen as an ancient philosophy. Now in a cityscape with urban screens, they followed this philosophy in a main idea of Matters of Virtuality.

"The virtual phenomena in the sense of potentiality are not opposed to the real space. In addition, differs fundamentally from the concept of the possible. They believe that real (physical) and virtual phenomena are much belonged together. They make physical space into a data space: Then extracting data from it. Converting data to visual is the main point of this approach." (**Demidenko 2007**)

This idea investigated not only effects of media urban screens in a citizen's perception, but play with imagination and fantasy like some examples of these screens in Los Vegas.

4. CONCLUSION

The conclusion here, after evaluating both case studies, is an interpretation of the field study that investigated in this research and supported with the research that did it in advance. According to the number of questions in the questionnaires, that filled by citizens in both Kyrenia and Istanbul, that the results are indicated in the bar charts(Fig. 5,8,10,11) all positive reactions about this type of screening in public space in Istanbul was more than Kyrenia .Furthermore, the character of location that these screens are use in public space also affects their acceptance. When urban screens are located in shopping center or in crowded parts of the city such as city center, the attraction of this urban screening is more than the old and historic parts of the city. Because in historic part or in town and small city (like Kyrenia) people come to public space such as parks or gathering place to rest, read a newspaper or to chat with their friends. There is not more attraction for urban screen in this kind of spaces in a town. More than 95% of people, who filled in the questionnaires in Istanbul, agreed with the use of this modern element in the city. They feel better when they see the development of the public space in the city. (Fig.12)

This kind of screening is beginning of the using new technology and electronically effect s on the built environment or first step of to have a modern city and modern life. In addition, using this kind of new materials or new technology for façade of buildings can be a problem for architects to design a façade in not only a traditional style, but also use new material and new technology for design. In Istanbul as metropolis, the bar chart shows that around 90% of citizens who filled a questionnaire in Cevahir Shopping Center had positive opinion about the screen façade. (Fig.10)

After the data evaluation about Kyrenia, as a small town, even though the location of screen is in the historical part of the town, citizens were pleased with the view of the square. It concludes that the urban large screen did not spoil the sight and sense of historical character of this square.

Figure 23, 24, 25. Kyrenia, Old Square (Photo: author, 2008)

At the end, around 65% of people in Kyrenia and 80% of citizens in Istanbul agreed with the installing these screens in future. (Fig 13)

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CHANGE AND TRANSFORMATION OF CULTURAL LANDSCAPE COMPONENTS: A CASE STUDY OF ULUS HISTORIC CITY CENTER, ANKARA

ALİ KEMAL ARKUN[1]

ABSTRACT

Culture is the factor, nature is the medium and cultural landscape is the result. Researches on cultural landscape is increasing and gaining significance in order to understand, evaluate and protect the values of landscapes. Research, evaluation and protection of cultural landscape features provide values to be transferred to the future. At the same time conservation of cultural landscape areas in urban districts is very important to read and sustain spatial identity.
Ulus Historic City Center (UHCC) which has the most significant cultural landscape features of Ankara, is the main material of this research. The objective of this research is to explore how UHCC is changed from past to present, how it is affected by this change, how it is used today and documenting change and transformation of cultural landscape components within cultural landscape criteria method.
Aesthetic value, identity value, historical and archeological value, social value, artistic value and scientific value are determined cultural landscape criteria for this research. This methodology is used for digital documentation, interpretation and presentation of cultural heritage of UHCC. Cultural landscape components which can be examined in open, semi open and closed spaces (structures related to historic fabric, paths, squares, green spaces and other physical components) and besides social and cultural features of spaces is the content of this research. UHCC's most important five nodes and its vicinities which make significant contributions to its character, are selected. These nodes are historical focal points and contain various cultural landscape components. In this article one node is explained as a case study.
Research included examining all available documentation dating from early settlement of the local area through present day. Historic maps, plans, photographs, pictures and drawings were examined and compared to determine changes and transformations occurred in the landscape throughout different periods of history.

Key words: Cultural landscape, landscape change, Ulus Historic City Center

[1] Dr.

1. INTRODUCTION

Landscapes change because they are the expression of the dynamic interaction between natural and cultural forces in the environment (Antrop 2005). The natural area changed by man can simply defined as cultural landscape. Cultural landscape is the collection of natural, historical and cultural heritage.

Cultural landscape as a term was apparently invented in academia in the earlier 20th century. In 1925, Carl Sauer introduced the term cultural landscape in his essay on the morphology of landscape, believing that a cultural landscape expressed the ways of life in a place. He stated that the cultural landscape is fashioned from a natural landscape by a culture group. Culture is the agent, the natural area is the medium, the cultural landscape is the result (Anonymous 2008).

The relationship between landscape and culture is reciprocal, in the sense that, the landscape not only shapes, but is also shaped by culture. Since 1992 significant interactions between people and the natural environment have been recognized as cultural landscapes by UNESCO.

Today, the concept of cultural landscape become an increasingly important in order to understand and assess the value of landscapes.

This article focuses on methodology of a cultural landscape research. The methodology provides a way to bring the tangible and the intangible qualities of a cultural landscape into focus, to highlight possibilities for understanding change, transformation, significance, history and identity. Ulus district which is the historic city center and cultural landscape area of Ankara is selected as a research area. In this article the methodology is explained with At Pazari Square case study.

2. METHODOLOGY

The research is organized in five sections. Firstly the concept of cultural landscape is introduced. And then, a new cultural landscape criteria approach is developed to determine the change, transformation, and the current status of a cultural landscape area. Thirdly, UHCC which is selected as the research area is examined. UHCC's natural features and socio-cultural features are studied to have an overview about its evolution. Then the planning stages of the research area are examined within the historical development and transformation process. In the fourth section UHCC's most significant five nodes and its vicinities which contribute to create Ankara's character, are selected. Each of these sub areas are examined in terms of the cultural landscape criteria, ideas that shaped them and the forms that identified them. Changes, transformations and the current status of cultural landscape areas are analyzed. The findings are presented in charts by using visual expression tools like paintings, photographs, drawings, engravings, maps, plans, aerial and satellite photographs in chronological order. In the last section findings are evaluated and recommendations are made for planning, protection, treatment and management of cultural landscape of Ankara.As an example of application of methodology, At Pazari Square which is the oldest node of UHCC is examined in this article.

2.1. Cultural Landscape Criteria

The cultural landscape identified in UHCC can be assessed by cultural landscape criteria. For this research new cultural landscape criteria are determined with respect to cultural landscape, cultural heritage and architectural values.

The cultural landscape criteria approach integrates natural and cultural heritage conservation by examining them at a landscape level. This concept emphasizes the landscape scale of history and the connectivity between people, places and heritage items (Anonymous 2008). It recognizes that the current landscape is the product of long-term and complex process.

The criteria methodology is not only for analyzing but also for assessing cultural landscape area. By applying cultural landscape criteria method, the history and integrity of the landscape including any changes to its geographical context, features, materials and use are evaluated.

The criteria methodology is used for digital documentation, interpretation and presentation of cultural heritage of UHCC. The cultural landscape criteria are listed below:

1. Aesthetic Value
2. Identity Value
3. Historical and Archaeological Value
4. Social Value
5. Artistic Value
6. Scientific Value

2.2. Introduction of cultural landscape criteria

1. Aesthetic Value: Aesthetic not only includes the beautiful in art and philosophy of art (philosophy of art is a part of aesthetic) but also includes the beautiful in nature (Anonymous 2005). On the other hand it comprise not only beautiful object, but also the creation and existence of beauty. This value derives primarily from an appreciation of style, beauty and art.

Aesthetic value is related with responses of people to outer environment. Emotions and thoughts evoked by a landscape is generally expressed as "beautiful" or "ugly".

Cultural landscape properties like topographical relationship, vista, appearance, sound, smell, form (similarity, rhythm, scale / volume, rate, direction), texture and light influence aesthetic value.

2. Identity Value: Identity may be defined as the distinctive characteristic belonging to an animate or inanimate asset. Identity is the set of features that help to determine dissimilarity, originality and uniqueness. Every city has an identity. Urban identity is set of characteristics and components that identifies and distinguishes it one from others.

Urban identity occurs as a result of interactions of components and their features. Urban identity formation includes change and transformation process. And also it is formed by the accumulation of overlapping layers of different cultures throughout history. Positions, characteristics, relationships and changes of the urban elements positively or negatively influence the identity value.

Urban identity is composed of a composite view of urban artifacts: landmarks, bridges, monuments, vistas, sacred places and other special features. Urban identity depends on the revival of the culture and the protection of historical values.
Components of a city are usually divided into two main groups, residents and the city's physical environment.
Components that creates the identity value are as follows:

- Terrain - Landform
- Landuse
- Urban fabric
- Silhouettes and image
- Circulation network
- Buildings and monuments
- Soft landscape
- Hard landscape

3. Historical and Archaeological Value: Legends, battles, historical events of recorded history, notable figures can be considered as historical value. Historical value also called archival value or continuing value, shows the importance of a record that justifies its permanent retention. Archaeological remains means physical evidence of human habitation, occupation, use, or activity. Any material remains of past human life or activities which help to understand past societies and the development of the human race create archaeological value. Prehistoric and ancient settlements, single burial mound, the site of a known battle, tools, art products are objects of archaeological value. Past and the human way of life can be understood by examining the archaeological features.
4. Social Value: Social value reflects the common feelings and thoughts of members of a community. Social value is the basis of social rules that depends on moral values, traditions and religious beliefs. It strengthen the unity of society. It can be transferred from generation to generation. Social values are also certain qualities and beliefs that are shared within a specific culture or group of people.
Social values can change over time and vary from one community to another or in same community. In a sense, social values are attitudes and judgments on events, objects, and behaviors that are imposed by a community.
Cultural landscape which is formed by older generations represent the significant portion of cultural heritage. Traditions and customs, religious attitudes and behaviors, ethnicity, traditional crafts and professions, the legal structure, administrative structure, trade and economy, habits, customs, traditions and customs, behaviors, forms of consumption are main components of social value.
5. Artistic Value : Lewis (1979) explained that the cultural landscape is the area of one group of people associated with the daily beliefs and art. According to Ingerson'a (2003), culture and art actions that concentrated in the cities are one of the main factors of urban fabric formation.
Painting, sculpture, drawing, wood carving, stone carving, glassware, stained glass art, mosaic, ceramic art, wallpaper art, metalwork, graphic design, furniture design, industrial design and other categories of decorative arts used in the development of open and closed spaces. In monumental and civil structures, it is possible to observe

the works of art culture. The works of art give form to fundamental beliefs and feelings and they serve as a culture carriers.
6. Scientific Value: Cultural landscape areas have research potential with their natural, historical, cultural, social and economic properties and diversity. This potential provide contributions to landscape architecture, city planning, architecture, history, literature and other science and art branches.

3. RESEARCH AREA

Turkey's capital city, Ankara, historically known as Angora is a very old city with various Hittite, Phrygian, Hellenistic, Roman, Byzantine, and Ottoman archaeological sites. UHCC is the oldest cultural heritage site of Ankara's center.
UHCC's most important five nodes and its vicinities which make a significant contribution to its character are selected (Figure 1). These nodes are historical focal points and contain various cultural landscape components. Both nodes emerged at different periods of time. They have similar and different cultural landscape features. Cultural landscape components which can be examined in open, semi open and closed spaces (structures related to historic pattern, paths, squares, green spaces and other physical components) and besides social and cultural features of spaces are researched. According to formation time these nodes are as follows:
- At Pazari Square and its environs
- Bentderesi and its environs
- Haci Bayram Square and its environs
- Hukumet Square and its environs
- Ulus Square and its environs

In this study, the cultural landscape criteria method is briefly explained with At Pazari Square case study.

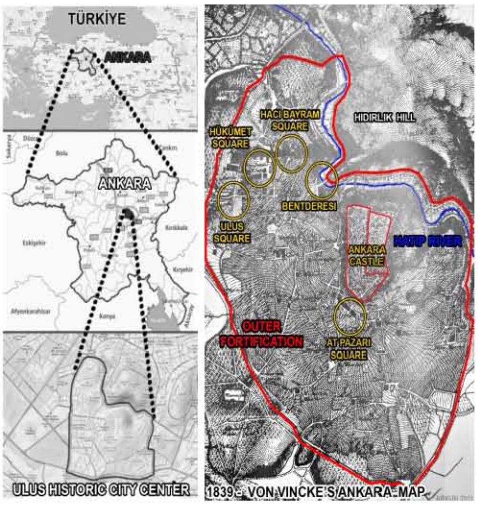


Figure 1. Location of Ankara UHCC (left) and research nodes on Ankara's first map (right)

4. CASE STUDY - AT PAZARI SQUARE

At Pazari Square (Horse Market) is the rectangular plain area in front of the South Gate (Hisar Kapısı) of Ankara Castle. It is outer plaza of the castle and has great cultural significance as it was surrounded by historic structures and landmarks. The south of the square is bordered by Cukurhan, Cengelhan, Pilavoglu Han, old fountain and Koyunpazari Street. In the north, it is bordered by South Gate (Hisar Kapisi), walls of the Ankara Castle, Clock Tower, Kale Kapisi Street, pulses market structure and in the southeast by At Pazari Street. Gozcu Street run from east to west horizontally.

At Pazari Square has the shape of a long and narrow (total area 45,000 m²) rectangle, in west–east direction. The square slopes upward to the castle entrance.

At Pazari Square and its connected four streets are open to motor vehicle traffic. There is no public transportation access to the square.

Ankara was first established on Ankara Castle's hill. The settlement firstly spread to the south of outer citadel, around the At Pazari Square.

The export of cloth made from the hair of the Angora goats turned Ankara into a major stop of the caravan route. At Pazari Square was the major commercial and accommodation center of Ankara during the Selcuks and Ottomans eras. It takes its name from horse market, established in the At Pazari Square in Selcuks eras. Along with the development of trade and craft activities lots of hans were built around the At Pazari Square during 14th and 16th centuries. This primary commercial node was also known as Zone of Hans. Besides market stalls were placed on the east side of the square. The Ottoman economy was adversely affected by the impact of the industrial revolution, and Ankara textiles became less competitive in the face of the challenge from English textiles and goods exported by other European countries. Therefore the market place in and around the square started to lose its significance.

The Zone of Hans was devastated by fires in 1881 and 1917. Many buildings in and around the At Pazari Square were damaged. Some of them were demolished and most of them lost their originality. The market stalls and sheds of the square were removed in 1930's. Ankara has experienced a phenomenal growth since it was made Turkey's capital. As the new capital, it was rapidly developed and spread. Therefore, new commercial centers were emerged and At Pazari Square lost its significance. It fell into decline shortly after the start of the 20th century. Most of the buildings were in need of detailed and intensive renovation.

After Ankara Castle was registered as a First Degree Urban Protected Area some restorations was started around the square. Firstly castle walls, traditional houses of outer castle and clock tower was restored. Çengelhan was transformed into Ankara's first and only industrial museum and opened in 2005. After that in east and south of the square some streets and facades was renewed. Çukurhan was transformed into a hotel and opened in 2010. These restorations attract attention. Today, At Pazari Square is a popular location for tourist attraction and pulses trade.

The cultural landscape criteria methodology used in At Pazari Square is explained with some sample charts to give an overview of the research and its method. In these charts especially identity value is considered. Findings are gathered by comparing and contrasting old and new articles, reports, books, photographs, maps, plan, aerial photographs.

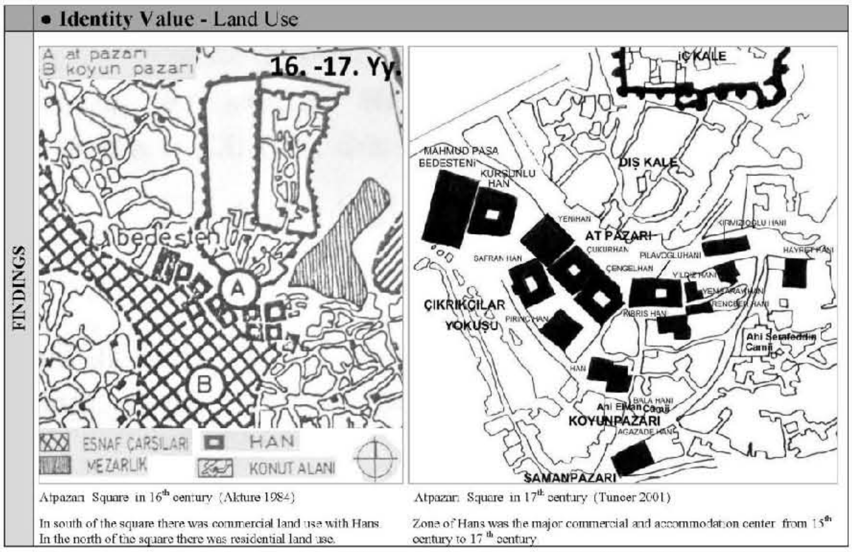


Figure 2. Sample charts of identity value's land use study for At Pazari Square

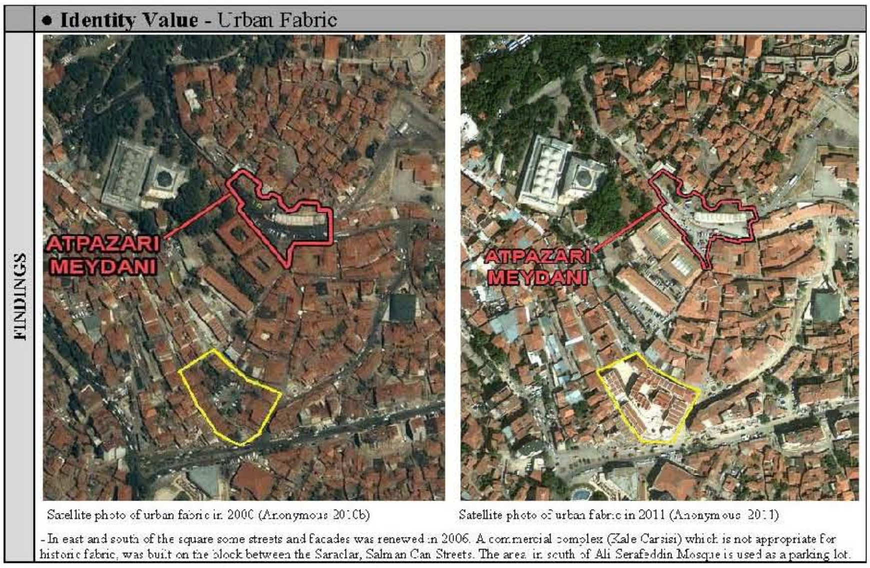
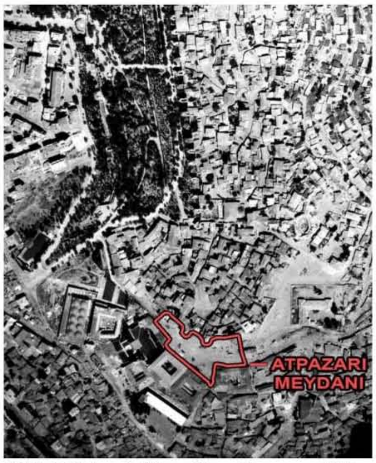


Figure 3. Sample charts of identity value's urban fabric study for At Pazari Square

• Identity Value - Urban Fabric

FINDINGS

1942 Aerial Photograph of Atpazari Square (Anonymous 1942)



1957 Aerial Photograph of Atpazari Square (Anonymous 1957)

- A few buildings in north of Atpazari Street was demolished in 1930s. There were empty blocks on south of the square in 1940s.
- Building density was increased around the square in the 1950s. Squatter fabric was emerged and spreaded in north and east of square. New commercial centers were emerged and At Pazarı Square lost its significance. Historic fabric was deteriorated over time.

Figure 4. Sample charts of identity value's urban fabric study for At Pazari Square

• Identity Value - Buildings and monuments

FINDINGS

- Structures which were built in Byzantine, Seljuk, Ottoman and Republican periods in and around the square are main components of the cultural landscape.

- Hisarkapisi (Castle Gate), Mahmud Pasha Han, Kursunlu Han (Museum of Anatolian Civilizations), Cengelhan, Cukurhan, traditional houses of Ankara Castle are registered structures that created identity of the square.

- The south of the square was surrounded by Hans from 15th century to 19th century. Some Hans were demolished, some of them were renewed and some of them lost their originality.

- Originality of the castle houses is deteriorated by extensions and unconscious repairs. Outer Castle houses have been transformed into cafes, restaurants and souvenir shops.

- Pulses District Market Structure which was placed in front of the castle wall on east of the square has negative impact on historic identity.

- Ankara Castle was an exclusive district with its precious houses. But it lost this significant feature.

Components affecting Atpazari Square's cultural landscape value:

1. (?) - Hisarkapisi (Ankara Castel South Gate) ✓
2. 1464 - Mahmud Pasha Han ✓ } 1968 - Museum of Anatolian Civilizations ✓
3. 15th c. (?) - Kursunlu Han ✓ }
4. 1522 - Cengelhan (2005 - Rahmi M. Koc Museum) ✓
5. 16th - 17th c. (?) - Cukurhan (2010 - Divan Cukurhan Hotel) ✓
6. 16th - 17th c. (?) - Pilavoglu Han ✓
7. 16th - 17th c. (?) - Zafranhan (Safran Han) ✓
8. 17th c. (?) - Kibris Han ✓
9. 17th - 18th c. (?) - Pirinc Han ×
10. 19th c.(?) - Yildiz Han ✓
11. 19th c. (?) - Yenisaray Han ✓
12. 19th c. (?) - Kirmizioglu Han ×
13. 19th c. (?) - Bala Han ✓
14. 19th c. (?) - Rencber Han ✓
15. (?) - (Name unknown) Han ×
16. Traditional houses ✓
17. 1885 - Clock Tower ✓
18. 1990s - Pulses market structure ✓
19. 1990s - Castle Taxi Stop ✓
20. (?) - Private Archaeology Collection Museum ✓

Legend: ✓ Existing structure × Missing structure

Figure 5. Sample charts of identity value's circulation network study for At Pazari Square

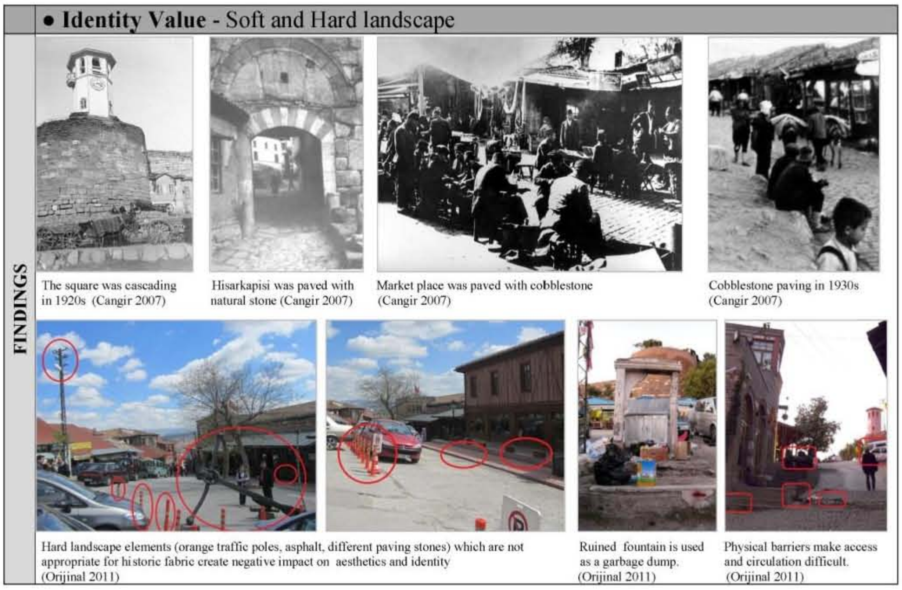


Figure 6. Sample charts of identity value's building and monuments study for At Pazari Square

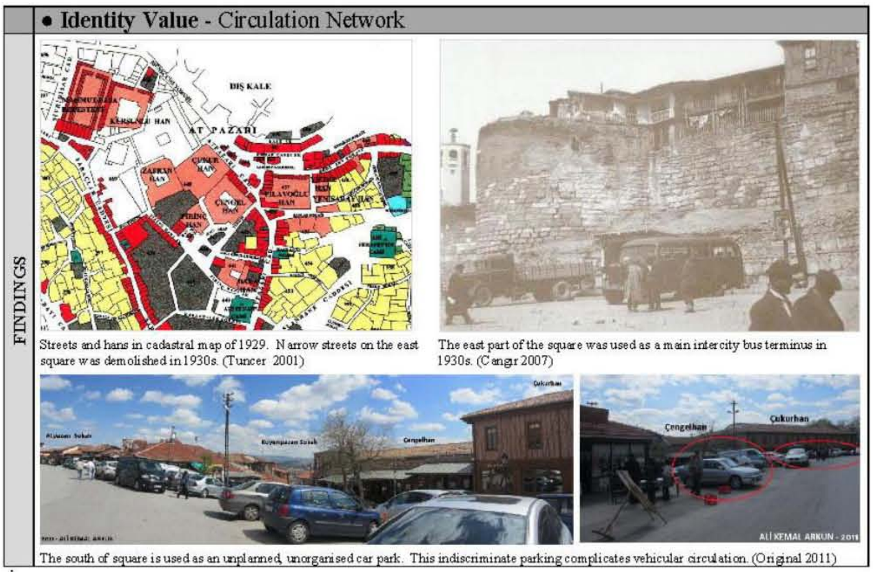


Figure 7. Sample charts of identity value's soft and hard landscape study for At Pazari Square

5. CONCLUSION

The results of the research, which was based on cultural landscape criteria indicated that At Pazari Square's historic fabric and character have become damaged and deteriorated over time. Restorations of Castle, Clock Tower, Cukurhan, Cengelhan, and some traditional houses started to revive heritage value. But it still has lots of structural problems. The oldest square of Ankara need to be designed and managed with in the cultural landscape criteria framework.

The cultural landscapes criteria method can be used to evaluate cultural the change and transformation of landscape's abstract and concrete components and to guide authorities for the protection and management of cultural landscapes.

This method is convenient to find out and clarify the continuities, transformations and changes in detail. The method enables to read and decipher the aimed physical components of the urban whole with minimum hesitation and mistake within the context of the used visual material.

Adding a cultural landscape perspective to planning and design is consistent with the integrated management approach to environmental planning favored by other agencies with land-use responsibilities.

Public's awareness and understanding of the importance and irreplaceable legacy of its cultural landscapes should be broaden. Cultural landscapes are priceless assets not only for one country, but also for the world.

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AN INVESTIGATION OF USER ATTITUDES TOWARDS PUBLIC SPACES WITHOUT BACKGROUND MUSIC

ONURCAN ÇAKIR[1]
MUSTAFA EMRE İLAL[2]

ABSTRACT

In the business world, customer satisfaction is a key factor for success. Naturally, all businesses aim to provide as much as possible for their customers. They analyze and try to meet all their needs. Designs for commercial spaces are especially well thought out. Marketing professionals are keen on observing consumer behavior and laying out design principles to increase spending. Background music is one aspect of commercial spaces such as department stores, supermarkets and shopping centers that has been studied for such purposes. The general acceptance that music is pleasing and everyone would like some music to accompany them, has led businesses to focus on choosing the right type of music and determining optimum sound levels without considering an option where music is absent.

Over the last half century, first, the boom in the recording industry and later, the digital revolution has made powerful equipment affordable and music itself accessible. As a result, background music has become almost ubiquitous in the public realm. However, more and more, music is being perceived as disturbing noise. The high levels of sound or the inappropriate choice of music, or both, are seen as the cause of most disturbances. Yet, the use of background music itself is not being questioned. As no community has a common music taste, in public spaces we need to share, elimination of background music should be given more consideration. This paper presents a summary of the literature focusing on background music in commercial settings and reports preliminary results from a questionnaire study for customer preferences with regard to background music in public spaces - cafes and restaurants in particular. The survey dwells on perceptions, expectations and preferences of customers in spaces with and without background music in order to determine if spaces without music are preferred over spaces with music.

Keywords: Background Music, Muzak, Music and Noise

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1. INTRODUCTION

The earliest known sound recording which is done with a phonautograph device was made in 1857 by Édouard-Léon Scott de Martinville (Rosen, 2008). Playback capability arrived with Thomas Edison's phonograph in 1877 and the recording and distribution of music quickly turned into a global industry (Edison, 1878). Recorded background music was a new invention for the early 1900s and was very effective in attracting customers and background music in cafes, department stores and restaurants became common. Over the years, many researchers have analyzed its effects on sales and human behavior in commercial settings and tried to define the appropriate type of music and sound levels in order to improve customer satisfaction. The basic assumption has always been that music is desired by everyone. Especially over the last decade as the digital revolution greatly increased accessibility to an ever increasing variety of music; technological advances in electronics have made powerful sound systems affordable. These two factors have led to an explosion of music in public spaces and as a result, our cities have become inundated with background music. It is difficult to find dining or shopping spaces without background music. In many public spaces competing loud music from neighboring stores creates disturbing noise far from being desirable. Today, "places without background music" are suddenly attracting attention. The assessment of this emerging situation where elimination of background music should be considered is clearly necessary in order to have a built environment that is shared and enjoyed by all. This paper presents the results of a preliminary survey about background music in dining places and the 'no music' case. The survey has been conducted in six cafes/restaurants. Three of them are places without music and three of them are places that play background music.

2. BACKGROUND

Acoustic comfort is one of the most important factors in occupant satisfaction, as noise comes in first place among discomfort reasons for inhabitants (Kuerer, 1997). Noise is defined as unwanted or disturbing sound. It is clear that sound does not necessarily have to be loud in order to be described as noise. A sound that is perceived as music by some people can be defined as noise by others (Ersoy & Görgülü, 2008).

There are no established universal borders between music and noise. Even in a society where people have many common traditions, the dividing line cannot be drawn, because everyone's perception of music and noise changes in time according to psychological and physiological factors. Due to this fact, music has no single, common definition which is agreed globally (Nattiez, 1990).

Previous research on background music and its effects on sales and human perception, found no significant positive or negative results. Background music can have positive, or negative effects on human behavior and perception, as well no effects at all (Kampfe, Sedlmeier, & Renkewitz, 2011).

During an ordinary day, people are forced to listen to background music in shops, cafes, restaurants, banks, waiting areas, shopping malls, transportation vehicles and many other places. In all these places, music is chosen by business keepers, and not by the users. Due to this imposition, numerous people opt to use portable music players and headphones which they carry with them (Rohrmann, 2003).
Performance on cognitive tasks are found to be reduced in the presence of background sound (music and noise) compared to silence (Cassidy & MacDonald, 2007). People have to face the negative effects of background music especially when they don't have control over the music and are forced to listen to music which they dislike. Although leaving places where unwanted music is played is an obvious solution, unwanted music has detrimental effects on people when it is not possible for them to walk away (Hallam, 2012).

3. OBJECTIVES

The relationship between the kind of music that is played and economic factors like productivity or sales are still being studied by researchers (Gordon, 1990; Guéguen & Jacob, 2010; Wilson, 2003). However, these studies consider the *absence of music* only as a control condition. One of the main goals of this study is to discover if the absence of music is a desired condition that can be an alternative to all the various types of music that are being studied in shops, cafes, dining places and public places.
Popular media and former scientific research on the use of background music established a general understanding of the effects of background music that is based on the following four assumptions:

1. Appropriate background music attracts more customers, encourages them to spend more time on premises and stimulates spending.
2. Background music in dining places enhances acoustic privacy by masking conversations in neighboring tables, and thus allows customers to engage in conversations more comfortably.
3. The genre of music that is being played is an important factor when people are making decisions on where to go.
4. Decisions on background music should be made by company executives according to the firm's sales strategies.

The correctness of these assumptions is what needs to be tested. After all it is clear that background music can be irritating for those who don't like a certain type of music or who don't want to listen to music at a given instance due to psychological reasons. Within this context, this preliminary study also aims to find evidence supporting the following:

1. A significant number of customers seek places with no background music.
2. People can hold conversations in places without background music at least as comfortably as in places with music, if not more.

3. When people are making decisions choosing a place where they will spend a certain amount of time such as cafes and restaurants; quality of service/goods and price range play more important roles than the genre of music being played.
4. Customers' lack of control over the music that is being played is a source of discomfort for them.

4. SURVEY STUDY

4.1. Location and site selection

The survey was conducted in the Beyoğlu district of İstanbul. Six dining facilities have been chosen on the İstiklal Avenue and its near surroundings. Aslı Cafe, Dilek Pastanesi, and Özsüt are three café & restaurant establishments that were selected as places that play background music. Helvetia, Saray Muhallebicisi and İnci Pastanesi are three café & restaurant establishments where there is no background music. The locations of these establishments are shown in Figure 1. The three places with music are all franchises and have established background music policies. The three places without background music have no music or television sounds inside the establishment.

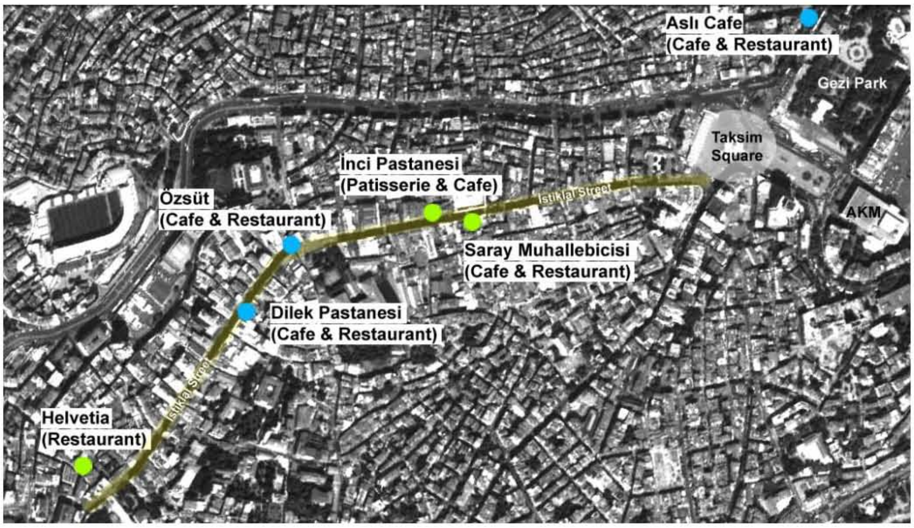

Figure 1. Map showing three 'with music' and three 'no music' survey places.

A total of 118 questionnaires, 40 from cafes with background music and 78 from cafes without background music, have been collected from customers selected at random. The questionnaire consists of two groups of questions. The questions in the first group are general questions that apply to all respondents. The questions in the second group depend on the existence of music in the space.

4.2. Results

The results of the first group of questions reveal that 50% of our respondents were women. Respondents were between the ages of 13 and 55 with an average of 28. 98% of respondents were either university graduates or students at a university.

Respondents' past experiences with disturbing background music

In the past, 68% of the participants were interrupted by background music in a cafe or restaurant while they were speaking with their friends. 65% of the participants had to ask the staff to lower the sound or to turn the music off because the music was disturbing. 53% of respondents had to leave a place or have decided not to go into a place because of disturbing background music. The observed decrease in the percentage of respondents, seen in Figure 2, is expected as the level of disturbance increases from simply interrupting conversations to causing customer complaints to forcing customers to leave. However, it should be noted that the figure of 53% for respondents who have either avoided or left places due to disturbing background music only underlines the fact that disturbing background music has become very common.

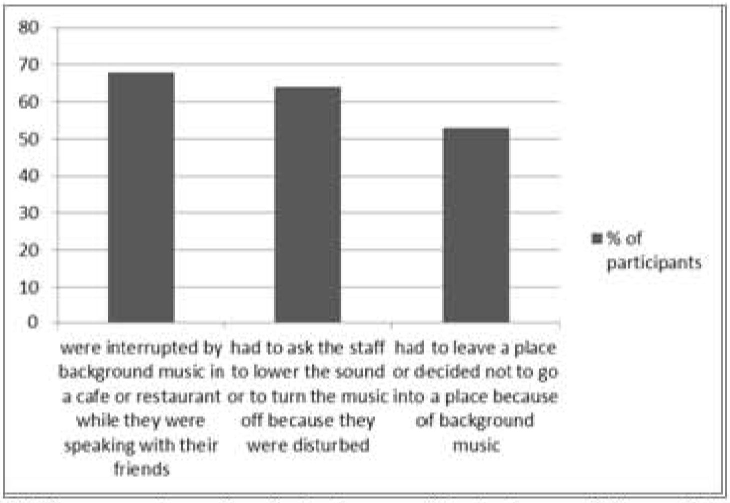

Figure 2. The percentage of participants according to stages of discomfort caused by background music.

Respondents' ability to voice their preferences

It is natural to assume that people would wish to control the music that is being played, but surprisingly only 44% of respondents declared that it is uncomforting when they cannot choose the music that plays at places they go to. Yet, we should not forget that in public places many of us are content with letting someone else choose and this might account for the 66% who are happy to have no say in the choice of music.

It is also assumed that people can complain when background music is disturbing to them. However, 76% of respondents felt they were forced to listen to background music which they dislike in public places they go to. This rather high value hints at the fact that in most public places it is impossible to communicate such preferences. Furthermore, even when we have the communication channels in place, there are many who would choose to stay quiet and avoid conflicts. 16% of respondents stated that they would hesitate to complain about disturbing music. Although 16% seems like a small percentage, this value represents a significant number of people who need to be considered when making assumptions about what customers/people want. When they have no control over the music, almost half of the respondents, 45%, prefer to turn off the music completely but this option is rarely considered.

Respondents and speech privacy

92% of people in the places without music and 98% of people in places with music; a total of 95% of the surveyed people could talk to their friends easily and comfortably inside the place.

Respondents' choice of locale and music

Without considering the background music or lack of it, when asked to mark the reasons for choosing a cafe, respondents mention the quality of food/drinks the most. The following vote counts have been recorded for each of the reasons mentioned: Food quality (87), Location (46), Price (38), Architectural and interior design (22), View (21), Friend's recommendation (11), Arrived with a group (8).

At locales with background music, respondents were asked to mark, on a 5-point Likert scale (from "No influence" to "Most important factor"), how much of an influence the existence of background music had on their decision to choose the café. Most did not believe it had a significant influence. The average vote was 2.3.

At locales with no music, respondents were asked to mark, on the same 5-point Likert scale, how much of an importance the lack of music had on their decision to come to the café. The result was even lower. The average was 1.9.

Respondents were also asked if their decisions would be affected in case the establishment reversed its policy on the use of background music. 75% of respondents at locales with background music stated that their decision would remain unchanged if music was eliminated. However, only 50% of respondents at locales with no music stated that introduction of music will not affect their decision.

Respondents and control of music

Given the option of controlling the music in the cafe, 47% of respondents in locales without background music chose to keep the music off. 53% of participants, on the other hand, wanted music to be turned on. Their preferences for music genres were widely varying. The most preferred genres were classical music, pop, and Turkish classical music.

Presented with the same option, in cafes with background music, 83% of respondents did not want to turn off the music. However, 50% of the respondents who didn't want to turn off music did want to change the genre of music. The most desired genres of music were rock, Turkish classical music, classical music, pop and hip-hop. Overall 57% of the respondents were displeased with the music.

4.3 Limitations

One limitation of this questionnaire survey study is in its representativeness. The survey has only been conducted in a small number of cafes all located in a single neighborhood. Another limitation lies in the fact that the survey was conducted only during the day. Yet, expectations and many variables with regard to built environment such as noise levels differ during night time. The major limitation of the sample is the fact that, while establishments that do not use background music are hard to find, the current sample includes an equal number of cafes that play no music. The rationale behind this biased sampling strategy for this preliminary stage of the study was to be able focus on the various differences in motivations and attitudes of the clientele that frequent the "musicless" establishments in order to increase the forecasting potential. Future work needs to expand the study with a more representative sample.

5. CONCLUSION

The results of this preliminary survey lead the study to *redefine* the emerging situation without background music.

The first assumption that, "Appropriate background music attracts more customers, encourages them to spend more time on premises and stimulates spending" seems to be contradicted by the results where 53% of participants declared that in the past, they had to leave a place or decided not to go into a place due to background music. Another contradictory result is that half of the respondents in cafes without music claim they would go elsewhere if background music started playing.

The second assumption that, "Background music in dining places enhances acoustic privacy by masking conversations in neighboring tables, and thus allows customers to engage in conversations more comfortably." is refuted with the survey result that 68% of the participants were interrupted by background music in a cafe or restaurant while they were speaking with their friends. Also, 92% of people in the places without music and 98% of people in places with music; a total of 94% of the surveyed people could talk with their friends easily and comfortably. Both in places with and without music occupants are equally comfortable in carrying out conversations.

The third assumption that, "The genre of music that is being played is an important factor when people are making decisions on where to go." likewise seems to contradict with the current survey results. In cafes with music, respondents' average 5-point Likert scale rating for the influence of the existence of music on their decision to choose the cafe was 2.3. Furthermore, in places with background music, 75% of respondents stated that their decision to choose the café would not have been affected (would remain unchanged), if there was no music in the cafe, suggests that the assumption was wrong. However, the survey was inadequate in determining clear importance factors for this decision making process.

The fourth assumption that "Decisions on background music should be made by company executives according to the firm's sales strategies." is again contradicting this study's results. 76% of respondents feel they are forced to listen to background music which they dislike in public places they go to; and 45% of respondents would like music to be turned off rather than listening to music which they are not able to control.

The results of this preliminary survey provide promising results towards challenging the established assumptions mentioned above hinting at the evolving soundscape in the urban fabric. Yet, the study only provides limited evidence to support the four hypotheses mentioned in the objectives. In places with no music, 50% of respondents wish to leave the locale if background music is introduced implying half the customers are there because the lack of music is an important factor in their decision making. However, the results are contradictory when this question is asked directly to the respondents. They do not believe the lack of music has a strong influence on their decision. This can be explained by a misstatement of the question and needs further study. The results do show that conversations are almost equally comfortable under both settings although the places with music seem to have a slight edge. The results identify quality of food, location, and price as the most important factors influencing the decision on choosing a café but are inadequate to make a comparison with the existence of background music. A separate survey will be required to study this relationship. Finally, results show that in places with background music, 17% would choose to turn the music off and half of the rest (41%) would choose to change the genre of music. This implies that 58% of customers are displeased with the background music.

Even this preliminary survey has shown that the modus operandi in many public places with regard to background music requires careful reconsideration. More studies are certainly needed in order to establish an in depth understanding of acoustic comfort parameters in public spaces.

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A NEW SPATIAL EXPERIENCE OF ART VIA TECHNOLOGY

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İLGİ HACIHASANOĞLU[1]

ABSTRACT

Art and technology are (must be) mutually exclusive according to the conventional approach, as they refer to distinct realms. However, these two fields have a great interaction, and this interaction occurs not only in the creation of an art object but also during its display. Museums and galleries increasingly deploy computer-based interpretation devices such as tour/personal guides, or suggest applications for smartphones and tablets. Such kinds of digital technology provide relevant information for visitors and allow for a better engagement with the art object. Furthermore, creators seek to provide novel experiences by using new technologies in exhibitions. This is not something like simple setups or demonstrations; technology here refers to a creative usage as an exhibition method for fine arts. Exhibition spaces, on the other hand, have an essential role in the presentation of art objects, and in the implementation of new technologies. Architectural space is reinterpreted by technology to create new experiences for visitors. The objective of this paper is to present the effects of technology on exhibitions and especially on exhibition spaces in today's digital age. It is proposed that this new technological insertion will make space the exhibition object itself; and this spatialized art will depend on a collaboration of technology and architecture. This concept is highlighted in the exhibition; "Van Gogh Alive – The Experience," which utilizes unique systems combining still images, motion graphics and surround sound together in a space. This new and different expression of art is also evaluated in comparison with the original exhibition in the Van Gogh Museum.

Key words: museums, exhibition spaces, new technologies, experiential design, Van Gogh Alive

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1. INTRODUCTION

Museums and exhibition spaces as one of the oldest typologies have an essential influence on the cultural and social structure of communities. Throughout the years, the ways of creating art have changed, along with the ways they have been presented. However, the concept and function of museums have dramatically evolved with developments in science and technology. New media and digital technologies have been rapidly applied to museums with the purpose of enabling visitors to engage better with the artwork. Digital computing and communication technologies, wireless Web, mobile operating systems and more have transformed people's everyday experiences, and consequently their expectation of museums in terms of gaining and sharing information. Technology has had a two sided effect on artistic disciplines; as art forms that exist at the hand of technology and that are enhanced by technology. In short, the deep impact of technology on the production and presentation of art have created a shift in museum and exhibition practice and theory. Innovative use of technology has provided interactive experiences for visitors. Museums are no longer conceived as spaces where artefacts are kept and displayed, but sites for experiences (Hein, 2000). Increasingly, museum professionals including curators, architects and administrators are searching for ways that include more pervasive uses of innovative technologies to promote the curiosity, imagination, and creativity of visitors.
Within the scope of this paper, what museums are in modern society is explained and the spaces in which art is displayed are discussed in terms of architectural design. However, the main goals of the study are to explore the new technologies used in museums as a means of enhancing visitor experience, and to emphasize the positive relation between exhibition spaces and technology. Literature review is used as methodology. A spatially based experience is cited as an example to broaden the concept. Comparative analysis is conducted for this case study by noting the main features of the traditional presentation and contemporary interpretation of the same exhibition. The significance of this article lies in handling both on-line and on-site use of technology, and in underlining the potential of space to provide new experiences when art and technology are coupled together.

2. EXHIBITIONS AND THEIR SPACES

A museum today is a place where collections are kept and displayed, and where people can learn, study, share and connect, also be entertained, and have bodily involved experiences instead of be passive spectators. The notion of the 'museum' as a cultural organization and a public asset first appeared in the 17th century by scraping away its primary objective of the safekeeping of artefacts towards an educational and management organization (Tallis and Mytilinaiou, 2008). International Council of Museums; ICOM (2010) defines museum as "a non-profit, permanent institution in the service of society and its development, open to the public, which acquires, conserves, researches, communicates and exhibits the tangible and intangible heritage of humanity and its environment for the purposes of education, study and enjoyment." This definition states the role of exhibitions in teaching and entertaining. *Education* through museum exhibitions has always been an important topic. Designers have employed new approaches to reach more diverse audiences by embracing all parts of society – all ages, gender, ethnicities, people of differing skills and backgrounds. *Enjoyment* is seen as an influential way to make people engage with the exhibition, which also makes it easy to learn and understand in a more relaxed environment. Moreover, other types of exhibitions independent from the usual structure of a museum such as temporary exhibits and expos have the same identity in terms of stimulating education and enjoyment.

Exhibition space is only one of the various functions a museum could house, along with storage, offices, a library, a café, shops etc. However, the most important part of a museum is being a junction for art objects and visitors. Designing an exhibition is a work of visual and spatial arrangement; a fiction targeting the visitor, and Dean (1996) lists the elements of a design as follows; value, colour, texture, balance, line and shape. Today, exhibition space is redefined as a site of experimentation. Hence, design of an exhibition space is changing according to the impression that curator or architect intends to give. Space becomes an inextricable part of the artwork. Özden (2011) discusses that since the gallery space is devoted to function as a place for display, it is primarily a site for artistic installations. And there are many galleries either wholly or partly devoted to installation art. It is clear that the architectural space and the artwork turn into a "unified display." This active role of the space mainly depends on two antecedent theories; (1) "Gesamtkunstwerk" (total work of art) appeared in Art Nouveau as a way of unifying building and decoration in an overall composition, and later used in Bauhaus, (2) "Einheitskunstwerk" (unified art work) used by Gutschow (2006) as an emergence of a single art form differently from Gesamtkunstwerk which is a fusion of interrelated discrete arts.

3. NEW TECHNOLOGIES

Exhibition design for galleries and museums has been impacted by technology with respect to the digital and information age. The Horizon Report: 2010 Museum Edition (Johnson, L. et al., 2010), which is focusing on museum education and interpretation, has called attention to six most important emerging technologies affecting exhibitions. These are mobile technologies, social media, augmented reality applications, location-based-services (such as geotagging and geocaching), gesture-based computing (as started with Nintendo Wii and the Apple iPhone), and the semantic web.

Today's digital media technologies alter the way of display and representation in museums, and as a consequence the perception and understanding of the visitors. Those new technologies redefine the meaning of exhibition as we once knew. Stogner (2009) classifies the technologies according to what we might do with them. *1. "To be entertained."* That is an immersive, interactive and experiential way of engaging visitors with the exhibition by using high definition videos, animation, music, sound effects, sets and lighting, 3-D movies, 3-D interactive, 4-D sensoramas, holographic imagery, simulations, gaming and more. *2. "To do it now."*

That refers to instant access, on-demand information and streamed media, which means visitors could have multimedia tours using mobile phones, PDAs, barcodes, and GPS locators. *3. "To do it everywhere."* That extends the visitors' experiences out of the museum building via on-line exhibitions and educational modules, or social networks such as MySpace and Facebook, or virtual experiences on Second Life, or cyber-exhibitions. *4. "To do it my way."* That is about personalizing and individualizing using devices enable visitors to bookmark or tag. It is highly convenient for personal relevance and interest. *5. "To share with others."* That comprises social tagging, participatory and crowdsourcing. *6. "To create something."* That is supported by a variety of software make it possible for visitors to create artworks and artefacts. In a nutshell, we are in an era of technology; not a point of whether we would use them, but how more efficiently we could use them.

Technology redefines the limits of space for museums. Virtual reality (VR) and augmented reality (AR) technologies are important with regards to their reinterpretation of exhibition space. Virtual museums are constructed by using World Wide Web and HTML technology. Paquet et.al. (2001) categorize the virtual reality-based museums under three fields; 1. Using panoramic images and QuickTime VR to view them, 2. Browsing still views of museum rooms and clicking on objects to view 2D still images and detailed text information, 3. (Exists in prototype phase) Using 3D representation of the architecture of the museum and add to it 3D objects created from scanned data. It is intended that visitors feel as if they are actually visiting the museum via a truly immersive 3D experience. With a more advanced system, museum patrons could have a virtual space tailored to their visit through a meta-search on the collection, and when other patrons are online, they could have real-time interactions (Jones and Christal, 2002). Programming artificial intelligence that takes visitors on a tour of an exhibit is also possible. In general, virtual museums are spaces where virtualised artefacts are stored and displayed. Besides the experience depending on a type like Second Life, the real value and benefit of virtual museums is that they could present fragile, very precious artefacts or destroyed heritage environments. On the other hand, augmented reality is used in exhibition spaces to enrich the reality and to interact in real time. Nowadays, a smartphone is an option to perceive AR artefacts. Augmented exhibitions aim to show location based AR artworks in the empty museum space, using smartphones with AR viewer applications. Bimber and Raskar (2005) highlight that AR is becoming an emerging edutainment platform for museums. And they tell that novel approaches have taken AR beyond traditional eye-worn or hand-held displays; by exploiting large spatially-aligned optical elements such as mirror beam combiners, transparent screens, or holograms, as well as video projectors.

A museum is regarded not only as a place for information gathering but it is a place for sharing a social fact. Galani and Chalmers (2004) draw attention to *the social aspect of pace* in museums, as being in the relative proximity of each other or at least in visual contact with their companions. Visitors are there to learn or to be entertained, whilst they have an implicit sense of presence. The 'art' presented in a space and the 'experience' given is not comprised of only a collection of objects, but a collection of people at a certain time. People walk around, stand, sit down, view objects, talk, catch phrases of other's conversations, express their feelings or witness others'. They shape the exhibition space and the unique experience as active participants. It is possible to say that the museum experience is a group activity deliberately or not. From this point of view, Boehner et al. (2005) investigates "ambient systems" to measure affective presence in museums. They have usage patterns and physical location paths collected through use of wireless guides, and activity values measured through a combination of motion and sound sensors. And by a visualisation of information, they obtain visitors' paths, visitor traffic over time and emotional climate maps (Figure 1). By doing so, authors aim to reveal the crucial role of the visitors in a museum activity, and to show their ability to impact on the space of the museum and to influence the overall experience. It is possible to interpret why one area of the exhibition space remains undiscovered, or in what people are most interested. This analysis may also serve as a tool for curators to alter exhibits by obtaining information about popularity, traffic flow and more.

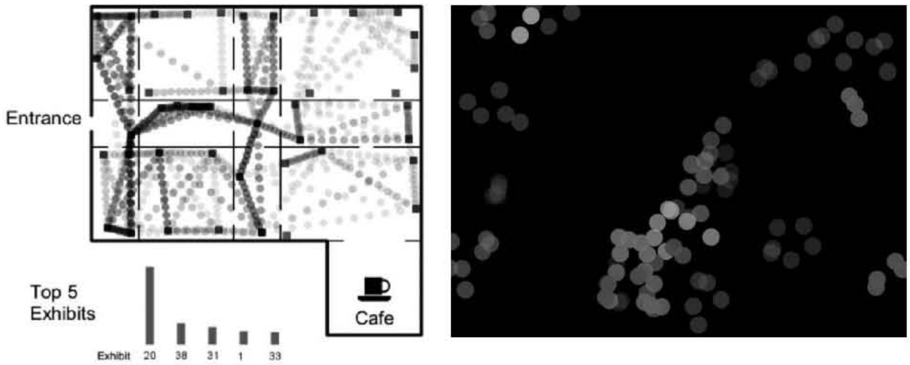

Figure 1. (left) Animated display of visitor traffic over time, and (right) emergent art display of affective presence (Boehner et al., 2005).

4. AN EXAMPLE: VAN GOGH ALIVE

The largest collection of original works by the Dutch painter Vincent Van Gogh is displayed in the Van Gogh Museum in Amsterdam, Netherlands. The museum houses 200 paintings, 400 drawings and 700 letters, as well as the artist's own collection of Japanese prints (html link 1). The permanent collection is in the main building which was designed by Gerrit Rietveld. Opened in 1973, the building is a rigid prism with a rectangular floor plan scheme. Museum galleries are grouped flowing into each other around an empty central space (Von Naredi-Rainer, 2004). And the paintings hung on the walls are displayed in these exhibition spaces where people walk around, stand and look at the art objects. Temporary collections are housed in another building which was added in 1999. This Exhibition Wing designed by Kisho Kurokawa accords perfectly with the main building despite its oval and dynamic mass.

The main function of the Van Gogh Museum is to preserve the collection of artefacts, and to present them to the public as well. However, there is a pursuit to encourage different perceptions of art objects through new ways of engagement. Developing technologies certainly prompt these sorts of attempts. Hence, new exhibitions take place to allow for new experiences of art by Van Gogh. An on-going exhibition (from September-2012 to May-2013): "Van Gogh, My Dream Exhibition" in the Beurs van Berlage, Amsterdam is one of them. The exciting and innovative aspect of this exhibition is that seven well-known paintings by him are brought from 2D to 3D animations. Visitors receive special 3D glasses to enjoy these animations. Suggested movements come to life, new layers and details become visible (html link 2). For example, during one of his famous paintings "Wheatfield with Crows" (1890) in motion, crowds loom on the horizon, fly towards you, and then pass over your head as probably Van Gogh himself envisioned it.

This paper presents a *spatially* based exhibition of Van Gogh which is enriched by digital technologies. **"Van Gogh Alive – The Experience"** is a travelling exhibit conceived and executed by Australian based Grande Exhibitions' curators. Fantastic images of the masterpieces by Vincent Van Gogh are displayed through multimedia display technology to create a multi-sensory experience for visitors. The show has taken place in Singapore, Istanbul and the United States, and will make its next appearance in Ankara in October of 2012.

The technology used in Van Gogh Alive is unique. More than 3,000 images comprised of the artist's paintings and photographs of some of the locations that inspired him between 1880 and 1890 are displayed on huge projection screens, curved or flat surfaces, walls, columns, ceilings and even the floor (html link 3). Designers of the exhibition use Dataton's WATCHOUT software system to synchronize the images through 40 different projectors onto multiple areas of a gallery (html link 4). The software integrates still images, graphics, video, animation and sound. Photographs and video have also been augmented with Van Gogh's works to demonstrate his sources of inspiration.

The exhibition space that is full of art immerses people in the artwork. The images presented are in a scale unseen before; far larger than the life version of Van Gogh's works, which allows the visitor to put himself into the painting (Figure 2). They could reach new levels of detail that could only be achieved by large HD projections. For example, "Wheatfield with Crows" is experienced in a totally different way. The giant image of the painting makes you feel as if you are walking on the wind-swept wheat field where the crows fly over. At another screen you see the ears of wheat wave in the wind, where the painting is zoomed in and augmented. And classical music in the background helps to feel the dramatic, cloudy sky with a sense of isolation. It is a stage on which you can experience the feelings of Van Gogh; a sense of his life coming to an end, while he was painting the amazing "Wheatfield with Crows," which is commonly claimed as his last painting.

Figure 2. Van Gogh Alive – The Experience (html link 3, 4)

The Van Gogh Alive exhibit recreates space as an environment of experience for artwork without using any art object, except installation equipment. With an imagination of huge canvas, visitors view art in a whole new way, as curators put it; "forego all preconceived ideas of traditional museum visits, dispel all notions of tiptoeing through silent art galleries to view masterpieces from afar, change how you engage with art, stimulate your senses and challenge your beliefs of what an 'exhibition' can be." At this point, for a further conception, it may be useful to reveal the new experiences of Van Gogh Alive by comparing it with the original exhibit in the Van Gogh Museum. Table 1 aligns the features of both exhibits for each element relevant to exhibitions.

Table 1. The original exhibition and Van Gogh Alive

In Van Gogh Museum	***In Van Gogh Alive Exhibit***
	
Sound and motion in presentation	
✗	✓
Images of presentation	
An ordinary canvas size	A gigantic size
Visitors' position-movement	
At one certain point for each object. *Static*; standing still and looking	Everywhere in the space. *Dynamic*; walking, sitting, getting much closer
Crowdedness (or feel of crowd)	
more	less
Uses of exhibition space	
walls or panels and paintings hanging on them	A total space; art on walls, extra surfaces, columns, ceilings and floors
Visitors' expectation	
Conventional	Depends on surprise (What is next? Where to look?)

According to the table, Van Gogh Alive has a distinct character in terms of the notion of exhibitions. It is an interpretation of original paintings using a transformation to giant images with sound and motion. The design of exhibition space is totally different from well-known arrangements of painting collections. Space itself becomes the 'art object,' whereas it is only a physical shelter for a traditional exhibition. During their visit to the Van Gogh museum, people stand in front of the art objects and observe. However, in Van Gogh Alive, visitors walk around or sit on the floor; they are free to choose the most convenient place to engage with the art. As a result of this availability, the space is not so crowded or has no clusters in specific points. In parallel, visitors feel less crowded with the individual presence of the visitor being stronger. Additionally, expectations in Alive depend on surprise, since people are curious about what will happen next or where the first image will appear. In other words, visitors are more excited and inspired by a constant regeneration of space.

5. CONCLUSION

This paper argued how new media and digital technologies support new experiences in art exhibitions, and particularly the interaction of these experiences with architectural space. Recent developments in web and wireless technologies, mobile telecommunications or sensing technologies are applied to enhance the engagement of visitors with art, also to assist education and communication in museums. Furthermore, new technologies prompt new interpretations mostly depending on fascinating perceptual and sensual experiences. By going beyond a simple function of accommodation, exhibition space becomes an important part of this twist. Its relation with art and the art object is reintroduced by technology. The conception of space has evolved with technology in terms of both the creation and presentation of art.

"Van Gogh Alive – The Experience," a novel presentation of the masterpieces of Van Gogh, one of the most talented artists in history, was examined as a case for the topic of this study. It is a vibrant performance of light, colour and sound combined and amplified, very different from the traditional notion of exhibitions. It presents a new experience of both art and space. The space here is redesigned by technology to create a new form of *derived* art by Van Gogh.

In sum, exhibitions like 'Van Gogh Alive' create new art experiences and usher in new ways of engagement with art objects, where the perception and cognition of artworks change. New environments of art are emerging by means of modern technologies, where visitors are informed and entertained, and can also interact, communicate and share. The exhibition spaces become inspirational for those new experiments. The enquiry about how the volume could be an inseparable part of the presentation or even re-creation of art gives birth to new spatial experiences. And it is clear that the future of the exhibition practice is closely associated with what technology can do by combining art and space.

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Html link 2. http://www.vangoghexhibition.com/

Html link 3. vangogh-alive.com/

Html link 4. http://entertainmentdesigner.com/news/museum-design-news/van-gogh-alive-art-appreciation-through-digital-immersion/

SESSION 5

16 November 2012 Friday, 10.45-12.00

Topic: Using computer software in architectural and urban design processes

Chairperson: Prof. Michele CHIUINI

Res. Assist. Yelin DEMİR, Instr. Dr. ÜLKÜ İNCEKÖSE
The Problematizing of Structural System Design in Digital Architectural Design Process: "A New Relation between Form and Structure"

Assoc. Prof. Dr. Tuğçe KAZANASMAZ, Res. Assist. Pelin FIRAT
Comparison of Simulation Tools Mostly Used in Daylighting Performance Studies

Res. Assist. Işıl RUHİ SİPAHİOĞLU
Sustainability in Architecture and the Limitations of Environmental Assessment Tolls

Researcher Maria João de OLIVEIRA, Assist. Prof. Alexandra PAIO, Assist. Prof. Vasco Moreira RATO
Fabricating a Living System - Uploading the Design Process into Materiality Performance

Assoc. Prof. Dr. Leman Figen GÜL
Embedding Digital Media in Architecture

THE PROBLEMATIZING OF STRUCTURAL SYSTEM DESIGN IN DIGITAL ARCHITECTURAL DESIGN PROCESS: "A NEW RELATION BETWEEN FORM AND STRUCTURE"

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ABSTRACT

In contemporary architecture, digital architectural design goes beyond the scope of designing. Design and production converges into a unique process in digital medium. Structural design becomes an architectural design problem in that unique process rather than being an engineering problem.
In digital architectural design, it is possible to define the design process as form based. Computer aided design allows architects to derive and transform wide range of forms. Complex, irregular, indeterminate, limitless forms become the representatives of the contemporary zeitgeist for architects. However, form based approach brings forth problems in relation to constructability. There is exactly a problem of designing and fabricating structural systems of complex and free forms in architectural design processes. Thus, the new approaches are developed for form-structure relationship to overcome the constructability problem.
In this context, the main aim of this paper is to realize the questioning of form-structure relationship and reveal the problematizing of structural design in digital architectural designs processes. Therefore, this study explains the realization (designing, manufacturing, constructing) of "architectural designs/forms" that are produced in digital medium. It presents the new kinds of relationships between design process and construction process through three cases which exemplifies three different approaches. Each case is discussed in the design process -from conceptual thinking to fabrication- focusing on the type of the relationship between form and structure.

Key words : Digital architectural design, Structural design, Form-structure relationship, Constructability

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1. INTRODUCTION: FORM BASED ARCHITECTURAL DESIGN PROCESS

With development of digital technologies, significant differentiations occur in architectural design processes. Design with its all sub-processes take place in digital medium. Computers become the digital design mediums rather than being used as design tools. Design becomes a computational process; therefore, digital knowledge becomes the background for computer aided design which is based on mathematical equations and parametric relations. Software programs such as Alias, Softimage, Maya, Rhino and Mudbox from industries like automotive industry, aircraft industry and movie industry are used “to introduce new formal vocabularies into the discipline of architecture” (Lynn and Gage 2010). In these changes over architectural design process, it is seen that architects go towards and focus on form based design processes. A design approach is in question where main concern is generally form production. Models that architects use as biological models, motion and force based models, performance based models, parametric models and evolution based models provide directly to intervene in the final product. In contemporary architectural discourses, the process of form creation is expressed as “generation of form”, “exploration into new forms”, “a new approach to form”, “finding of form”, “derivation of form” and “potential in new forms”. In this context, either for defining and controlling the design processes or identifying the new forms, prevalent concepts change. Architects use the concepts of irregularity, deformability, continuity, transformability, emergence, indeterminacy, adaptability, dynamism, interactivity and variation to define a different design process and new forms. Such a form-based interest is clearly expressed in architect Steve Hatzellis’s article of “Formal Complexity in Digital Architecture” in 2006. He asserts that; “digital architecture is an area of design that is leading exploration into new forms of non-standard architecture” (Hatzellis 2006).
Researchers Francesco de Luca and Marco Nardini focus on “generation of form” in their researches and see digital architectural design as “a new approach to form” (Luca and Nardini 2002). Form concern in Bernhard Franken’s discourse can be read as “form generation” (Franken 2003), whereas “finding of form” is the approach of Branko Kolarevic for a form based design process (Kolarevic 2000).
Usage of the concepts such as complexity, interactivity, emergence, transformability and variability in project descriptions indicate the group of Zaha Hadid Architects’ focus on formal concerns (Patrik Schumacher 2012). Greg Lynn’s definition of “animate form” also indicates “form generation” (Lynn 1999).

2. CONSTRUCTABILITY OF FORM

As digital architectural design focuses on “form generation”, constructability of these digitally computed, designed and represented forms becomes a crucial problem. Bagneris focuses on the constructability problem in his article of “Structural Morphology Issues in Conceptual Design of Double Curved Systems” in 2008. He states that; “the flexible forms are mainly characterized by portions of

double-curved surfaces. But this is only their formal aspect and is only a geometrical characterization. Problems occur when the mechanical behavior, and moreover, technological solutions have to be handled. Engineers have to solve difficult problems, which can end in nightmares" (Bagneris et al. 2008). Constructability problem necessitates examining the place of structural design within architectural design. Therefore, the problematizing of structural design in digitally driven processes is questioned in this paper in order to find out the response of structural design to the changing environment of computational "form generation." In addition, the relationship of architectural design and structural design is questioned from a viewpoint based on structure. The main of aim of this paper is to realize this questioning and reveal the different approaches which define new relationships between form generation processes and structural system solutions.
In this paper, literature review is done over digital architectural design for answering the questions of how structural design turns into a problem in digitally driven processes which start with constitution of design idea and end with construction. The problem is examined over three different main approaches to form-structure relationship. For studying these three different approaches, case study research is done. For every approach one case study is examined. Therefore, three case studies are selected from digitally designed and realized buildings because of the discussed problem of constructability. Every case is investigated over its general view, design phase, structural system and manufacturing. In addition, architects' discourses and projects and the relationship between them are also examined for understanding the design processes. Architects' firsthand statements are taken as primary source for the paper.

2.1. Relation between Form Based Architectural Design Process and Structural Design

Different approaches to form-structure relationship in digital architectural design process can be collected under three main topics. First approach is the composite approach where digital architectural design is seen as the integration of structural design and architectural design. All processes from constitution of design idea to construction such as form generation, structural design, and materiality integrate and converge in a common platform that is the digital medium. In addition to design of the form of the buildings, structural system and materialization decisions are also given using digital design processes. Computer aided design enables to think about form, aesthetic, structure, and material at the same time on the same model during the computational processes. Models, tools and concepts that are valid for architectural design are also applicable to structural design. Different disciplines such as engineering and architecture do not need to use different programs for architectural design and structural design. There is a unique process and it continues by articulation of the processes. Hierarchical nature of design where disciplines are specialized and completed in themselves is demolished. In his article titled "Mimarlıkta Değişmekte Olan Ne? Biçim Bilgisinden Süreç Bilgisine", Uğur Tanyeli gives the example of Walt Disney Concert Hall of Frank O. Gehry in Los Angeles where aeronautical software CATIA was used in every phase of the project as the only design medium. Design process acted as a unique process where all the project participants worked in their area of responsibility in relation with each other from form design to construction by using the same software (Tanyeli 2012).

The integrated model in digital architectural design is called as Building Information Modeling (BIM). Architect Jon Pittman describes BIM in his article titled "Building Information Modeling: Current Challenges and Future Directions" as; "a model that takes into account performance characteristics, cost and other issues related to the construction and operation of a building, as well as its design" (Pittman 2003). BIM collects all the useful data throughout the entire design, construction and maintenance processes and provides the opportunity to present the necessary information when it is needed. BIM is accessible by all project participants from designers to manufacturers and tradespeople via online databases such as project websites (Pittman 2003). If any participant makes a change on the model, all the other participants are informed with this change with the updates in the program.

The new understanding of architecture, where there is an integrated development of form design, structural design, materiality, fabrication and construction, actually is not a new approach. Computer scientist Fabian Scheurer argues that this integration of knowledge of different processes has always been the lodestar of every good design (Scheurer 2010). However, digital architectural design's difference is the integration of all different kind of knowledge in the computational design process.

For keeping the integration between architectural design and structural design, some specialized techniques are needed. Software programs such as MoSS and GENR8 by Peter Testa and Devyn Weiser from the Emergent Design Group (EDG) incorporate structural design with material qualities and form generation during computational processes. With the availability of entering different parameters such as geometrical definition of the form, dimensions of the structural system and material quality, a complex contemporary design approach can be assisted. The programming languages of MoSS and GENR8 integrate "knowledge and awareness of structural forms and material qualities along with aesthetics and computational processes" (Testa and Weiser 2002). These two programs can be used in conjunction with AliasWavefront Studio and Maya platforms (Testa and Weiser 2002).

Designing a form and then designing a structural system just for supporting the form is meaningless and problems occur when technological systems have to be solved. Form and structural design should be thought together such as using the folds and contours of the form for its constructability_(Balmond 2002). Alejandro Zaera Polo also supports the integration of form and structural design processes, and he argues that construction should be taken into consideration before the construction phase (Zaera Polo 2002).

Architect and civil engineer Wolf Mangelsdorf offers four design strategies, which are form-finding, simple mathematical geometry, free form and hybrid approach, in his article titled "Structuring strategies for complex geometries" in 2010. These strategies provide the integration of structure, architecture and fabrication. Therefore they overcome the challenge of solving the structural system after the design of form (Mangelsdorf 2010).

In second approach to the existence of structural design in digital design processes, structural design becomes the main concern. It controls the whole design process from the beginning of the constitution of the design idea by giving shape to the overall form. Engineers such as Arup, Buro Happold and Kristina Shea apply this approach, where structural design drives the design of the form, in their studies. Shea also expresses in the article titled "Creating Synthesis Partners" in 2002 that; "rather than creating the form and then considering structural options, structure is now treated explicitly and drives the definition of the exterior and interior form" (Shea 2002). In this reversed process, Shea uses computational techniques like the program of eifForm for generating structural systems (Shea 2002).

Greg Lynn's Port Authority Gateway Competition project is an example to second approach. Design process is just a structural design process. Initially, the site was modeled and some geometrical particles were located. Particles were movable based on the attraction fields in the site. By superimposing the frozen moments of a period of time, curvilinear vectors were created from the particles and these vectors became the tubular beams of the structural system (Lynn, 1999).

In the third and last approach to the existence of structural design in digital architectural design, there is a linear process. Form is designed first, a suitable structural system is designed according to form design, and finally materiality decisions are made. In this approach, structural design, its analyses and optimizations are not allowed to make changes on form. There are two subcategories for this linear approach. In firstly one, there is an integration where structural design takes the shape of the skin like a surface structure. In second one, structural design and architectural design are separated from each other where skin of the building is supported by an independent structure.

It is possible to see form as the main concern in the projects of architects. For example Frank Gehry's Marta Herford Museum in Herford Germany is a product of linear design process. As form was designed firstly, structural engineers had difficulties in case of finding a suitable structural solution for carrying the form. Therefore, rather than taking the shape of skin, structural system was designed independently from the main form (Bagneris et al. 2008).

In the project of Saint Lazare metro station in Paris by Arte Charpentier & Associés, there is also a linear approach. Structural system was designed based on the geometrical logic of the free form of the metro station (Bagneris et al. 2008).

3. CASE STUDIES: UNDERSTANDING DIGITALLY STRUCTURAL SYSTEM DESIGN

3.1. Composite Relationship of Structural Design and Form Design: Kunsthaus Graz

Kunsthaus Graz of Peter Cook and Colin Fournier was first designed for a competition in Graz, Austria. As Graz was named as the European Culture Capital for the year of 2003, Kunsthaus was planned and designed as an art museum for representing the technological developments of the end of the 20st century (Szalapaj 2005). In addition to representing the technological developments, there were other criteria for the design of the main form such as complex geometry of the site, to establish the alien nature of the building and to make the building look cuddly and friendly (Cook and Fournier 2004).

The Kunsthaus Graz is an example for the first approach of integrated process to form-structure relationship. Structural design is allowed to make changes on the shape of the form during architectural design process. Although structural optimization and form generation feed each other and constitute the final shape in Kunsthaus project, main concern is the form generation. According to the architect Colin Fournier, the irregular form has a "blobby" character which is a suitable example for today's contemporary architecture zeitgeist. Starting architectural design with a sphere and deforming it according to site constraints and architect's formal desires give the building the "biomorphic appearance" like a living organism which adapts to its site for living. Structural system of the building also has an irregular and blobby character which comes from its abstraction from form. Therefore, what defines the form also defines the structural system.

During design process of the irregular form of Kunsthaus to competition, architects did not utilized CAD-CAM technologies. Form was not designed in a digital medium by using computational models based on scripting. Physical model of the project was also handmade. After winning the competition, they took advantage of digital technologies for the realization of the building. Rather than scanning the physical model in three-dimension for creating the digital version of it, they computationally created a 3D model from scratch relying on the design decisions. They began with the conceptual phase to form generation process with the collaboration of architects and engineers using Rhinoceros modeling program (Kloft 2006). Non-uniform rational B-splines (NURBS) were used for modeling the surface which are specialized curves with control points, weights and knots on it. By changing the location of control points, weights and knots; various curves, surfaces and finally forms can be created (Kolarevic 2000). Originating from the shape of a sphere, the irregular final shape of the building was created by positioning the location of the control points and therefore, deforming the sphere (Szalapaj 2005).

During design process, architectural design and structural design were integrated with each other. Based on structural design optimization considering "its geometrical stiffness, and to address some of the manufacturing issues," shape of the form was modified (Kloft 2005). For example, roundness of the roof was increased for improving the structural performance of the building (Chaszar, 2012). Civil engineer Harald Kloft as the project leader emphasizes this integration of form and structure in his article as; "the digital design model of the Kunsthaus was shaped in an iterative process to capture the design intent of the original scheme, optimize the form with regard to structural behavior, such as its geometrical stiffness, and to address manufacturing issues" (Kloft 2006).

Branko Kolarevic also emphasizes the role of structural system optimization over form generation in his book of "Architecture in the digital age – design and manufacturing" in 2003. He asserts that; "the original blobby shape of Peter Cook's and Colin Fournier's competition winning entry for the Kunsthaus in Graz, Austria was altered somewhat after the digital structural analysis, by consulting engineers Bollinger + Grohmann from Frankfurt, revealed that its structural performance could be improved with minor adjustments in the overall form" (Kolarevic 2003).

Having the width of 60 meters, structural system of Kunsthaus consists of the main load bearing structure and the surface structure. As the main load bearing structure, there is a post and beam system with two exhibition levels. Lower exhibition level is made of solid steel framework. In addition there are concrete cores in the building for reinforcement which are also used for access and infrastructure (Szalapaj 2005). The surface of the building behaves as a shell structure which takes the shape of the doubly curved form. Tubular steel members form the surface structure by constituting a triangulated pattern. The surface structure also supports the skin where there are acrylic glass panels as covering materials (Kloft 2006). All the detailed design information is directly transferred from digital model to construction site and therefore produced with the help of computer aided manufacturing technology.

3.2. Structural Design as the Main Concern: Channel Tunnel Railway Terminal

The Channel Tunnel Railway Terminal of Nicholas Grimshaw and Partners in Waterloo, London is a railway station that Nicholas Grimshaw sees as a 21st century airport with all its accoutrement. Site constraints and Grimshaw's desire "to create a sense of wonderment" were taken as design criteria that shaped the building. Asymmetry of the roof structure as the most striking and elegant feature of the building came from the asymmetrical geometry of platforms and the location of one track. As one of the tracks is on the western edge of the site, roof height was needed to be higher at this point for trains to pass. Trains also approach to the terminal from this western side and for providing the passengers "a public showcase" of Westminister and the River Thames, Grimshaw's team decided to make this façade entirely glass. In addition, structure was set outside of the building over the cladding at West façade. East façade is the inverse of the west façade where structure is under the cladding of solid material (Moore and Powell 1993).

The Channel Tunnel Railway Terminal is an example for the second approach to form-structure relationship where main concern is the structural design rather than form generation. Structural system design is the architectural design itself. In Waterloo Terminal, site constraints are the input parameters as the design criteria. "Irregular", "curvilinear" and "asymmetrical" character of the final structure is the result of design inputs. The asymmetrical building structure is designed by parametric model which provides "variation" in width and size over structural system and its components.

Working as a canopy, design of the irregular roof structure of the Waterloo Railway Terminal was the focal point during design process. For designing the structure, digital technologies were used as Rowan Moore asserts; "the complex geometry of the roof structure was mastered using computer-assisted design" (Moore and Powell 1993). Parametric model was the design method for the structural design which was used starting from the constitution of the design idea to the construction phase. The characteristics of the site as the changing width of 35m to 48m, its narrowness and irregularity and the location of tracks were the design parameters. Initially an arch module was created from two bowstring trusses. The reason why arch was chosen was its perception of lightness and non-necessity for interior supports for crossing the span. Trusses in arches worked against the bending moments and compression forces that were the cause of the asymmetric structure of the arch. As the arches were asymmetrical, longer and shorter sides of these arches worked differently from each other. Inside of the longer side worked for tension while inside of the shorter side worked for compression (Popovic and Tyas 2002).

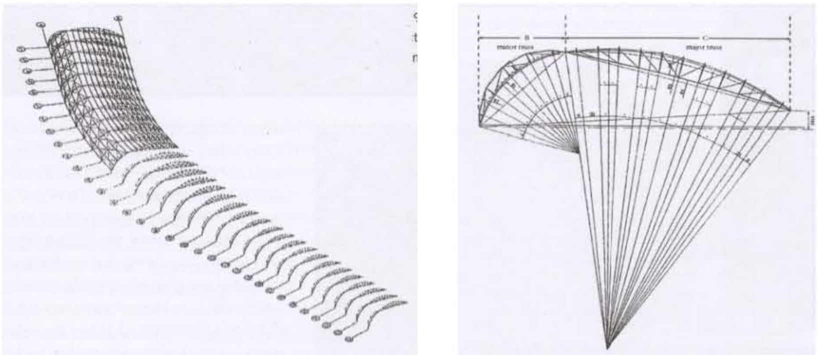

Figure 1a-b. Parametric design process (*Taken from 'Architecture in the Digital Age: design and manufacturing' Edited by Branko Kolarevic 2003)*

There are 36 different arches in the structure with different widths and curvature. Rather than designing every arch separately, a parametric model was created. By changing the value of the design parameters, all the other varieties of arches were created automatically based on the parametric equations. Therefore, different in span, position and curvature yet identical in topology; arches were created in a short time. Generated arches were located through the curvilinear site and constituted the main building. In addition to the configuration of the arches, joints between these arches were also designed with parametric model (Kolarevic 2003).
During design, where the span increased, the arches in the structural system became wider. For an arch to be wider, structural elements that constituted that arch also became longer. Briefly when an input parameter changed such as increase of the span, all the other related parameters such as structural element length were resized based on the parametric equations.
In detail, steel trusses that generate the arches have three pin connections on it. Two of them are for the ground connections of the structure and one of them is for the connection between the major and minor trusses. For these connection details mild-steel pin joints are used (Moore and Powell 1993).

3.3. Linear Design Process from Architectural Design to Structural Design: BMW Exhibition Pavilion Dynaform

The BMW exhibition pavilion Dynaform for the IAA 2001 by Bernhard Franken in association with ABB Architekten in Frankfurt, Germany was designed to host a car exhibition. Communication was an important criteria for the design. Main concern was to create a new spatial experience. Franken and his team developed a design method which included the usage of special-effects software from movie industry. They embraced an approach where "form follows force." Effects of the forces in the design medium reflected to design. Changes in form was realized and calculated by force field application. As Franken asserted that; "admittedly we cannot grasp forces

directly with our senses, but can only infer them through their effects" (Franken 2003), visitors could comprehend the forces that affected the design process by experiencing the space (Franken 2003).
The BMW exhibition pavilion Dynaform is an example for the third approach to form-structure relationship where structural system is designed after form generation process. In this project, main concern is the "digitally generated form" which is designed via motion and force based model. During design process, "virtual forces" in the "dynamic" design field are used for the "deformation" of the form. "Deformed" form, which "bends" and "twists," has an "irregular" character. After determination of the final geometry, structural system takes the shape of the "irregular" form.

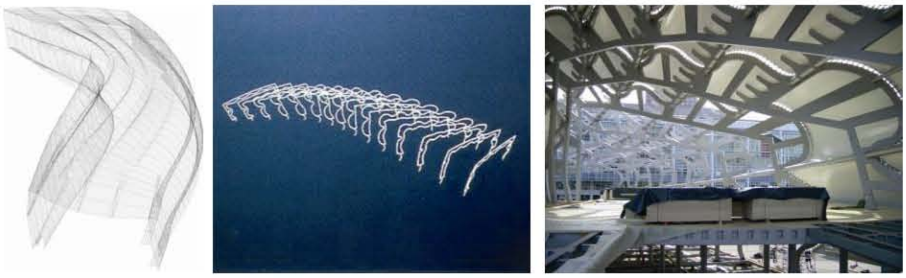

Figure 2a-b-c. Design process of Dynaform (© B+G Ingenieure Grohmann GmbH)

Motion and force based model was the design method for the generation of form. Initially, some basic rectangular structures were handled. During design process, these basic structures were deformed via the field forces by using force field simulations. The field forces were inputted into computational design process as design parameters and therefore, generated the final form. As the forces and the information in the design medium were recorded into the surface of the building, every curve and contour on the surface had a meaning. Final form was not arbitrary. The forces that were used for shaping the form were not only environmental forces such as wind, sun, gravity, pedestrian movement and car traffic. There were also conceptual forces which did not originate within the context itself (Franken 2003). They were created as a result of the acceleration of the space around the vehicles for creating the sensation of driving (Franken \ Architekten 2012). Computational design process continued until an architectural form was found. The found form was called the master geometry which was a single layer surface without any details such as thickness. Franken emphasizes the importance of master geometry by stating that; "the form arising from the force-field simulation process becomes the master geometry, which may not be changed manually in any way; otherwise, the forces of its creation would no longer be perceptible" (Franken 2003). In addition, during design and construction, master geometry was the dimensional reference for the project collaborators including engineers (Kloft 2005).
After generation of form and definition of the master geometry, Franken and his office collaborated with Bollinger + Grohmann Ingenieure for structural system solutions. They used finite element analyses program for analyzing the behavior of

the form as a shell structure, which was abstracted from the master geometry of the building. Structural design was not allowed to make changes on the geometry of the form as Franken asserts in his article titled "Real as Data" in 2003; "since the structural system must not change the form, the load bearing system is continually altered until a suitable system is found for the master geometry" (Franken 2003). After the studies over structural design via the collaboration between architects and engineers, fifteen cross sections were generated from the main form. Structural frames were then inscribed into these cross sections. Outer layer of structural frame was the abstraction of the master geometry which tracked the guidelines of the form. Inner layer was the reverse of the same master geometry. Finally, all planar sections were connected with welded plates for the stability throughout the building. For covering the structural system, pre-tensioned membrane layer was decided to be used as choice of material (Kloft 2005). With the help of CNC plasma cutting, the structural elements manufactured in factory and mounted on site (Franken 2003).

4. CONCLUSION

Form based architectural design process entails the interrogation of constructability problem of buildings. Constructability of digitally designed complex forms is directly related to structural design. Today, structural design gains a digital dimension. Therefore, new kinds of relation between architectural and structural design occur. The approaches that are presented in this paper define different types of relationships between form and structure that are designed in digital medium and constructed with the assistance of computer aided manufacturing.

The three types of relationships that are computationally created are searched by a structural point of view. Constructability of the free forms of the digital era is questioned by emphasizing the existence and place of structural design. By defining the new types of relationships, it is seen that digitally designed forms can be constructible at the same time.

It is possible to say that the second and the third approach do not define totally new approaches to form-structure relationship besides being designed in digital medium. The first approach which is the composite approach defines a new type of relationship considering contemporary approaches where there is a unique process. Hierarchical nature of design where disciplines work separately from each other is demolished. Models, tools and concepts that are used for form generation are also valid for structural design. All disciplines work on the same program in relation with each other (Tanyeli 2012).

Examining contemporary digital architectural production only within the context of "design process" is insufficient. Production process turns into a unique process starting from design to fabrication. So, in case of discussing the constructability of the designs, it is necessary to comprehend the structural design. Therefore, this paper examines the relationship between structural design and architectural design. It presents in which different ways digital structural design becomes a part of digital architectural design.

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COMPARISON OF SIMULATION TOOLS MOSTLY USED IN DAYLIGHTING PERFORMANCE STUDIES

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ABSTRACT

In recent years, sustainable architecture shows great interest into the daylighting design of buildings, regarding energy saving strategies and user comfort. Increasing usable daylight and creating efficient daylighting strategies help to decrease the total energy consumption and enhance user comfort in the buildings. There are many factors and considerations that need to be taken into account in the process of daylighting design; such as, solar heat gain, glare, artificial lighting control— dimmers and sensors— and predictable or unpredictable variations in sky conditions. Therefore, commencing the daylighting design in the first steps of the designing process is needed. Computer-based daylighting simulation tools help the designers to make time and cost effective pre-tests before the construction stages and understand how their buildings act under different sky conditions throughout the year. This paper presents the basic principles and the discussion of four daylighting simulation programs that have been more commonly used in daylighting design in the recent years. These programs are Desktop Radiance, DesignBuilder, Autodesk Ecotect Analysis and Velux Daylight Visualizer. In this study, the basic working principles of these programs are discussed and a comparison is made regarding the differences in potential quality of the tools in terms of physical correctness of the results, adaptability for new technologies and usability for design decision support. Other criteria that are taken into account in the comparison are compatibility with third party programs, working as a plug-in or as standalone in nature, user interface, ease of use, characteristics of output data, existence and source of climatic data, daylighting analysis and calculation methods, 3D modeling capability. The paper ends with the discussion of the overview literature results.

Key words: Daylighting, Simulation, Performance

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1. INTRODUCTION

Simulation tools have become essential in the design and evaluation process of buildings. Specifically, they assist in daylighting performance studies and design with a growing interest (Kim and Chung 2011, Reinhart and Fitz 2006). Well-proposed daylighting strategies may decrease the buildings' total energy consumption and enhance user comfort. Thus, it is necessary to evaluate the quantity and quality of daylight in a space both in the early design stage and during occupation (Kim and Chung 2011; IEA 2010). This has recently become a considerable component of sustainable design. Thus, it is expected that, simulation software tools provide accurate visual and quantitative outcomes in the preliminary steps of design.
To examine what kind of deficiencies about daylighting systems and components exist in occupied buildings, we may use simulation tools. They provide this for various climatic conditions. Several daylighting software are integrated in the comprehensive energy performance calculation methods and legislations. Thus, it is necessary to obtain daylighting numerical outputs and visual outcomes close to the real situations. The question related above is how their physical correctness, adaptability and usability are determined and which one is more suitable in design decision support and evaluation process than others.
This can be examined by comparing recently-used daylighting simulation software in daylighting design with the ones integrated in analysis process. Thus, this paper includes an overview of four software; namely, Desktop Radiance, DesignBuilder, Ecotect, Velux Daylight Visualizer. It based on the review of literature mentioned about studies of these tools. The most reliable, adaptable and usable one would become the prevalent one to develop new daylighting technologies. The major deficiencies pointed out as a result of a comparison among software would be inputs to improve such software technologies in future. The best accuracy obtained from one software would assist professionals to design high energy saving potential buildings, and high user comfort in interiors, and low construction and operating costs. The consideration is to seek the proper tool to predict the daylighting performance and take precautions against deficiencies in the early design stage. The objective is to determine the appropriate tool to propose daylighting technology decisions such as innovative shading and light guiding devices as building components. This determination will depend on pointing out their strengths and weaknesses. Consequently, several criteria such as, compatibility with third party programs, working as a plug-in or as standalone in nature, user interface, ease of use, characteristics of output data, existence and source of climatic data, daylighting analysis and calculation methods, 3D modeling capability are examined.

2. OVERVIEW OF DAYLIGHTING SIMULATION TOOLS

2.1. Desktop Radiance

Radiance is developed to assist designers in the prediction process of the lighting levels and the appearance of a space before application. The lighting simulator

engine of the Radiance uses a hybrid approach of Monte Carlo and deterministic ray tracing in lighting calculations. The software is initially developed for the Unix environment and works on a text-based input format (Bhavani and Kahn 2011; Kim and Chung 2011; Minstrick 2000). On the other hand, Desktop Radiance is a more user-friendly version of Radiance in terms of its graphical interface and ease of reach through the integrated pull-down menus within other programs such as AutoCAD, Autodesk Ecotect Analysis and DesignBuilder. It works under the Windows operating system through these programs and its graphical user interface also allows using most of the key operating features of Radiance. It is also possible to reach the remaining Radiance features by modifying the original text-based inputs (Minstrick 2000; Lim et.al. 2010). The 3D model used in Desktop Radiance is created either in Radiance or in the above programs. It is also possible to import the model from other 3D modeling tools in compatible 3D formats.
To obtain proper photometric analysis, the model should include appropriate amount of details and the exterior should be modeled closely enough to calculate amount of daylight striking an opening adequately. Before proceeding to simulations, the complete 3D model should be edited by assigning Radiance materials onto each surface. These materials can be chosen from the Desktop Radiance Library or the Material Editor can be used for creating user-defined materials (Minstrick 2000). The site location (entering longitude-latitude values or choosing from one of the available cities), the date, the time and sky condition should also be defined too, before running a simulation. The sky models used by the Desktop Radiance are the models of International Commission on Illumination (CIE) which are CIE clear sky, CIE intermediate sky, CIE overcast sky and uniform sky. It is also possible to discard daylight computations by entering the time as the middle of the night (Kim and Chung 2011; Minstrick 2000). The Desktop Radiance can make analysis on "single reference points" or "grids of reference points"; the latter is used to compute the horizontal illuminance. It is also possible to produce "detailed renderings" of the 3D model through which the illuminance or luminance values of each rendered surface can be learned. The Desktop Radiance has two alternative rendering modes; batch processing and an interactive mode that utilizes the rview program. (Minstrick 2000)

2.2. DesignBuilder

DesignBuilder is a building simulation tool which carries out the analysis on energy consumption, carbon emissions, occupant comfort and daylight availability and works as an evaluation tool on determining the current conditions of the buildings with regard to several building regulations and certification standards.
DesignBuilder was launched as the first Graphical User Interface to the EnergyPlus simulation engine and the latest version of the program (Version 3) includes the first advanced Graphical User Interface to EnergyPlus HVAC systems and a daylight evaluation tool that uses the advanced Radiance ray-tracing engine (DesignBuilder 2012)
The 3D model used in DesignBuilder can be created by an integrated OpenGL solid modeler or can also be imported from 3rd party BIM tools supporting the gbXML standard like ArchiCAD, Microstation and Revit. Imported 2D CAD floor plan data

can be traced by DesignBuilder and used as a base for modeling. DesignBuilder provides three types of daylighting calculations; "daylight contour plots, average daylight factor and uniformity outputs by using the Radiance simulation engine", "reduced electric lighting and consequent energy and carbon savings through EnergyPlus simulations" and "photo-realistic renderings by Radiance" (DesignBuilder 2012) By using the Radiance simulation engine, it is possible to calculate daylight factors and illuminance as well as to generate high quality illuminance contour plots within the zones, the blocks or for a slice through the whole building. The sky models are similar to the ones used by Radiance (DesignBuilder 2012). DesignBuilder uses also EnergyPlus simulations to determine the impact of daylighting strategies (decrease in electric lighting usage) on energy and carbon savings based on analysis of available daylight, site conditions, window management regarding solar gain and glare, and various lighting strategies (DesignBuilder 2012).

2.3. Autodesk Ecotect Analysis

Autodesk Ecotect Analysis is a sustainable design analysis tool that provides a wide range of simulation and building energy analysis functions by using desktop and web-service platforms. The program uses Green Building Studio web-based service to carry out whole-building energy, water and carbon analysis and integrates them with desktop tools for visualizing and simulating building's performance. The program aims to help the designers in the schematic phases of their designs and guide their design decisions on orientation, floor plan depth, glazing sizes, etc. Regarding this purpose, the 3D model used in the software needs to be as simple as possible with no non-essential details; almost like a massing model with defined zones for air-conditioning or daylighting (Ecotect 2012; Green Building Studio Manual 2011). Ecotect Analysis together with Green Building Studio can produce data on whole-building energy analysis, thermal performance, water usage and cost evaluation, solar radiation, daylighting and shadows and reflections. (Ecotect 2012)
Ecotect Analysis carries out lighting analysis by several different methods. The program can create daylighting information by using the BRE daylight factor calculations integrated into Ecotect Analysis or by exporting the model to Radiance. Autodesk Green Building Studio also performs daylighting calculations using the LEED prescriptive method for evaluating the buildings for LEED Daylighting Credit Potential. It is also possible to calculate electric lighting as footcandle levels by BRE daylight calculation or by Radiance exports (Ecotect 2012).

2.4. Velux Daylight Visualizer

Velux Daylight Visualizer is a daylighting design and analysis tool aiming to increase the use of daylight in buildings and help designers to predict the daylight quality of their designs before construction stages. The program runs on both Mac OSX and Windows7 platforms. The integrated modeling tool of Velux Daylight Visualizer can be used for creating quick and simple 3D models. The modeler only

Table 1. An overview of daylighting simulation tools

	Desktop Radiance	**DesignBuilder**	**Autodesk Ecotect Analysis**	**Velux Daylight Visualizer**
References	Kim and Chung 2011; Minstrick 2000; Bhavani and Kahn 2011; Lim et.al. 2010; Acosta et al. 2011; Ng 2001; Christakou and Silva 2008.	DesignBuilder 2012	Ecotect 2012; Green Building Studio Manual 2011, Acosta et al. 2011, Attia et.al. 2009; Christakou and Silva 2008.	Velux 2012; Labayrade et al. 2010.
Available daylighting calculations	reference points detailed renderings	reference points detailed renderings	reference points detailed renderings by Radiance; evaulation for LEED Daylighting	reference points detailed renderings
Daylighting Outputs	illuminance, luminance, daylight factor, photo-realistic renderings, daylighting contour plots	daylighting contour plots, average daylight factor, illuminance, and photo-realistic renderings by Radiance; electric and carbon savings by EnergyPlus	daylighting contour plots, average daylight factor, illuminance, uniformity outputs and photo-realistic renderings by Radiance; results for LEED Daylighting Credit potential	daylighting contour plots, average daylight factor, illuminance
Available sky models for daylighting calculations	CIE clear sky, CIE intermediate sky, CIE overcast sky and uniform sky	CIE sunny clear day, CIE clear day, CIE sunny intermediate day, CIE intermediate day, CIE overcast day, CIE overcast day (10000 lux) and uniform cloudy sky.	CIE clear sky, CIE intermediate sky, CIE overcast sky and uniform sky	CIE Standart Overcast Sky, Partly Cloudy Sky, CIE Standard Clear Sky
3D Modeling	in Radiance or in the programs DR is a plug-in. Importing is allowed.	by integrated OpenGL solid modeler or importing from programs	in Ecotect or importing in compatible formats	by the integrated modeler or by importing

permits creating orthogonal shapes as well as the exception of the rotatable custom object entity, so it can be inflexible and inadequate when trying to model complex geometries. By using the 3D importer feature, it is possible to import 3D models. The imported 3D models should only be made of polygons and to prevent light leaks, the polygons should be attached together properly. Furniture created with other programs can be used in the imported models if they are inserted before importing the model to Daylight Visualizer. There are some other restrictions in Daylight Visualizer like the textures can only be applied to horizontal surfaces and there is no undo function in the program. In the simulations, Velux Daylight Visualizer uses sky types defined by CIE. By utilizing Velux Daylight Visualizer, the simulation outputs that can be acquired are; luminance, illuminance, daylight factor and daylight animation (Velux 2012)

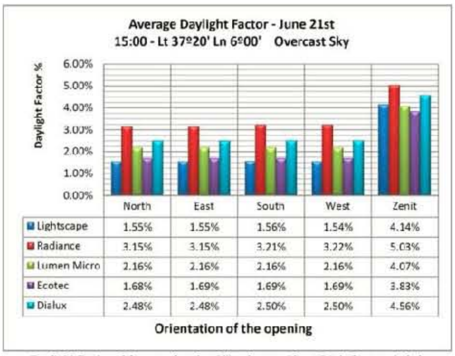
3. PHYSICAL CORRECTNESS AND ADAPTABILITY FOR NEW TECHNOLOGIES

In recent years, daylighting simulation tools have become commonly used by lighting designers and professionals. Increasing trust in their accuracy and decreasing use of scale models may result in their wider use. However, their users still remain less than the others using other building simulation software. Since, users may tend to use easy, practical and reliable daylighting tools and when they cannot reach adequate information, self-teaching materials, convenient databases, practical user-interface or reliable analysis results; they avoid using them. (Reinhart and Fitz 2006; Reinhart and Wienold 2010) In this section, "physical correctness" and "adaptability to new technologies" and in the following chapter, "usability" of four programs; Desktop Radiance, DesignBuilder, Ecotect and Velux Daylight Visualizer, were discussed through a review of related previous studies.

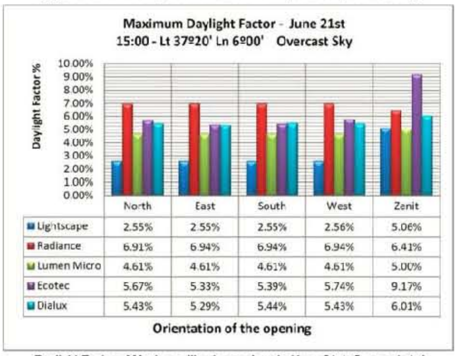
Physical correctness depends on competence of 3D models, the various characteristics of materials, sky conditions and external obstructions. Various sky model types are used by these tools to indicate different sky conditions. However, it is almost impossible to cover all real sky conditions since they vary unpredictably due to time, location and occlusion. This inconsistency between the real sky conditions and the sky models of daylighting tools cause simulation errors and affect physical correctness of the tools.

To show these dependencies, a study by Acosta et al. (2011) tried to identify how the sky models of the different tools affect daylighting calculations. To achieve this, a simple room with a square opening on one side was modeled identically in five tools; Lightscape, Desktop Radiance, Lumen Micro, Autodesk Ecotect Analysis and Dialux. Overcast sky conditions and a common day were selected for each simulation. Firstly, the researchers changed the opening orientation in each simulation (North, East, South, West, Zenith) to understand how each tool responded to this variation. Findings showed significant differences in daylight factor results, illuminance levels, and coefficients of uniformity for each simulation tool (Figure 1 and 2). Highest illuminance levels were obtained by Desktop Radiance for all orientations. Ecotect results were almost half of them. But they were in acceptable limits for all software. The understanding of overcast sky by each tool was differed from each other. So, physical correctness of each tool varies due to their sky interpretation.

Secondly, distribution of light according to time was analyzed in the same study. Only the uniformity coefficients of Desktop Radiance varied with the time remarkably. Thus, Desktop Radiance was sensitive to time variation due to the addition of sky-turbidity-factor in its algorithms. Ecotect resulted very small shifts in daylight factor values for the same time interval, but Desktop Radiance showed inconsistent and relatively greater values when compared to the other tools (Figure



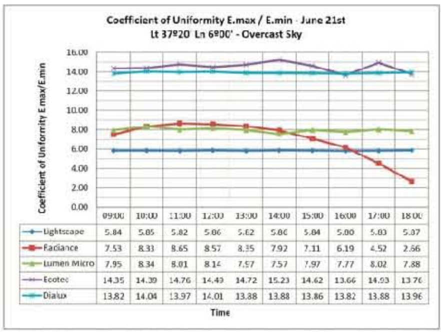
Daylight Factor of Average levels of Illuminance (June 21st, Overcast sky)



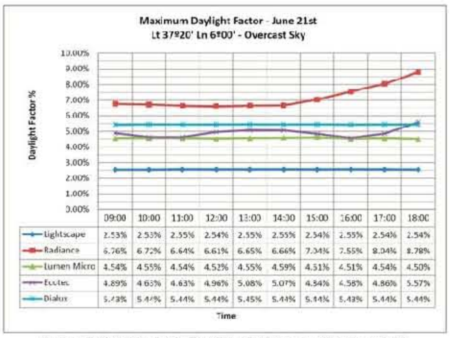
Daylight Factor of Maximum Illuminance Levels (June 21st, Overcast sky)

Figure1. Distribution of daylight factors obtained from each software due to orientation. (Acosta et al. 2011)

2). Consequently, in overcast sky conditions, Desktop Radiance was found to be more sensitive to time when compared to Ecotect and other tools. Its daylight factor values tend to be higher than Ecotect in all conducted simulations in that study.



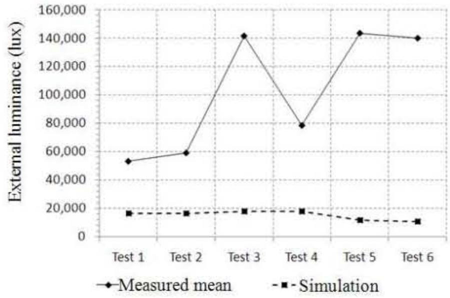
Coefficients of Uniformity (Max/Min illum. levels) (from 9:00 to 18:00 on June 21st, Overcast sky)



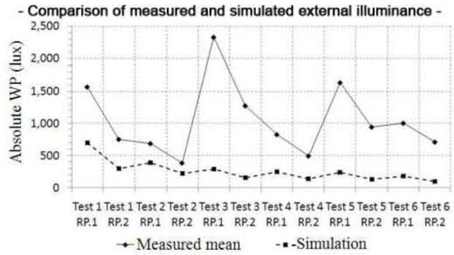
Maximum Daylight Factor Levels (from 9:00 until 18:00 on June 21st, Overcast sky)

Figure 2. Coefficients of uniformity and daylight factors due to time (Acosta et al. 2011)

With a similar purpose, another study compared Desktop Radiance results with scale-model measurements conducted under intermediate and overcast tropical sky conditions in Malaysia. The simulated results showed high mean differences from the scale-model measurements such as 81.63%, 71.06% and 49.71% with external illuminance, absolute work plane illuminance and absolute surface illuminance respectively (Lim et al. 2010). Daylight factor and luminance ratios were better comparisons with 26.06% and 29.75% mean differences. These errors basically based on the inconsistencies between the tropical sky and CIE sky models. Desktop Radiance failed to predict the external illumination in acceptable limits, though results were closer to the actual conditions under the CIE overcast sky when compared to CIE intermediate sky. According to Lim et al, this was due to the luminance distribution of the tropical sky being more uniform during overcast conditions.



- Comparison of measured and simulated external illuminance -



- Measured and simulated absolute Work Plane Illuminance -

Figure 3. Comparison of measured and simulated illuminance (Lim et al. 2010)

It is challenging for daylighting simulation tools to use sky models that are in complete harmony with extreme and rapidly changing real sky conditions. One reason for that may be the tendency of the software developers to constitute sky models that imitate general sky characteristics worldwide. Using these sky models for extreme sky conditions like tropical sky, the inconsistencies in the simulation results are inevitable.

High external obstructions affect the amount of daylight striking to openings. In some cases that may lead computational errors due to the distorted local sky conditions, and affect the physical correctness of daylighting tools. Regarding these concerns, in a research by Ng (2001), the simulation abilities of Radiance and Lightscape under conditions with high external obstructions were tested. Simulations carried out with the two software were compared with the calculated results and the on-site measurements in an extremely dense urban environment in

Hong Kong. The on-site measurements were carried out in three apartments located at different levels in a building block between June – October 2000 on cloudy days. For the simulations, the CIE Standard Overcast Sky was used. It was concluded that, on-site measurements substantially matched with the calculation results. Desktop Radiance simulations were similar to the calculation results at higher floor levels and with obstructions less than 30 degrees angles. At lower floor levels or with greater obstruction angles, both Desktop Radiance and Lightscape overestimated the daylight availability. The Desktop Radiance errors increased when the angle was greater than 35 and the error was close to 50% at 60 degrees. It was derived from trial-error simulations that, by lowering the reflectance to 0.2 from 0.4, Desktop Radiance could minimize the errors.

It was proved that external obstructions caused remarkable inconsistencies on daylighting simulation results and affected physical correctness. The obstruction angle and height of the simulated environment does also affect the results and may increase the errors. Under overcast sky conditions Desktop Radiance simulation results can be remarkably manipulated by external obstructions. Desktop Radiance overestimates daylight availability with an increasing error at lower floor levels and with obstruction angles higher than 35 degrees.

The comparison and validation studies of simulation programs in the literature that we could be able to attain were mainly included Radiance, testing it alone or among other simulation tools or simulation results were validated with measurements. We could hardly reach any studies of validation or comparison neither with Velux Daylight Visualizer nor with Ecotect and DesignBuilder, apart from the ones that are testing the two programs with their Radiance based simulation capabilities. The dominance of Radiance on these studies can be explained by the previously mentioned survey (Reinhart and Fitz 2006) results. Among 42 different daylighting simulation programs that the survey participants routinely used; over 50% of these programs were the ones that operated with the Radiance simulation engine.

However a study by Labayrade et al. (2010) aimed to validate Velux Daylight Visualizer against CIE 171:2006 test cases. The validation results showed an average error of 1.8% and a maximal error of below 6% with respect to the reference for eight identified settings proving the accuracy of Velux Daylight Visualizer.

In designing low-energy buildings, material selection becomes an important criterion. By modifying the material characteristics like transparency, reflectivity or absorptivity, architects aim to design high energy performance buildings. To evaluate their daylighting performance, such tools should be adaptable to accurately simulate these complex new materials. For example, Thanachareonkit et al. (2006) conducted an error analysis on the complex fenestration systems (prismatic films and laser-cut panels) simulation techniques by using Radiance. A 1:10 scale model under a scanning sky simulator and an identical Radiance model under CIE overcast sky were compared while both equipped with conventional glazing, laser-cut panel and prismatic film on the side opening respectively. With conventional glazing, the results showed a relative divergence of 1-9.2 % proving high accuracy of Radiance. With a laser-cut panel mounted to the window, it was 0.5-16%, while with prismatic film; it was 2.2-35%. Secondly, a sensitivity analysis of surface reflectance was carried out. 10 -50% overestimation of surface reflectance caused 5-52 % relative deviation above the scale model values, while a similar underestimation range of surface reflectance caused 10-40% lower values. Laser-cut panel and prismatic film results were slightly differed from each other and both results were comparable with the glazing model. Thus, simulation techniques of laser-cut panels and prismatic films by using Radiance were validated. A similar research was conducted aiming to validate trans and transdata Radiance material types and to constitute corresponding Radiance material from a translucent panel by using goniophotometer and integrating sphere measurements. After adjusting indoor illuminance simulation results with a ratio of measured to simulated façade illuminances, the errors were under 8% and 10% for transdata (Reinhart and Andersen 2006).

As mentioned above, daylighting designers have been rapidly using the complex materials and advanced daylighting systems in their designs recently. Apart from the design decisions like orientation, amount of openings, floor plan depth, etc; using these modified materials and advanced daylighting systems provide remarkable energy savings. To evaluate the daylighting performance of the buildings with these new technologies, simulation tools should be adaptable to these consistent changes. As can be derived from the mentioned studies, simulation techniques of Radiance for complex fenestration systems (in this case laser-cut and prismatic panels) as well as the trans and transdata Radiance material types has been verified recently. Also, the ability of Radiance; constituting corresponding Radiance material from a translucent panel by using goniophotometer and integrating sphere measurements has been validated. With the new technological progresses in daylighting systems, materials and co-elements like paints or isolative films; the adaptability of the simulation tools to new technologies is crucial.

4. USABILITY OF SIMULATION TOOLS

Researchers pointed out that, professionals, in general, prefer to learn such daylighting software by themselves. The ones which are easily understood by intuition and provide easy operation decrease learning period of time. Even, the longer the time spent in self-teaching, the faster to avoid from using these software. Daylighting simulation software should offer efficient tutorial options and simple simulation environment (Reinhart and Fitz 2006; Reinhart and Wienold 2010). User interface is the center of interest for architects, since it is the link between them and digital processes (Christakou and Silva 2008). Related studies mostly based on users' opinion and preferences, and the concept named here as "usability"(or user-friendly) involved such criteria as being intuitive, less learning time, user manual options, being simple and data output options. This term mainly depends on the interface operation (graphical based or text based) and capability. Menus, on screen clickable items which are perceived immediately are requisite. Usability secondly based on information management of interface (Attia et.al. 2009). In relation to this, Reinhart and Wienold (2010) define barriers such as the misleading interpretation of simulation results or outdated evaluating schemes. Visually accessible simulation results are preferable.

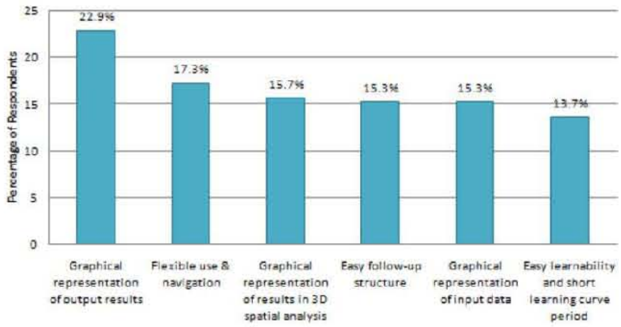


Figure 4. Criteria concerning usability and graphical visualization usage pattern (Attia et.al. 2009)

According to the research conducted among users' opinion about simulation software, usability is related to "better graphical representation, of simulation input and output, simple navigation and flexible control. Ecotect and Design Builder fully matched these criteria except easy follow up structure for the former and graphical representation of results in 3D spatial analysis for the latter. Due to the criteria concerning information management, users considered Ecotect as insufficient in creation of comparative reports and Design Builder as unsuccessful in the quality control of simulation input (Attia et.al. 2009). (Figure 4,5). On the other hand, Radiance's interface was not defined as friendly by a reference cited in Christakou and Silva (2008). Their research included both users' opinion and the application of software in a design process. Findings showed that Ecotect was not the most suitable software and not intuitive when compared to Relux, but had user friendly interface (Christakou and Silva 2008).

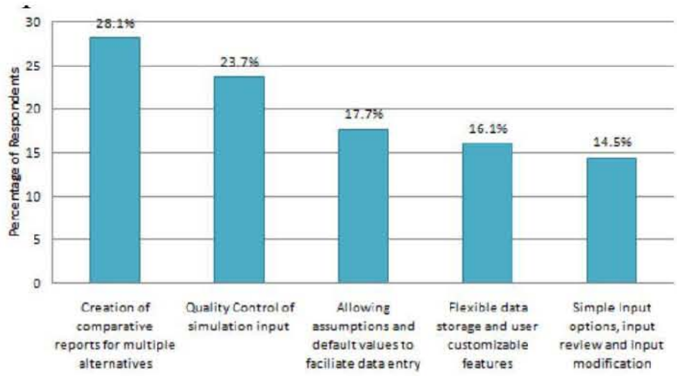


Figure 5. Criteria concerning information management (Attia et.al. 2009).

Table 2. Strength and weaknesses of Ecotect, Radiance and DesignBuilder due to their usability

	strength	weaknesses
Ecotect	Less learning time and simple navigation (simulation tips for instructors) user friendly interface better graphical representation	inappropriateness in flexible data storage and input options (Limitations in 3D modeling) not easy follow up structure not intuitive
Design Builder	simple navigation flexible control	graphical representation of results in 3D spatial analysis
Radiance		Not user friendly Not preferred by beginners

The study by Reinhart and Ibarra (2009) supported the usability of Ecotect due to users' preferences. According to this study about beginners' choice for using a software (Ecotect versus Radiance), it was stated that none of them preferred to run simulations by exporting to Radiance, but they used Ecotect analysis. However, a large number of students imported their model into Ecotect after modeling it with another program due to limitations of modeling capabilities of Ecotect. This showed that inappropriateness in flexible data storage and input options were the cause of this. Users in this study also paid attention to simulation tips which can be useful for the instructors. So, this approved that easy learnability and simple navigation were suitable features in Ecotect. Unfortunately, literature about the usability of Velux was not cited.

5. CONCLUSIONS

This paper is an overview of four recent simulation tools mostly used in daylighting design and performance studies. It is based on contemporary researches cited in literature and on inspection of simulation characteristics. When compared to the scale models and mathematical calculations; the number of users of the daylighting simulation tools is higher. Their priority depends on being less-time consuming, providing various visual scenes for various physical and sky conditions. It is possible to detect any deficiency in the design phase and provide solutions before its construction. So it is cost-efficient. In this paper, the discussion is based on the physical correctness and usability of these tools for daylighting design decisions and performance analysis. A majority of the studies analyzed Radiance as the mostly used daylighting tool. Output results by Radiance were found to be within acceptable limits, although its physical correctness might fail due to real sky conditions (such as tropical). However, it is sensitive to time variation when compared to Ecotect. In regard to usability, Ecotect seems to be a practical tool because of its shorter learning time and simple navigation, user friendly interface and better graphical representation. Desktop Radiance also uses Ecotect's user interface as a plug-in. The authors concluded that, this is a complex task to determine the most accurate simulation tool. Each one has its own strengths and weaknesses. And it is obvious that the developments in the field of simulation technologies will continue with a growing acceleration aiming to improve these weaknesses. This study suggests that; among the analyzed simulation tools, Radiance and Ecotect together might be preferred in daylighting calculations, especially when designing and examining the effects of advanced daylighting technologies such as laser-cut or prismatic panels in glazing.

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SUSTAINABILITY IN ARCHITECTURE AND THE LIMITATIONS OF ENVIRONMENTAL ASSESSMENT TOOLS

IŞIL RUHİ SİPAHİOĞLU[1]

ABSTRACT

The methods to achieve sustainability in architecture have continuously entered the architectural scene with different conceptualizations of the tie between the elements of the 'tripolar model:' Society, environment, and economics. Although the roots of this model are first delineated in Brundtland report (1987) and concretized at the Rio Conference (1992), there is actually no consensus on how to conceptualize its framework. The model acts as a discourse, but it hasn't yet reached such a status to define a Khunian paradigm that might lead to a universal way of interpreting the elements of the model. Despite the lack of a generally accepted paradigm, the field is in the search of defining "best practices." Current researches on building environmental assessment tools best illustrate this trend. The paper aligns itself with researches that aim to take benefit from multiple perspectives of designing sustainably to enable the making of "green knowledge." In order to pave the way for this multiplicity, the paper discusses the influence of environmental assessment methods on design process, through three case study methods: BRE Environmental Assessment Method (BREEAM), la Démarche Haute Qualité Environnementale (HQE) and Deutschen Gesellschaft für Nachhaltiges Bauen (DGNB) certification system. While underlining the aspects of design process that is torn between objective and subjective decisions, the paper discusses the role of assessment methods in framing these decisions. The paper first delves into the epistemological and theoretical point of views that have prepared these methods. This examination bases on the design epistemology of Nigel Cross, that is, the study of "designerly ways of knowing." The paper, then criticizes these tools as to their positivist approach to design problems and their influence on limiting the design alternatives. This discussion is essential because due to the appeal of these assessment tools in marketing the projects, they would become the mainstream practice.

Keywords: Building environmental assessment tool, sustainability, BREEAM, DGNB certification system, the Procedure HQE

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1. INTRODUCTION

Ever since its introduction into the design discourse conceptualizing sustainability in architecture has gained paramount significance in designing and the term 'sustainable architecture' has acquired various meanings. Here I say meanings, because even though the aim of sustainable architecture remains the same, its definitions change contingent on suggested methods to achieve sustainability. These methods have continuously entered the architectural scene with different conceptualizations of the tie between the elements of the 'tripolar model:' Society, environment, and economics. Even though the roots of this model are first delineated in Brundtland report (1987) and concretized at the Rio Conference (1992), there is actually no consensus on how to conceptualize its framework (Findeli 2008).
This model, usually represented with the shape of a triangle (Fig.1), has become a commonplace in architectural researches. However, one can observe that it hasn't yet reached such a status to define a Khunian paradigm. That is not to overlook its role in shaping the discourse, but it still lacks the needed tools that define and that guide a paradigm. Even though in the past, designing sustainably was in our agenda, implicitly most of the time, nowadays there is a call for precise methods or tools for attaining sustainability in architecture. The paper aligns itself with researches (Cole 2005, Guy and Moore 2007) that aim to take benefit from multiple perspectives of designing sustainably, thus those multiple meanings in order to "make green knowledge." This knowledge could possibly enable us to define a sustainable paradigm. To this end, paper focuses on one of the major tools for sustainability, that is, the building environmental assessment tools. The aim is to examine their possible role in limiting the design alternatives. This examination bases on the design epistemology of Nigel Cross (1982, 2001), so called "designerly ways of knowing" in regard to its appropriateness for such a research.
The paper first discusses the diverse meanings of sustainable architecture, and then continues with a brief account on the role of paradigm in sciences and in design. After explaining the suitable design epistemology for this inquiry, it surveys the following tools: BRE Environmental Assessment Method (BREEAM), the Procedure HQE (La Démarche Haute Qualité Environnementale) and Deutschen Gesellschaft für Nachhaltiges Bauen (DGNB) certification system. The paper finds it essential to discuss the role of assessment tools, because due to the appeal of these tools in marketing the projects, they would become the mainstream practice.

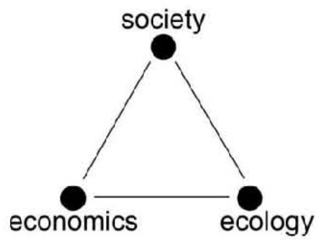

Figure1. The tripolar model (Findeli 2008, p.305)

2. MEANINGS OF SUSTAINABLE ARCHITECTURE

Canizaro and Tanzer (2007), through their analysis of the field, inform us about five competing definitions of sustainable architecture.

1. Buildings and environments that help to establish an integrated relationship with nature.
2. Buildings and environments that preserve and/or improve local ecosystems and which focus on long-term planning and a wider geography.
3. Buildings and environments that result from civic action in which environmental quality, understood both physically and socially, is essential.
4. Buildings that satisfy a series of benchmarks (i.e., LEED) defined by experts, interested parties, and politicians.
5. Buildings and environments that save and/or conserve energy and satisfy our real and perceived needs (Canizaro and Tanzer, 2007, p. 4).

It is observed that each definition foresees the problem from different lenses, and thus reframes the solutions from different point of views. But obviously their reference is the same, as defined by Findeli (2008), the tripolar model, which is first accumulated in the Brundtland report (1987) and concretized at the Rio Conference (1992). Most of the definitions converge on defining frameworks that establish the relationship between the three poles, referred also as forces or goals of sustainability: Economics, environment, Society. Herein lies two problems. The first stems from how these poles conceive sustainability. They belong to different research contexts, and interpret the problems through their proper tactics and strategies that depend on diverse parameters. For example, an economist reflects upon the environmental and social issues depending on his/her "economical theoretical and conceptual framework," (Findeli 2008, p. 306) and this goes without saying that the same process of argumentation for sustainability accounts for an environmentalist or a sociologist. Their solutions to be implemented into projects drive from their own point of view and this situation prepares the ground for the second problem, which is bound to the complexity of attaining such a balance between the solutions of these poles. Besides, each project is specific to its context, which represents different economic, social and environmental problems. The correlation among these problems is therefore dynamic, that might be handled only through a systemic logic (Findeli 2008).
So far there is no consensus on how to handle this complex relationship. In an architectural project, handling the tripolar model, despite its problems, is left to a designer, whose strategies and tactics of analyzing design problems are completely different from those of the economists and sociologists.

2.1. Sustainability as a discourse

Michel Foucault in his book *L'Archéologie du Savoir (The Archeology of Knowledge)* (1972), defines discourse as "regularity (an order, correlations, positions and functionings, transformations)" between a numbers of statements, events or objects, appearing in a specific time. This regularity conveys a "*discursive formation*" (1972, p. 38). As pointed out by Foucault

> [t]he conditions to which the elements of this division (objects, modes of statement, concepts, thematic choices) are subjected we shall call the *rules of formation*. The rules of formation are conditions of existence (but also of coexistence, maintenance, and disappearance) in a given discursive division (1972, p. 38).

While dealing with a definition or statement, discourse is actually active on "its existence and the rules that govern its appearance" (Foucault 1972, p. 30). From this point of view, the tripolar model implicitly merges into the statements. The introduction of this discourse is not a coincidence, as indicated by Foucault, the emergence of discursive rules is not random; there are several conditions preparing the background of a discourse. Just to name a few, environmental movements of 1960s, energy crisis of 1970s, and aftereffects of climate change are seen to have underpinned this model. As a consequence, its sudden emergence has a specific time and space which has its own social, economic, geographical identities (Foucault 1972). The multiplicity of these identities therefore reflects onto the diversity in the interpretations of the tripolar model. Besides, institutions, in our case architectural firms, ecologists, researchers are essential on the formation of the discourse as well as its appropriation with the knowledge and the powers they carry (Foucault 1972). Even though this tripolar model does not lead to a single interpretation of ways of living with nature, it somehow defines a system of rules, and controls the formation of sustainable discourse. It can be considered as a judge formed of special communities who ensure the rationality of the answers, exemplified with spreading of many building assessment tools. The significance of such a discourse is that it helps to maintain the focus of designers on specific parameters.

2.2. Sustainability as a paradigm

In his book *The Structure of Scientific Revolutions* (1962), Thomas Kuhn (1922-1996) states that an accepted paradigm has its own defined rules, can influence the way –in his case, the scientific area– we perceive the world and it has the opportunity to impose a way of thinking. The rules of a paradigm are not accepted by the whole scientific world, but their perspective on the events influence traditions and practices (Kuhn 1996). The formation of a paradigm, like a discourse, is a process accompanied with effective events, ideas, and traditions (Kuhn 1996). Herein, the paper underlines the important role of paradigms in revealing available tools, because a discourse does not equip the researchers with tools or methods of investigation. Kuhn compares the paradigm to a vehicle for a scientific theory, since it puts forth invaluable information about how, in his case natural sciences, nature behaves and what it does and does not contain. These explanations, acting as a map, enable the researchers to delve into complex details. He states that

> since nature is too complex and varied to be explored at random, that map is as essential as observation and experiment to science's continuing development… paradigms provide […] also with some of the directions essential for map-making. In learning a paradigm the scientist acquires theory, methods, and standards together… Therefore, when paradigms change, there

> are usually significant shifts in the criteria determining the legimacy both of problems and of proposed solutions (Kuhn 1996, p. 109).

As suggested above, the tripolar model acts as a discourse, it does not define a paradigm. Thus the perception of the designers is guided by a loosely gestalt. There is no direction to teach someone to develop a paradigm, but ways to convert this discourse into a paradigm. A group sharing a paradigm will have a consensus on beliefs and values that might lead to a universally distributed across the world, however locally sensitive way of interpreting the elements of the model. This does not mean that a paradigm shall dictate a universal definition, but it should guide the designers to deal with the poles.

2.3. The epistemology of design suitable to address the problems of sustainability

Acquiring knowledge in the design field necessitates an epistemology of design suitable to make researches on problems of sustainability. Researches in sciences – here I refer to sciences such as, physics, biology, and chemistry,– even though depending on diverse epistemologies, have so far established various criteria to justify their quality of knowledge. In contrast to scientists, whose aim is to define the components of existing structures, designers "try to shape the components of new structures" (Alexander cited in Cross 2006, p. 97). Designs are the outcome of objective and subjective decisions.[2] This duality reflects also on the dichotomy of sets of epistemological perspectives of the researches on design processes: Positivism and constructivism. Positivist approach draws possible inferences from the scientific methods for a rational way of treating creative design problems. Positivist approach holds that by processing the sensory data, which are gained from an objective world, through a priori categories enables the subject to know the object (Dorst 2004). The constructivist one deals with making that knowledge by investigating design-based practice, in this sense it also involves a phenomenological perspective as it conceives the environment and history of the subject (Dorst 2004).

One objection to the positivist approach is related to the nature of design problems. Researches in the field converge on the impossibility to define design problems, since they are ill-defined and in Rittel's words they are actually "wicked problems" (1972). They are not amenable to decomposition, thus to a positivist and inductive approach. To overcome this problem, one of the main pioneers of constructivist approach, Donald Schön proposes an epistemology based on the investigation of practice, because practice is "implicit in the artistic, intuitive processes which some practitioners do bring to situations of uncertainty, instability, uniqueness, and value conflict" (2006, p. 99). That is what he calls "reflective practice." In line with Schön, Nigel Cross states that an appropriate paradigm for design research is still building and the design epistemology lies in the study of "designerly ways of knowing" (Cross 2006). He identifies five aspects of "designerly ways of knowing:"

[2] Bartneck (2008), for example, points to the overlaps between the quality criteria of science and design, but they are inefficient in enhancing the formation of a proper epistemology.

- Designers tackle 'ill-defined' problems.
- Their mode of problem-solving is 'solution-focused'.
- Their mode of thinking is 'constructive'.
- They use 'codes' that translate abstract requirements into concrete objects.
- They use these codes to both 'read' and 'write' in 'object languages' (2006, p.12).

If the designer uses this epistemology in designing, then the design research should follow this path. In a similar vein Gadamer points out that "the basic operation in the acquisition of knowledge" is interpretation, which is formed of two activities: Objective interpretation and subjective interpretation. While objective refers to "what the thing itself already points to," the interpretative one questions the "attribution of value to something" (Dorst 2004). While referring to design processes, Dorst states that "the type of interpretation that is dominant varies through the phases of design activity, and across design situations" (2004). Therefore, an epistemology suitable for the design process and consequently for the researches on design processes should conceive ways of knowing the interaction between the subjective and objective decisions.

In line with this understanding, we should refer to Guy and Moore's (2007) call for a pluralist approach to sustainable architecture that may flourish the "making of green-knowledge" (2007, p. 16). Released from all the epistemic communities, they suggest that we should not limit ourselves with labeling best practices,[3] but instead we should look for diverse examples, which are produced in different contexts with different ways of seeing and practicing sustainable architecture. At first look their approach seems to be pragmatic, but it is possible to argue that a constructivist epistemology underlies in their researches. Dealing with diverse objective and subjective interpretations of designers could enable the researchers in generating a paradigm.

3. DESIGNING WITH "METHODS"

Despite the lack of a generally accepted paradigm, the field is in the search of defining "best practices" to enable the growth of the "green-making knowledge." Current researches on building environmental assessment tools best illustrate this trend. In regard to ambiguous meanings sustainable architecture and the discussion above on "making of green knowledge," the paper aligns itself with Moore and Guy's approach. This approach is best explained in Cole's words:

> A clear difficulty is the existence of a multiplicity of views of what form a sustainable future may take and each is capable of generating a wide range of approaches to building design and construction. Moreover, given the uncertainties of climate change and associated social, economic and political consequences, there will be no single or easy path to a sustainable future (Cole 2005, p.460).

With the intention to pave the way for this multiplicity that enriches our knowledge on sustainable design, the paper discusses the influence of building environmental assessment tools on design process, through three case study assessment tools:

[3] Actually we do not know whether this label is attributed properly.

BREEAM, the Procedure HQE, and DGNB certification system.[4] First, it delves into the epistemological and theoretical point of views that have prepared these tools and secondly reveals the possible impact of the use of these tools on limiting the design outcome.

3.1. From theory to methods

How do the building environmental tools limit the designerly ways of knowing of the architect? How "the designerly ways of knowing" is integrated into these assessment tools? How these tools influence the designers' interpretation of design problems? In order to answer these questions, the paper refers to a graphic illustration (Fig.2).[5]

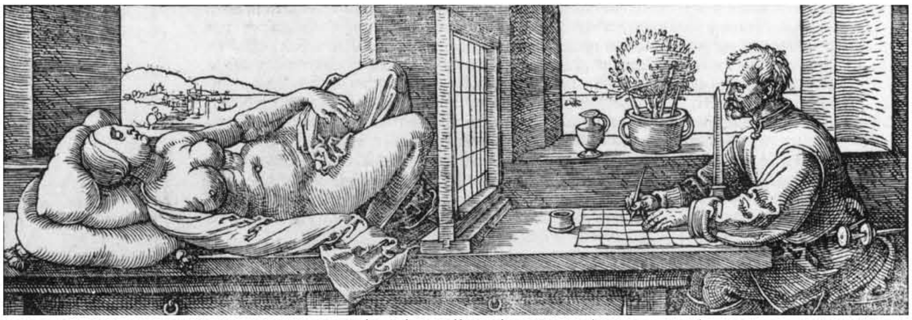

Figure 2. A woodcut by Albrecht Dürer (1471-1528).

In Dürer's woodcut, the artist does not only contemplate on the object but he also draws it according to prescribed method. He views the object through a grid, which acts as a measurement element. The artist trust the data gained from the grid. Groat and Wang states that

> [i]t is that he accepts certain presuppositions about the empirical universe, to wit, that the objects that make it up can be understood by certain geometric relationships that hold constant. What he assumes is theoretical. What he does based upon those assumptions is methodological (2002, p.74).

This illustration is given to better explain the role of assessment tools, because even though these tools are not originally generated as design guidelines, in the absence of better alternatives, they have become as such. Consequently, researches in the field discuss the use of these tools as guidelines during the design and construction process (Crawley and Aho 1999; Ding 2005; Ding 2008).

3.2. Building environmental assessment tools

By evaluating and making public the sustainable qualities of buildings, environmental assessment methods aim at reducing the detrimental effects of

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[4] This paper is limited to the BREEAM-Offices, HQE–bâtiments/enseignement, and DGNB certification system –New Construction of Office and Administration Buildings.

[5] This illustation is used to explain the relationship between theory and method by Linda N. Groat and David Wang (2002, pp. 73-74).

construction practices on natural environment. The following table summarizes the major characteristics of each assessment tool.

Table 1. Table explaining the characteristics of building assessment tools

	Modes of qualification	Modes of certification	Definition of sustainable (green) building	Implicit epistemology
BREEAM	After Design stage (DS) and Post-construction stage (PCS)	Checklist	Efficient use of resources + maximizing the use renewable energy + quantitative evaluation of social aspects (indirectly)	Positivist
The procedure HQE	After the program, the design process, and after the construction	Checklist + a system that evaluates the working systems of the design professionals	Efficient use of Resources + Economy + quantitative evaluation of social aspects (indirectly)	Positivist in evaluation + Constructivist owing to its working check system
DGNB Certification system	After Design stage and Post-construction stage	Checklist	Efficient use of Resources + Economy + quantitative and qualitative evaluation of social aspects (directly and indirectly)	Positivist

Evaluation schemes act in a checklist manner to demonstrate whether a building meets certain qualitative and quantitative criteria, and the final performance is the sum of the points gained from the constituent environmental credits. The performance credits are independent so as to avoid double-counting; they are thus isolated from each other (Cole 2003). All these methods exhibit a positivist approach in evaluating a building. They entail that evaluation can be made by decomposing the design problem. However in regard to the discourse on sustainability, designing requires the optimization, hence the interaction of parameters of the tripolar model.

In the tools, criteria are composed of both quantitative and qualitative performances. Although quantitative ones, such as annual energy, water consumption, and green gas emissions, can easily be represented, the qualitative ones, such as, impact on ecological land, and impact on local wind, can only be evaluated on a feature specific basis, where the points or credits are given in case the project has or has not the needed features. Ding underlines that it is these qualitative criteria that become decisive in environmental issues (2008). Therefore the knowledge gained from these best practices could not be justified.

The definition of sustainable building differs among these tools, which exhibit different tactics and strategies to define the relationship between the elements of the tripolar model. Then it does not mean that a project labeled as "best practice" with a method will receive the same label when assessed with another one. The relationship between poles is established with different weightings and credits of criteria. A possibility of subjective decision on the relationship of the poles is lost. Besides given the lack of intense prerequisite criteria that a project must comply with, in BREEAM and DGNB certification system it is possible obtain a significant label if the design process focuses only on particular categories. A low score obtained from one category can be compensated by a higher score in other categories to certify the building as environmentally sensitive. A good or a very good label does not mean that the building pushes the edge towards an environmental project. The evaluation of HQE is more convenient in regard to its evaluation method, since in order to obtain the certificate, the integrated design process is controlled by the Système de Management de l'Opération (Management system of the operations, SMO). Despite a positivist in the evaluation process, its control system enables to build knowledge.

3.3. Building environmental assessment tools as a "grid"

How can a designer trust these methods or "grids" in gaining data? In regard to their characteristics, the paper illustrates the problem for BREEAM and DGNB certifications system with reference to the Dürer's woodcut (Fig.3-4).

There is no such true way of attaining sustainability, but these tools define methods, which base on the sustainable definition of the tool, thus the problem especially stems when these tools are used as design guide. Designing is a top-down system, and these tools starts from a bottom-up direction, that is, from technical details of a system. Focusing on these details would possibly hinder subjective interpretations, thus variety. They are not suitable for "designerly ways of knowing," as their evaluation bases on an epistemology suitable for researches in natural sciences. They suggest a way to tackle ill-defined problems through a pre-defined path and frame the interpretation of the designer. In case several of these tools gain significance in the field, their "grid" would disseminate in the market and would fuse into the design process of new projects. Consequently, multiple solutions would be lost to the field, and thus the formation of a generally accepted paradigm in the future.

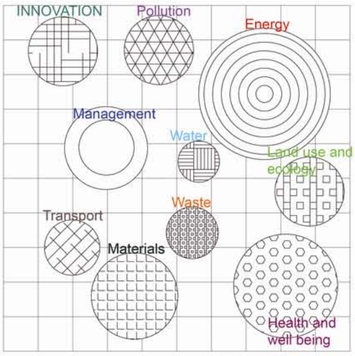

Figure 3. 'Grid' of BREEAM

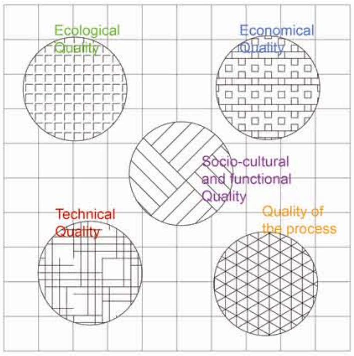

Figure 4. 'Grid' of DGNB

4. CONCLUSION

Starting with the discussion on multiple views on sustainable architecture, the paper aimed to put forth the role of the tripolar model in shaping the discourse on living with the nature. It is observed that even though there are diverse interpretations on how the model should be conceived, so far a paradigm, which reveals proper tools to deal with issues on sustainability, has not been yet founded. To this end, it might be possible to call this situation in Kuhn's words, a "pre-paradigm" period or maybe there is no possibility to talk about a paradigm for sustainable design. In order to arrive at such a conclusion, the paper suggested to uptake multiple perspectives that have generated architectural projects.

In order to make "make green knowledge," the paper suggested pursuing suitable epistemologies for design and referred to Nigel Cross's design epistemology. While underlining the aspects of design process that is torn between objective and subjective decisions, the paper aimed to discuss the role of assessment tools in framing these decisions. This intention is bound to the current use of these tools as design guidelines.

The paper argued that the tools, due to their positivist method, do not suit to the epistemology of design. Or put differently, their evaluation questions, I may say, do not stem from a suitable epistemology to know the sustainability of the project at stake. More importantly, their methods and tactics bases on frameworks, which are not prepared according to a general consensus. The paper concludes that the limitations put onto design processes could possibly obstruct to attain diverse, or maybe, more efficient, and optimized design solutions. Currently, the effectiveness of these assessment tools in defining best practices is ambiguous, but accompanied with marketing tactics, and extensive use of these assessment tools might lead the society to conceive their definition of sustainable design and their methods as a reality.[6]

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FABRICATING A LIVING SYSTEM - UPLOADING THE DESIGN PROCESS INTO MATERIALITY PERFORMANCE

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ABSTRACT

This paper presents a key area under investigation in Vitruvius FabLab at ISCTE-IUL, Lisbon. A new and unexplored convergence between material and computation is rising up. The increasing capacity of architects to integrate more multidisciplinary and complex design information combined with technological developments and industrial logics are leading the Vitruvius FabLab researchers into a context of computer-controlled manufacturing and fabrication. Our pilot experience was held by an interdisciplinary Lisbon Workshop "Discursive Wall – a Living System" held at the Vitruvius FabLab-IUL, in March 7th-11th (LS_01) and March 29th-April 1st (LS_02), 2012. The main challenge presented in this workshop was how the combination of traditional and national materials like cork and Valchromat (color MDF derived) with mechanical devices could be able to built a 'Discursive Wall' that physically responds to movement, interacting spatially and temporally with the environment and its inhabitants. Understanding, studying and knowing the material natural properties, performance, limits and strengths, was the key to determine and conceive the design, performance and assembly processes of the super 3x5m wall panel. In other words, form follows performance that follows material. More than expecting to find architectural surfaces solutions, this experience enables us to explore materials SWOT's leadings us into new behavioral forms and performance according to different surroundings and inhabitants.

Key words : Materiality, Performance, Digital Fabrication; Morphogenesis.

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1. INTRODUCTION

"Material properties, characteristics and behaviour can now be employed as active design generators, and the microscale of material make-up and the macroscale of material systems in architecture can now be understood as a continuum of reciprocal behavioural characteristics and performative capacities. (Menges, 2012:16).
In the last decades several questions related with performance and interactions in architecture have come into the interest of architects (Hensel and Menges 2008). The increasing development of digital fabrication, manufacturing technologies, and design computation provides possibilities of integrating physical and material behaviour as generative drivers in the architectural design process (Volkov et al. 2008). Instead of conceiving by drew, modeled or even digitally generated geometrical parts, computational design material elements are defined by material physical properties, their components, coexistence and complexity just like a truly living system. The autopoiesis theory (Maturana and Varela 1971) seems to contain the necessary knowledge to enable the creation of individual self-producing systems at least up to the definition of the fabrication parameters; but several architects argued that going further, the implementation of locally-sensitive differentiation, achieved through morphogenetic responsiveness, can produce more flexible and interactive architecture (Kronenbur, 2007; Fox & Kemp, 2009).

1.1. Related work

The first relevant study (never built), was lead by Cedric Price, "the fun Palace" project. This project explores the central idea of belief that through the use of new technology the public could have full control over their environment and as a consequence, have a building which could be responsive to its visitor's needs and activities. The project was composed by modular panels and pre-fabricated elements that could be inserted or removed as an open framework that could be adapted according to different needs. More recently, in 2001, Mark Goulthourpe leads the "Aegis Hypo-Surface" project. The system is composed by a metallic surface, subdivided in thousands of triangles, that has the ability to physically deform itself, in response to electronic stimuli from movement, sound and light. In 2003 Michael Silver develops the 'Liquid Crystal Glass House'. The project aimed to solve sunlight and heat issues, through the development and constantly adaptation of the electronic building skin, shifting from transparency to opacity. Recently, Anshuman developed a smart surface designed to regulate light, solar radiation and views, as well as display dynamic signage called 'Pixel Skin'. Pixel Skin is an electrographic surface which allows the integration of illumination and view controls with real-time communications media. During the last decade, several projects aiming at exploring the material behavioral and performative potencial led the Living System definition to a new level. Some examples of architectural production, resulting from this principle, can be cited, like 'Differentiated Wood Lattice Shell' (Huang and Park, 2009), based on the development of a wooden truss establishing a dialogue between the property of the material, the behavioral system, the generative computational process manufacturing and robotics. The project explores the unfolding of material through the performative capacity of wood. The Hygroscopic Envelop Prototype (ICD, Stuttgard, 2010), based on a structural system responsive and hygroscopic, consists of a structural surface composed of several regions sensitive to local humidity, concentration moving and adapting to climate change. The AAETH Pavilion (AAEmTech and ETH Zurich, 2011), consists of a structure entirely derived from the performance characteristics and potential of the wood.

1.2. Discursive Wall – a Living System

The Lisbon Workshop "Discursive Wall – a Living System" was held at the Vitruvius FabLab-IUL, in March 7th-11th (LS_01) and March 29th-April 1st (LS_02), 2012. The workshop involved three main partners: VitruviusFablab-IUL, FabLabEDP and Rhino3DPortugal/DigitaLab.

Discursive Wall – a Living System was composed by four main factors: A) explore the integration of Black Cork and Blue Valchromat – both national production; B) the design of the Wall should be entirely conceived through parametric tools; C) to produce the movement of the Discursive Wall, virtual simulators and low cost technology should be used; D) the fabrication of the Wall should be entirely made through CNC resources, avoiding any kind of supplementary materials for assembly. So the physical goal of this workshop was to produce a periodic structure, customized using the digital fabrication processes. The main focus of this pilot project was the transformation of different data, from the materials, performance – wall components into the simulation and fabrication of the mutable and constant design and re-design process – behaviour of the wall when facing its environment and inhabitants (Oliveira *et al.*, 2012).

2. OBJECTIVES

2.1. Project scope

This paper presents a description of the process and results of the Workshop 'Discursive Wall – a Living System' held at the Vitruvius FabLab, ISCTE-IUL, in Lisbon, during March of 2012. The objective of this workshop, was to produce a 3x5m wall panel, constructed by national/traditional materials and low cost technology, that reacts and dialog with its environment and inhabitants. Discursive Wall – a Living System was divided in two main modules, (A) LS_01, Firefly + Grasshopper + Arduino and Scale Model Fabrication and (B) LS_02, Design Studio – Discursive Wall. The workshop had the participation of students and professionals from different areas of knowledge (architecture, product design, fashion design, sculpture, engineering, electronics, and programming) from different countries. The workshop explored materials properties and characteristics – understanding plasticity, lightness, resistance and robustness and its self limits; the use of Rhino Grasshopper plug-in – for the form design of the wall, enabling the participants to integrate several material characteristics components and defining form through the use of material limits; Firefly add-on – for the creation and movement simulation; and Arduino – as creative and technical movement tools.

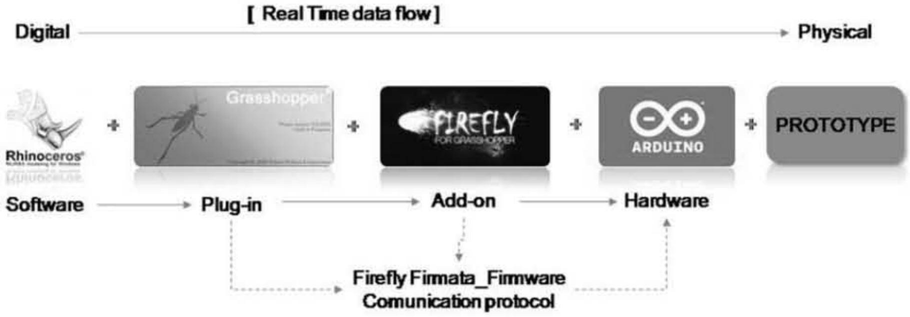

Figure 1. Workshop Framework (by Brimet Silva).

2.2. Goal

The goal defined for the 'Discursive Wall – a Living System' was to create a responsive wall to human interaction, using black cork, Valchromat and low cost technology through the use of digital fabrication processes and resources. Based on the hypothesis of an architectural living system the wall is constantly being designed and re-designed through its inhabitants and environment. This autopoiesis wall prototype organism has 3,0x5,0m, and physically responds to movement, establishing a direct dialog with the inhabitants, constantly reshaping their perception, minimizing acoustical problems of the space. The acoustical issue was determinant to establish the scale and the material of the prototype – Valchromat and Black Cork.

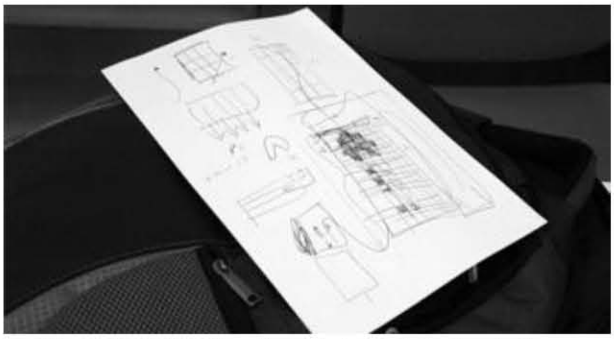

Figure 2. Elaborating idea. Photograph by the Authors.

2.3. Materials

Discursive Wall was built by two different materials: black cork as a front effect panel and valchromat as structure and movement mechanism. Cork is one of the principal raw material in Portugal. Nearly 720.000 hectares of cork oak trees and bark of the cork oak is known as cork. The mediterranean climate of Portugal is extremly apropriated to cork oak cultivation. Used in several products such as cork stoppers, in fishing rods and floats, in buildings as floor tiles and thermal and acoustical insulation, for artistic purposes, in pharmaceutical plants, in military and automobile industries etc. Its elasticity, plasticity, good characteristics for sonar and climatic isolation, makes it one of the most popular national resources. In the workshop we used black cork which is an insulation cork mainly used has acoustical, anti-vibratic and thermal panels. Generally produced in 0,5x0,5m panels, with 0,1m of thickness, this black cork panels are incredible exterior and interior coating.

Valchromat (a variable of MDF) is a product that combines the natural features of wood to the brightness of colours and, because of its flexibility, allows exploring the third dimension, textures and engineering. It is a wood fibre panel coloured throughout, impregnated with organic dyes and chemically bonded together by a special resin which gives Valchromat unique physic and mechanical features. There are available on the market panels with different sizes and thicknesses, enabling the consumer to analyze and choose the most indicated for each specific use. Not being a natural structural material, Valchromat presents a range of several characteristics that allowed us to make use of its resistance, robustness and elasticity.

3. METHODOLOGY

The workshop methodology development was divided in four phases: (A) LS_01 Grasshopper+Arduino+Firefly; (B) LS_01 Prototyping; (C) LS_02 Design Studio; and (D) LS_02 Discursive Wall.

3.1. (A) LS_01 Grasshopper+Arduino+Firefly

The A phase was dedicated to the creative process and the production of the cork units using the Grasshopper. The participants developed several design logics, like membranes of fibers over the cork, Voronois logics, Metaballs and the Pixel concepts, always regarding density and volume of the several units for each applied motors capacity and cost. The creative process was held through parametric software Grasshopper and Firefly, enabling the participants to control and define different conditional parameters and movements.

Figure 3. Essay movement with Firefly. Photograph by the Authors.

3.2. (B) LS_01 Prototyping

The B phase was the construction of the first test physical model. Four 1,0x1,0m structures with four different black cork design solutions supported by the pre-designed parametric structure, gave rise to specific customized structures so that a best possible match was achieved. Design, weight, robustness and movement effect were the election parameters to be voted for the construction of the final 3,0x5,0m Wall. A poll was held among the participants and trainers and the Voronois was the winner solution.

Figure 4. The four final prototypes from the first module of the Workshop. Photograph by Bárbara Varela.

3.3. (C) LS_02 Design Studio

The C phase was to adapt and fabricate the parametric structure. In the first two days of the second module, participants and trainers dedicated their time assembling the modular structures that together would form the 3,0x5,0m Discursive Wall. The full scale prototype is composed by five 3,0x1,0m independent blue Valchromat modules and a total of one hundred and thirty five 0,33x0,33 mobile black cork pixels. The first phase of construction was the structure, then the assembly of the movement rails and all electronic wires, motors, arduinos and power supplies and at last, the fixation of the pixels black cork.

Figure 5. Perspective view of the structure and the electronics incorporation. Photograph by Bárbara Varela.

3.4. (D) LS_02 Discursive Wall

In the D phase, after all the electronics and the cork panel were assembled in loco, it was needed to establish the location of the movement sensors. A major movement area was chosen, a passage zone. Then it was needed to validate the 1,0x3,0m modules movement, making sure that all the motors were responding and working correctly. This was a delicate issue, since this electronic material is specific to micro scale tests, their durability and precision were very sensitive within this larger scale model. The solution found was to control their velocity and concurrency of movement. The final challenge was to make sure that all of the five independent structures were able to work together and could produce a unique and continuum movement.

Figure 6. Fixing the Discursive Wall. Photograph by Bárbara Varela.

4. CONCLUSION

This workshop proved that architecture is no longer just a drawing exercise. The relations between traditional materials, performance and digital tools offers the possibility of incorporating processes of manufacturing and fabrication in the beginning of design process.A Multidisciplinary approach towards architectural thinking was the particular characteristic that brought this idea to reality. The challenge of translating complex geometries based in living systems into a physical artifact was allowed by the application of advanced parametric 3D modeling techniques that directly were linked to CNC fabrication technology, using traditional materials and low cost technology. The parameterization allowed a quick adaptability to the several elements of the structure, and the manipulation of the assembly parts only with simple assembly logic through the use of material properties parameters. The greatest difficulty was to improve the motors performance within the bearing system. The solution found was to improve the continuous movement with a shorter and slower step-by-step movement. This solution was still able to create the illusion of a continuous movement.

Figure 7. Discursive Wall. Photograph by the Authors.

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EMBEDDING DIGITAL MEDIA IN ARCHITECTURE

LEMAN FIGEN GÜL[1]

ABSTRACT

During the last decade, the practice of architecture has changed dramatically. This change has occurred partly because of a pressure to improve efficiency by stakeholders, and the commercial availability of design software and its reliant hardware technologies. These changes will continue and transform our everyday life and surroundings into a new architecture and digital culture. In this paper I discuss three different uses of the advance digital technologies to create built environment where the boundaries of virtual and physical are blurred. The first one is the employment of the digital technologies in the built environment which are ubiquity providing visual or auditory information; the second one is the use of visual environments for extending and augmenting the built environments providing interactivity; third one is the use of artificial intelligence in built environments including performative design, generative design, parametric design and algorithmic design. The paper concludes with a summary on the characteristics of the types of new place designs.

Keywords: Place making, Digital Technologies, Media Facades, Ambient Technologies.

1. INTRODUCTION

Architecture is always dependent on the technology and the representational techniques of its time. As William Mitchell noted that 'architects draw what they can build and build what they can draw'. Recently the developments in and the extensive use of digital design technologies have brought about fundamental changes in the way the architects design and represent. Design researchers and practitioners have shown an increasing interest in predicting and examining the effect of these technologies in transforming our everyday life and surroundings, notably in William J. Mitchell's epic trilogy: City of Bits[2], e-topia[3] and Me++[4].

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[2] Mitchell, WS (1995). City of Bits. Cambridge: The MIT Press.
[3] Mitchell, WS (1999). e-topia. Cambridge: The MIT Press.
[4] Mitchell, WS (2003). Me++. Cambridge: The MIT Press.

Being parallel to this transformation, an essential part of our existence, built environments have been occupied by digital technologies in several ways. These include the use of ambient technologies in buildings, animated surfaces and media facades, projectors, lighted surfaces etc.

The use of digital technologies in design process seems to have raised an issue concerned with the consideration of the digital model as the "design" in virtual environments. According to Achten and Joosen (2003), the digital model could be considered as the "design" "[…] rather than a representation of the design (technically speaking it is still a representation); in other words, to take a "designerly" stance towards the digital model". This new approach towards the digital model, in other words 'the conceptual design of spaces within virtual reality', makes possible the experience of being "inside" a 3D digital model space through external devices (Dorta and Perez 2006a). In addition, with the advent of digital technologies and the potentials of CNC (computer numerically controlled) construction, designers can develop a provocative and innovative architectural and spatial vocabulary. By using 3D scanning and rapid prototyping techniques, the designers are able to go back and forth between digital and manual mode, thus taking advantage of each one (Dorta and Perez 2006b) to create complex structures.

The emerging digital technologies as new place making elements illuminate interesting opportunities for innovative designs and ideas in built environments. From the use of commercial drafting packages to the advanced use of digital technologies, they come to play a major role in architectural production.

The aim of the paper is to discuss how these digital technologies facilitate design activity and enhance our experiences with architectural space and everyday objects. Whether they enhance the quality of the spaces in which we live. In this paper, we discuss three different uses of the advance digital technologies to create built environment where the boundaries of virtual and physical are blurred: The first one is the employment of the digital technologies in the built environment which are ubiquity providing visual or auditory information; the second one is the use of visual environments for extending and augmenting the built environments providing interactivity; third one is the use of artificial intelligence in built environments including performative design, generative design, parametric design and algorithmic design.

2. VISUAL AND AUDITORY INFORMATION DISPLAYS

The first type of the employment of the digital technologies in built environments is the use of the audio and visual information as an ambient display. The increasing ubiquity of computers and related devices (such as sensors and trackers) and their diffusion into our environment requires reconsidering of the complex interplay between technology and the human. One early view was expressed by Mark Weiser, who observed "that the most profound technologies are those that disappear" (Weiser, 1991), arguing for a vision of an unobtrusive computer technology called "calm technology " (Streitz et.al. 2005).

Built environments can become the interface to communicating remotely with friend, accessing information, executing computer programs and collaborating on projects, without being confined to the computer screens. Such innovative visualisation applications have been used for the portfolio and risk managements, trading analytics, real-time auction systems, customer management, text visualisation, network analysis, environmental impact and GIS information visualisation and so on. These ambient displays that are situated in office and domestic environments provide rich opportunities for information display. Ambient information sources that are the small indications of the state of the world are everywhere. For example, the indication of the number of people are around (via ambient noise), the indication of the weather outside is like (via ambient light). We normally spent very little attention to absorb the ambient information.
To take the calm technology idea further, researchers at the Carnegie-Mellon University developed a device, Breakaway, which is a small sculpture placed on the desk of stationery office worker, interacts with its user (Jafarinaimi et al. 2005), as shown in Figure 1. It draws from performing arts and animation by using pose and gesture to remind the user that she has been sitting for too long and needs to go for a short walk. The key idea of this project is to understand how interactions over time with an ambient display can potentially change human behaviour. The preliminary results show that Breakaway shows a positive relationship between the movement of the sculpture and the user's break times. It also confirmed the clarity of the lifelike and aesthetic aspects of the display to the user.

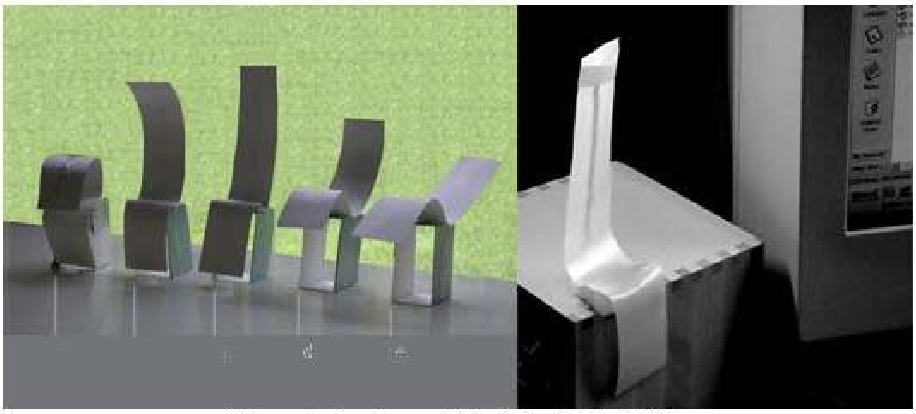

Figure 1. Breakaway (Jafarinaimi et al. 2005)

The advancement of the computer technology have enabled us to provide an architectural space with an electronically amplified memory, e.g. by using sensors that capture data about people's activity in the space and presenting an overview of this data in a visual display. This is different than smart objects which interact with the people around. Skog (2004) proposed the concept of ambient information visualization which is designed to provide subtle information presentation in public places. Skog (2004) proposed the Activity Wallpaper, an ambient visualization of activity information based on an analysis of audio data. The prototype of the

Activity Wall is set up in a cafe as shown in Figure 2. Using sensor technology, the collected audio data is analysed and then projected on a wall as patterns.
The above kind of Ambient information displays are intended to fit in a part of the surface design that does not necessarily have the usefulness property. Most of the ambient displays are designed to transmit background or context information that the user may or may not wish to attend to at any given time. Ambient Displays are designed to work primarily in the border of a user's awareness, moving to the centre of attention only when appropriate and desirable. Heiner et al. (1999) work on ambient display which is designed to give a rich medium of expression placed within an aesthetically pleasing decorative object. This display – the Information Percolator – is formed by air bubbles rising up tubes of water. By properly controlling the release of air, a set of pixels which scroll up the display is created. This allows a rendition of any (small, black and white) image to be displayed. In addition, the ambient display allows interactivity, when people walk past the device it follows their movements with a trail of bubbles. This is intended to invite people to stop and interact with the display. When standing in front of the display, the user can "paint" on the display in real time by moving back and forth in front of it, waving their arms, etc.

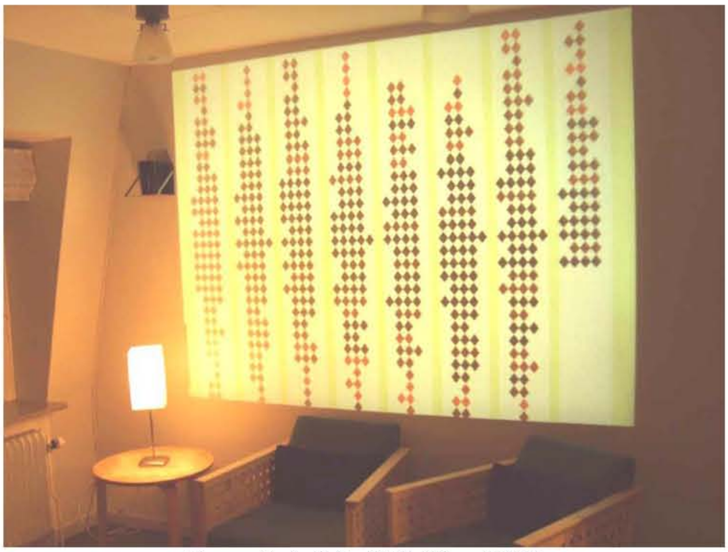

Figure 2. Activity Wall (Skog 2004)

Gu et al. 2008 reported the early attempts to apply digital media as place making elements were media façade; a technique that is very familiar to contemporary architects and artists. Examples of media façades used in architecture and art installations can be seen in Kunsthaus Graz[5], the Blinkenlights project for Haus des

[5] http://www.bix.at

Lehrers office building at Berlin Alexanderplatz[6], as well as Monuments of Switzerland art installation on giant cooling towers. Most of the media facades can be considered as art installations where computers are employed to generate patterns of light or sound. Unlike the commercial models for the smart house which uses different forms of multimedia flatscreens for climate control, light control etc. interactivity technologies have potential to further enhance the architectural space.

3. AUGMENTED REALITY IN PLACE MAKING

The second use of the digital technologies is the employment of the augmented reality technologies in built environment. The main aim of those technologies is to enhance our activities in the built environment and provide new ways of designing by articulation and test of the 3D space.

The term "Cyberspace" for artificial environments inside a computer was introduced by William Gibson in his science fiction novel "Neuromancer" (1984). Unlike Gibson's Cyberspace which was largely illusory and fantastic space, today we used the term in double sense: indicating "virtual reality" "mix-reality" and "augmented reality" that allows interaction within a computer-generated 3D space; and indicating any type of space generated by any computerized information medium. Cyberspace distinguishes itself from other networked technologies by having place characteristics. It is not just another communication tool but the "ultimate destination" where we shop, are entertained and get educated (Kalay and Marx, 2001). For architects and designers, cyberspace can be considered as an excellent tool, allowing the user to study and visualise the full implication of a 3D environments being designed. With the recent use of interactivity technologies in built environment, modifications of real architectural space have maximized. The implications are vast, as "architecture is recasting itself, becoming in part an experimental investigation of topological geometries, partly a computational orchestration of robotic material production and partly a generative, kinematic sculpting of space," as observed by Peter Zellner in "Hybrid Space" (1999, as cited in Kolarevic 2001).

Novak (1996) introduces the concept of "TransArchitecture" and "Liquid Architecture" a fluid, imaginary landscape that only exists in the digital domain. Novak suggests a type of architecture cut loose from the expectations of logic, perspective, and the laws of gravity, one that does not conform to the rational constraints of Euclidean geometries. "TransArchitecture is the architecture of hyperlinked hyperspace" which has a twofold character: within cyberspace is exists as liquid architecture that is transmitted across the global information networks; within physical space it exists as an invisible electronic double superimposed on our material world. According to this view, architecture is free of traditional and conventional forms, characterised as the "dematerialized" architecture. The focus of the concept is on the buildings that adapt and provide unique experiences for visitors, and buildings that interact with visitor, just as a virtual world can do (Novak

[6] http://www.blinkenlights.de

1991). In those responsive environments, enhancing perception and providing action become essential. Spuybroek (2004) argued that the perception depends on the action, and the action is only possible through perception.

Dutch architects in NOX group, designed H2O expo which is an aquatic experience and an interactive installation, "WaterLand"[7] , situated on the island of Neeltje Jans from 1993 to 1997. The design intention of the project is the generation of possibilities of perception of architectural space constructed through user action. The interior responds to the movement of people within the space producing constant changing of lighting, sound, and image projection. The space contains multiple distributed processors of sensors and trackers which produce interference in the continuous processing of a virtual real-time model of water on the walls and floors of the space, as shown in Figure 3. The images from which are projected into the interior changes according to the sensed changes in the environment. "There are interesting innovations here, not least in the distributed intelligence of multiple processors, but what is significant is not the qualities of the interior environment, nor even the real-time immediacy and content of the images projected, but the conceptual schema of interactivity" (Weinstock, M, 2005).

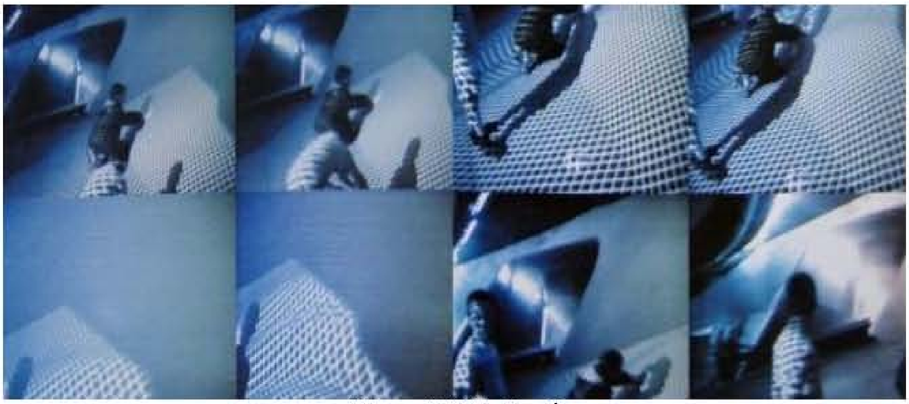

Figure 3. WaterLand
(source: http://www.vitruvius.com.br/revistas/read/arquitextos/11.125/3541)

4. EMERGENT DESIGN TECHNOLOGIES

Third, the emergent modes of computer aided design and manufacturing technologies have transformed the current processes of architectural design practise into a new understanding of the design realm by facilitating the creation of complex geometries, with greater accuracy, faster finishing and increased automation. "Digitally driven design processes characterized by dynamic, open ended and unpredictable but consistent transformations of three-dimensional structures are giving rise to new architectonic possibilities" (Kolarevic 2000).

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[7] http://inaugpea.blogspot.com/2011/09/fonte-httpwww.html

The potentials of algorithmic programming, generative design and parametric design for architecture have been demonstrated through the works of some of the well known designers of our time. A unique and innovative approach to the process of delivering complex building projects (Shelden, 2002) and design artefacts have been developed such as in Gehry Partners, Greg Lynn, ONL Architects and Herzog de Meuron. CAD/CAM (Computer Aided Design / Computer Aided Manufacturing) tools and CNC (Computer Numerically Controlled) technologies started to be used in design profession. These emergent tools provide many new possibilities for the development of industrial manufacturing, creating free-form / complex design artefact and building components. In particular, CNC technologies have the capacity to significantly alter and enhance the relationship between architect and material through the means of digital fabrication (Booth, 2009).

One particular example of the use of high-tech building systems for the design of a house, The Prairie House, is the implementation of the responsive technologies that aim to reduce the impact of building upon the natural environment designed by the ORAMBRA (The Office for Robotic Architectural Media & The Bureau for Responsive Architecture). The house is designed to use actuated tensegrity systems, in conjunction with new cladding systems, to produce a house that is estimated to emit less than half of the carbon of a typical house in Illinois. This work is driven by an attention in using programming as a type of architectural media that may reverse new modes of very specialized operation onto standardized building assemblies.

In addition to the above mentioned use of digital technologies in the architectural design, there is a growing body of research which is biodigital architecture. Biodigital architecture focuses on using nature and genetics to meet architectural objectives and on research into the use of new digital technologies to produce architecture at the real (Estevez, 2009). Estevez (2009) classified that the application of genetics to architecture has two folds: the first research objective is to obtain living elements, building materials and useful living space for architecture. In the Genetic Architecture Laboratory (ESARQ-UIC, Barcelona), researchers are working on the genetic control of growth to develop living cells that are converted into building materials and habitable space (see the Genetic Creation Bioluminescent Plants for Urban and Domestic Use in Estevez 2007). The second research objective is to work on digital design and production seen as a genetic process. This approach includes the creation of architecture by researching strategies using digital morphogenetic, or work using genetic algorithms by experimenting with emergent forms.

5. CONCLUSION

This paper presents three different uses of the emergent digital technologies in creating built environments where the boundaries of the physical and the digital worlds are blurred:

- The use of ambient information technology in built environments where the skin of the building 'facade', building components and objects in the environment are integrated with the digital information. The building components become the container of the user information, responding to its user;

- The use of cyberspace and augmented reality technologies in built environments where the building components interact with the users enhancing the presence and providing experiences. The spaces (virtual and physical) which we occupy become a functional networked environments providing fantasies and interaction; and
- The use of advance digital design and production technologies to create complex built environments where the skin of the building is alive (etc. biodigital architecture) or each individual components of the building is unique (etc. parametric design).

All of the above mentioned approaches of employing emerging digital technologies in architecture reveal interesting ideas, concepts and potentials for built environment designs. Those approaches provide us with new design resources, design tasks and languages which take the job of the architects beyond the creation of forms occupied by some functions. Architectural designs become a subject to consider a form of artificial life, principles of morphogenesis, genetic coding, replication and selection. We can speculate whether the use of digital technologies enhances the quality of the spaces which we live in. However there is one consequence which cannot be argued, that is the conceptual shift regarding the roles of digital technologies in design - to go beyond the traditional understanding and common practice of digital technologies as conventional CAD tools for design presentation and documentation. There is no doubt that the above mentioned three approaches of the use of emerging digital technologies in design will serve as a starting point for further research, practice and validation of digital technologies in innovating built environment designs.

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KEYNOTE SPEECH

16 November 2012 Friday, 13.00-13.30

Prof. Dr. Sevil SARIYILDIZ
Performative Computational Design

PERFORMATIVE COMPUTATIONAL DESIGN

SEVİL SARIYILDIZ[1]

1. INTRODUCTION

Human is the most advanced being in the universe so far. The objective of science is the well-being and prosperity of mankind as a whole and consequently all scientists are responsible to mankind and their function is essential for future generations. Science and technological developments bring advantages and disadvantages, but when used with consciousness, science and technology is able to yield solutions for almost all problems. The goal is to maximize the advantages and minimize the disadvantages.

Concerning the building sector in which we operate, Architecture is an important part of a culture because the buildings, settlements and the cities are the most enduring elements of the culture. Culture is the complex of everything related to the way of daily life and the patterns of behaviour of a certain group or a society correlative to a certain human environment. Belief, art, food, shelter, law, moral, custom, religion, government, social structures, knowledge and *architecture* are all part of a culture. In this respect, there is no cultureless society and the culture is a dynamic and creative phenomenon which becomes apparent in the long period.

The aim of the scientific Research and Developments of the building sector is to provide better buildings and living environment for the human being thus the whole society. Populations of cities overtake those of rural areas, and the majority live in cities**.** Up to the estimations 2/3 of the world population is going to be living in the coming decades in metropolitan areas, mega cities. *Built environment* in cities consume 75 percent of the world's energy and responsible for 80% of the greenhouse gas emissions. Especially in developing countries, the cities and living environment is getting over populated, almost no green and recreation areas and play ground for children in the cities. More and more citizens are being dependent on anti-depressive pills.

This all bring additional problems with, such as social, economical, physiological, health, safety, technical, cultural and the sustainability. As engineers and architects dealing with building science, we are urged to tackle also these material and immaterial issues in an integral approach to provide solutions to the contemporary problems.

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[1] Prof. Dr., Delft University of Technology, Netherlands

Due to the rapid technological developments of the last century and today's worldwide digital communications and the Internet brings us to a new era where the sustainability issues in urban and built environment demands urgent innovative approaches from the building sector in relation to the ICKT (Information, Communication & Knowledge Technology). As academics involved in this sector, our challenge is: how can we support environmental sustainability and enhance the quality of life as architects and building engineers, using ICKT?
The building sector and the built environment show increasing new demands. Contemporary cities require also recognizable, prestigious buildings as an icon of the city. Cities require new identities. In architecture, not only the design of an innovative form of a building (such as free form, fluid architecture, dynamic architecture) but also in aspects such as comfort, safety, wind, energy efficiency, health, indoor climate, building services and the new requirements on logistics, innovative construction techniques and materials, which fulfils the overall performance of a building.
Besides these economical, historical and cultural aspects in relation to sustainability issues needs attention in our buildings and contemporary cities.
Above mentioned complex aspects in the building sector brings new challenges which the existing knowledge can be captured with the new knowledge, to be progress as an integral part of design & engineering processes. Integral approach in design & engineering is partial solution to deal with complexity to reach sustainability as well.
General definition of science is the "Knowledge about the structure and behaviour of the natural and physical world, based on facts that you can prove, for example by experiments" (Oxford dictionary). In its essence, the scientists are trying to discover everything what we can experience and observe, which already exists in the universe and the nature. An exact scientist discovers the material world and the soft scientist mainly deals with immaterial world, such as psychologist, sociologists. In the exact science generally the immaterial aspects, such as intuition, perception, comfort, cultural, spatial perception and the spiritual values are neglected and considered as not existing, since they cannot be observed or measured by traditional measurement means.
The Architects are dealing with the design of the future reality of the living environment. In this respect we have a big responsibility for the society where we live in but also for the generations to come.

2. ARCHITECTURAL DESIGN

Design is the Description (projection or model) of the (future) reality. Everything we see around us is designed. In architectural design, we deal with Alpha, Gamma and Beta sciences. **Beta** mind scientist deals with the objective world of facts & logic represented by rational mind. **Alpha** mind scientist deals with the subjective world of beauty & moral represented by artistic intuitive soul and the **Gamma** mind scientist considers the interest of society and culture. The mixture of these sciences makes the designer and the design task unique. While processing the design, the

designer uses her/his intuition and logic. The successful designers and architects are the ones who use the mathematical and intuitive intelligence in their design work. Up to Pascal, human being has 2 types of intelligence, namely *mathematical* and *intuitive*.
It is very hard to define exactly what a design is and how architects design, because every single design is as unique as the designer her/himself. There are no general, unanimous rules applicable to each process and each designer. The starting point is always different, although there are certain questions every designer will have to face. In the design task, whether it is a bread toaster, teapot, mobile phone, bridge, off-shore work, settlement, a district design or a building, each design starts with fulfilling *program of requirements*, independent of an object. All objects have functional requirements where then the form qualities added.
In this case different added values will be expected, in particular those regarding quality of form. Of this design of the architect people will expect even more, namely the perception of space. Not only should a new building look attractive, but people should also feel good inside the building and in its immediate surroundings. In this respect there is a fundamental distinction between architectural design and the designs in most other disciplines.
In the eventual realization of a design various disciplines will play a role, and in the completed design, function, technique and form should be expressed as integral parts. The concept of an architectural design shows similarities with the real object, the building itself. At the end of the design process a virtual object is created, showing the same geometrical and morphological qualities as the real object, both in space and in time.
Emeritus Professor Helmut Emde of the 'Technische Hochschüle Darmstadt' ('Darmstadt University of Technology') explains the notions of space and time in his book 'Simulation und Wirklichkeit' ('Simulation and Reality') by placing the ideas of Kant, Newton and Leibniz next to each other. According to Kant, space and time are: "The two ways human consciousness beholds", by which he means the forms of insight of human consciousness. Newton postulated: "Space is God's sensorial area", with which he wanted to indicate that it is in *space* where we can sense God.
Leibniz' concept: "Space is the arrangement of the being-togetherness" connects the statements of Kant and Newton, which relate to consciousness and the material being respectively. In this sense: "Time is the arrangement of things that come after each other", also applies.

3. ARCHITECTURE, TECHNOLOGICAL DEVELOPMENTS & GLOBALIZATION

Architecture refers to the science of designing and constructing buildings and built environment to meet people's physical, **moral** and **spiritual** needs, and **cultural values** making use of alpha beta and gamma sciences as it was stated earlier. Therefore it encompasses soft and hard aspects. It is the combination of arts and sciences.

Famous innovators and architects such as Buckminster Fuller in the history was also a man of many trades: engineer; architect; mathematician; poet; teacher; and philosopher. He is best known for his invention the geodesic dome which is extremely light and almost indestructible. He was also a person very concerned for humanity in many respects.

The most significant difference between the other designer's discipline and the architect is the additional spatial value of an object, thus the spatial design qualities. For example the Rotterdam Erasmus Bridge was designed by the Dutch architect Ben van Berkel of UNStudio NL Amsterdam, who was asked to bring the additional design qualities to that bridge which should be considered as an signature or an icon of the city of Rotterdam. Santiago Calatrava is another example who built bridges in many countries as an architect. The bridges he designs have also become world famous which is breaking tradition and symmetry is truly unique. Calatrava's designs are ambitious, intricate and innovative. It is due to these architects integrated approach and the spatial perception abilities that they have been asked to design all over the world, internationally recognized. In contemporary architecture, Santiago Calatrava is one of the most successful architects of the world. He is an Engineer, architect and an artist. Calatrava's most obvious contribution to the contemporary architecture is the Combination of expressionism and mathematics. He integrates the Design and Engineering in a spatial context, by exploring the creativity.

In the design task of an architect, it is expected that the architect brings additional qualities next to the spatial perception qualities. Those are the material and immaterial-spiritual, physical and non-physical values. The most successful and enduring architects are the ones who are able to realise this balance of physical and non-physical values in their buildings. But how can we make these values explicit due to their soft nature?. The physical values are possible to process in design by various methods, by calculating structures, firmness, detailing etc. But can we make these soft aspects such as non-physical, emotional, spiritual and beauty aspects explicit?

Technological developments have always influence on human behaviour and in the long term culture. Since the ongoing developments on internet and visual media and ICT technology, we see also the other side of the medallion. Some scientist are concerned about the visible disadvantages in social behaviour, such as the Founder and director of the MIT Initiative on Technology and Self, sociologist, anthropologist, and psychologist prof. Sherry Turkle in her best seller book entitled *Alone Together. Why we expect more from technology and less form each other* she says: “We've gone through tremendously rapid change, and some of these things just need a little sorting out. I believe we shouldn’t applaud the existence of technology without criticizing which is not showing respect to traditional values…”.

Another award winning journalist, ethicist and communications specialist prof. Michael Bugeja claims: "We have forgotten how to respond ethically, emotionally and intellectually to the challenges, desires and opportunities of life at home and at work" .

Prince Charles at the opening lecture of the Islamic Centre, at Oxford University, entitled “İslam & Environment”, (10 June 2010) points out that the blind pursuit of

the exclusively material oriented values is the source of the environmental sustainability problem. He emphasized the value of the sacred traditions of the world as a creative resource to solve this problem. In particular he mentions the unexplored potential of the sacred geometrical knowledge in arts and sciences.
Globalization and technology have indeed positive and negative effect on human behaviour and therefore on the sustainability issues as well in broader term. The societies are becoming more and more a consumer society, which we only consume without producing. This includes also the production of new, novel knowledge.
One of the most significant negative effects of the globalization in architecture is that:

- Too little attention paid for people's moral and physiological needs,
- Disappearing vernacular, traditional building technical knowledge,
- Disappearing cultural identities and values.

"First we shape our dwellings, and then our dwellings shape us", as Winston Churchill stated. This statement reminds me the situation of many cities in Turkey as well.
The figures underneath are the examples of how we dealt with our building cultural heritage and the values in the contemporary cities and buildings in Kayseri Turkey. It is an example of my hometown Kayseri, which the history of the city goes back to 4000 years BC. It show the cultural lost and the lost of the old city grid which is now filled with the bad copy of the western architecture which does not fit in the culture of the people and life-style. In this respect, we believe that the academics and architects should find solutions for this lost try to find the balance between old and new. We believe that the partial solution will be also returning back to the soul, to self origin and cultural historical values, which needs academic research and new knowledge to capture.

Figure 1. The house of Ataturk and the interior in Kayseri-TR
Figure 2. The so called modern city of Kayseri


Figure 3. Traditional house architecture
Figure 4. Modern architecture building in Kayseri-TR

4. COMPUTATIONAL DESİGN & DEALING WITH COMPLEXITY

Integration of various academic disciplines with architecture also takes place in our subject area, computer science in architecture. The old craftsmanship which we had in the past has been complemented with a new kind of craftsmanship, in which the knowledge used in the architectural design process is coupled with the machine, namely the computers.

Computers have been used till now in architectural spatial design, for sketching, 2D drafting and later for 3D modelling as a tool but they haven't really been used in a computational sense with algorithms.

In his lecture at the Delft University of Technology, Robert Aish stated: "Necessity is the driving force behind the innovation". Indeed, when there is a need, human being is able to find innovative solutions. In another interview Aish talks about the migration from handcraft to industrial craft to digital craft. He says it is not so much about how to use digital tools but how a user can program tools and present algorithms in order to realize the design intent.

We are now in the stage of being use computers as a partner, by transforming our requirements to algorithms for their support as partner.

Then we can define the term Computational Design as: Computational tools, methods and techniques, which enable designers to formulate their design needs, requirements and rules, and translate them into algorithms that generate designs for buildings, a design approach which exceeds the use of computation as a representational or drafting tool.

Robert Aish describes Computational design as an emerging approach to design that uses the power of the computer to aid the design's progress. Traditionally the designer would create and document drawings or a model as a representation. Computational design provides a framework where various design ideas can be quickly generated and evaluated. It does require some different thinking, for instance the designer would have to consider what variables would need to be driven by the system prior to design, assess what elements depend on one another and identify the desired performance criteria. With these identified a script can be written to provide a framework for the design creation and assessment. So by putting in a little more time at the start, many more design variations can be created, tested and assessed.

5. PERFORMANCE DRIVEN COMPUTATIONAL-INTEGRAL DESIGN

Malkawi defines Performance driven design in their book Performative Architecture as:“ Performance-driven design is based on the recent advances in engineering, simulation, computation and construction to provide with most suitable solutions for the contemporary complex demands for the built environment. It could be argued that this approach is steadily gaining ground and will soon become the norm in the architectural practice.”

In our understanding and handling, within the complexity in a building, overall aspects, such as social, economical, cultural, safety and sustainability till the form, aesthetic, functional, constructional, climate and energy aspects which can be considered during the conceptual phase of the building design process which aims the maximum optimality of a building, using ICT tools, techniques and methods.

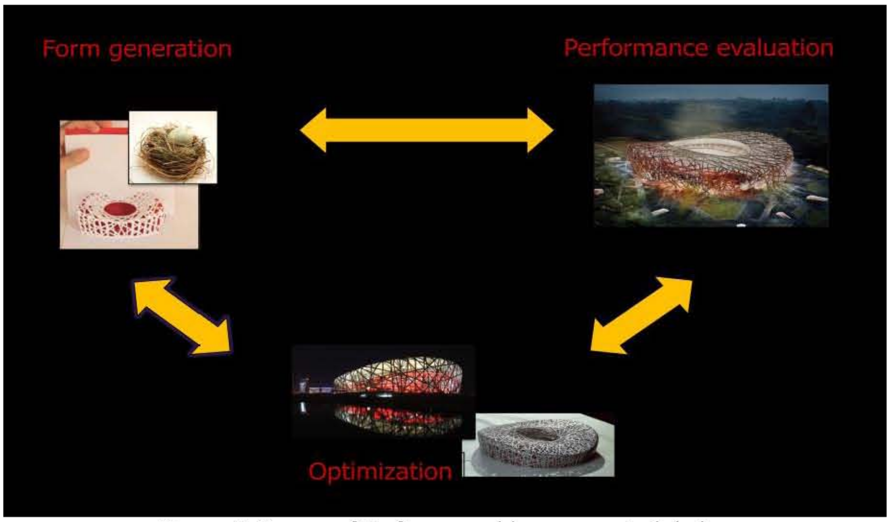

Figure 5. Process of Performance driven conceptual design

It is common knowledge that a computer is very appropriate to check exact criteria, but in the conceptual phase of the design process there are hardly any exact data. In the consecutive phase, the materialization, however, data become more and more exact. To date, materialization has been achieved through a time-consuming procedure, according to traditional methods, which often fails in effectiveness and consistency and does not offer all the possibilities from which to select. The development of methods by which three-dimensional materialization can be supported by means of computer science technology is largely unexplored territory.

During the conceptual (initial) design process, the emphasis is shifting to the processes of form generation, based on performative strategies of design such as structure, acoustics or environment design and the technology has opened up new possibilities for designers to assess certain performance aspects of their designs as it becomes realistic.
The well known contemporary Dutch architect of Ben van Berkel- UNStudio, Amsterdam states: "Architectural practice has expanded over the years and become much more complex. It's no longer the case that a project simply involves the architect and the client. These days the architect works not only with the client, but also with a large network of specialists and advisors. At the same time, not only building and design techniques have expanded, but also the conceptual arrangements of projects; the practice no longer involves only pure architecture, but politics, fashion and the sciences also play an important role. Teaching architecture today means that you have to help students to focus on developing their individual talents on the one hand, but also teach them to choose very carefully within the range of pragmatic possibilities on the other."
(http://www.staedelschule.de/architecture/interview_ben_van_berkel0.html)

Contemporary architecture and engineering practice is working in an integral and collaborative manner, which they handle the complexity as an interactive process where the form and the performance outcome interact with each other to come to the optimal solution. The architects, computational modellers and engineers are working in close collaboration to create most extra-ordinary impossible structures. The leading offices such as ARUP Associates, Bollinger+Grohmann Engineers, and Foster & Partners are working in this manner. Hugh Whitehead, who set up the Specialist Modelling Group in Foster & Partners: "I run the specialist modelling group, which is a research and development group. We relate very closely to all the support groups, so even if we are known as the specialists, we actually deal with modelling in its broadest terms. It takes into account physical processes as well as computer modelling, and also analysis, digital fabrication and rapid prototyping."
At the same office, prof. Stephan Behling (teaching integrated design at the University of Stuttgart -Germany) leads the practice's research into sustainable design and the use of new materials and methods in construction, and established the Material Research Centre (MRC). He is also responsible for the Specialist Modelling Group (SMG), a multi-disciplinary, project-driven research team consisting of architects, engineers, mathematicians, building physicists and environmental scientists who are experts in all aspects of environmental analysis, computational design and digital fabrication.

Figure 6. Foster & Partners office studio in London where they work in an integral approach for the form and performance evaluation, with physical and digital modelling. (http://www.earchitect.co.uk/images/jpgs/products/foster_partners_desks_q191011_5.jpg)

The current concern for the environment evokes fresh challenges for the building industry, such as the necessity of developing building materials that can be recycled and re-used, buildings which can offer maximum comfort and minimum energy use even plus energy buildings as it is already being built in Germany. PlusEnergy is a coined concept developed by Rolf Disch that indicates a structure's extreme energy efficiency so that it holds a positive energy balance, actually producing more energy than it uses.

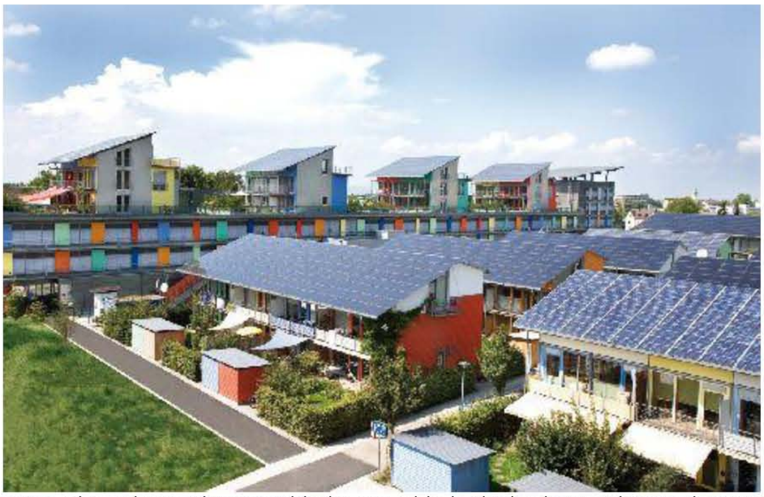

Figure 7. The Solar Settlement with the Sun Ship in the background: two Plus Energy projects in Freiburg (http://en.wikipedia.org/wiki/PlusEnergy)

Figure 8. Efficiency House Plus with electromobility, Berlin-Germany
(http://downloads.german-pavilion.com/downloads/pdf/exhibitor_28292pdf)

The Institute for Lightweight Structures and Conceptual Design (ILEK) at the University of Stuttgart has won First Prize in the architectural planning competition *Efficiency House Plus with electro mobility* issued by the German Federal Ministry of Transport, Building, and Urban Development. The proposed design is developed under the leading of Professor Werner Sobek, which demonstrates the potential of actively coupling energy flows between the emerging fleet of electric vehicles and our built environment. This concept is architecturally embodied through a striking glass showcase in which all of the core technical systems are laid out prominently to form a full-scale living display. The project not only illustrates the feasibility of building future single-family homes which generate a significant surplus of energy – enough to power the electric vehicles of their occupants – but also demonstrates how future buildings can be designed and built to allow for complete disassembly and recycling at the end of their life cycle.

Added value of computational performance means is the Interaction and integration among various knowledge disciplines and involved actors. This yields deep knowledge; so that optimal solutions can be reached that satisfy the broad range of goals at the same time. Indirect contribution of these means to the environment and sustainability is the Modelling and *collaboration* in: design, construction, realization and operational services, *visualization* and *analysis* of the *sustainability performance* of buildings and built environments and search for optimal solutions as an enabler for data, information and knowledge processing, re-use and communication.

Due to the developments in computational design tools, techniques and methods where architects are able to design complex forms, there is increasing new demands on performance aspects of sustainability such as comfort, safety, wind, energy efficiency, health, indoor climate, building services and the new requirements on logistics, innovative construction techniques and materials during the conceptual phase of the design and the interaction between the form and performance aspects.

Figure 9. Serrenia residential resort and hotel complex-Egypt, by Foster & Partners

An example of a performance driven design from the practice is the Serrenia's Marina 'Hub' which is one of the focal points of the development, with an extraordinary wave shaped floating roof and a vast airy, cool space below. A central pier, yacht marina and beach club extend from the hub.

6. COMPUTATION & PERFORMANCE RESEARCH PROGRAM OF THE CHAIR DESIGN INFORMATICS

At the Faculty of Architecture, Delft University of Technology, one of the 6 research programs which run under our leading is the Computation & Performance. The aim of the program is to improve the performance of buildings by using computational methods for model generation and analysis, decision-making and design communication and collaboration in an interdisciplinary environment. Performance in this context refers to technical performance as well as qualitative performance – physical, psychological and cultural. We deliberately do not define performance in any strict manner; comfort and safety, visual attractiveness and iconic quality can be considered performance aspects in the same way as structural integrity, energy efficiency and sustainability, etc. Computation and performance go hand in hand in the aim of this program: computation serves as the means to reach the goal of performance. At the same time, performance is in itself a means to reach better buildings and a better built environment, from urban and regional planning till the building design which we strive for as an ultimate goal.

Few examples of ongoing Phd research projects:

• **Du XIAOYU:** Building Form Generation for Passive Cooling: Digital Generation of Contemporary Rural Residential Building Based on Passive Cooling Strategies of Chinese Vernacular Building

This research focus on digital approach for building form generation and performance evaluation. General objective is to clarify the principle of Chinese traditional vernacular building form design for passive cooling and integrate the current digital design approaches for building form generation based on building performance in the early stages of architectural design. Then, applying this integrated design approaches to the generation of Chinese contemporary rural residential building in hot summer areas based on passive cooling strategies of Chinese vernacular building.

Sub-objectives:

- Clarifying the relationship between Chinese traditional vernacular building form and passive cooling.
- Finding the main characteristics of climate in hot summer area of China and the suitable passive cooling strategies.
- Finding the available techniques from Chinese traditional vernacular building which can be utilized for passive cooling in contemporary building.
- Finding the main characteristics of the new contemporary Chinese rural residential building and the suitable way for its improving.
- Finding the suitable parametric design software for form generation
- Finding the main parameters of building form which can influence the passive cooling effect.
- Finding the suitable evaluation method for passive cooling.
- Integrating the digital environment for the design process.
- Final Products will be the *Guidelines* for new contemporary Chinese rural residential building design with passive cooling system and a Method for *Integrated architectural design approaches* for building form generation based on performance evaluation in a digital environment.
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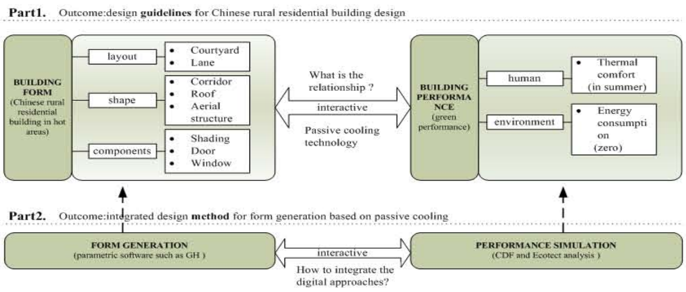

Chinese Vernacular Building Form for Passive Cooling

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- **Abdul BIN IMADUDDIN:** Bioclimatic design in Vernacular Architecture.

The main reason for the existence of vernacular architectures that are different between regions in the world is due to the different climatic condition in the region which they are dealing with. It was known that climate was the main factor that influences the shape and the technique of building constructed before man has a good knowledge on technology and materials. Buildings that have the most economic, most useful and have most effective solutions to the climatic conditions of the region in which they exist are best examples of vernacular architecture (Engin, Vural et al. 2007). Vernacular buildings are the architectural products that come out as a response to the requirements of local climate and as a result of the interaction between human and experience collected by seeing natural environment. Vernacular buildings, either individually or a whole settlement, are the best examples of the harmony between human behaviour, building and the natural environment.

In the studies of the thermal comfort of buildings, they are mainly referenced under bioclimatic design or the vernacular, with the emphasis on basic and good design principles. Relating to bioclimatic design with features of the local vernacular; it aims to create a digital design method for an appropriate domestic architecture for the popular suburban settlements of growing cities around the world.

Bioclimatic design can be defined as a design of an indoor, exterior and outdoor building and space by considering the local weather and climate. The aim to apply bioclimatic design in building preferably to provide a thermal and visual comfort to the building occupant by utilizing natural and environmental source such as wind and solar. The basic element of bioclimatic design is passive cooling which integrate the building with the environmental source for cooling, heating and lighting such as wind, solar, air, vegetation, water etc. to create indoor and outdoor thermal comfort. Hence, bioclimatic design studies on the whole more technical and scientific in nature, while vernacular architecture highlight the issues of culture, tradition and aesthetics as well as comfort. In this writing, both bioclimatic and vernacular designs are discussed for the various setting of the region and different world climate.

Passive cooling means cooling building by utilizing the efficiency of building envelope / fabric without mechanical device assistance. It is only rely on natural ventilation to provide indoor thermal comfort by evaporation, convection and radiant without using electrical device. Passive cooling relay on daily temperature changes and relative humidity thus it will depend on the climatic conditions. Some design strategies to reduce heat gains into internal spaces is natural ventilation, wind towers, courtyard effect, earth air tunnels, evaporative cooling and roof spray.

- **Michela TURRIN:** Performance oriented design of adjustable modular roofs

Performance oriented design of modular roofs

By focusing on modular wide span roofs, the research refers to the field of performance oriented design and relates it to integral design as a way to approach the complexity of architectural processes; the use of parametric modelling is investigated in combination with performance simulation software and genetic algorithms in order to support such design process and the integration of reconfigurable structures is investigated in order to allow roofs for adjustability. By referring to this context, a first concept that needs to be discussed concerns performances in architecture; and this leads to the interrelated concepts of, on one side, complexity and, on the other side, adaptability.

Performance and kinetic architecture

The concept of performance in architecture takes into account the impact that the built environment has on human life, both from a daily and long term perspective, and confronts human needs and wants in their various levels, from basic to high. As a consequence, in order to define and asses a range of performance requirements, data sets need to be identified and managed both for the human needs to be satisfied and for the environmental conditions that may either inhabit or facilitate the accomplishment. Given a specific data set describing the context in its parts, identifying a design solution which satisfies the expected performances is already a challenging task. The complexity of this operation increases even more when considering that the data set does not offer a fixed frame. Human needs and demands change over time, in the short and long term use of the space; and the environment also changes both in the short and long term. Therefore, while traditional buildings are quite static and are usually designed based on the average satisfaction of the most common or predictable conditions, the idea of a building able to properly react to changing needs and environmental factors should be considered.., Possible ways to satisfy changing needs in changing environments include changes in geometry (based on geometrical reconfigurations of elements) and changes in material properties (without implying geometrical variations). The first one requires a change in shape through the movement of one or more elements or parts of them; it is here called kinetic architecture, and has been closely investigated according to the key influence of geometry upon architectural performances.

Parametric geometry and reconfigurable structures for modular roofs

This context gives emphasis to the importance of early integrating performance simulations during the design process, in order to evaluate different geometrical alternatives. On one side, this process refers specifically to the concept of performative architecture, defined by Branko Kolarevic as the one in which building performance, broadly understood, and becomes a guiding design principle (Kolarevic, 2003). On the other side, it requires a network of interdisciplinary interrelations and recalls the concept of integral design by referring to the simultaneous integration of various and interdisciplinary aspects. Such process has been explored based on the combination of parametric geometry and performance simulation software, where the first ones allow the algorithmic creation of geometrical design alternatives that are meaningful for the investigated performances, and the second ones allow their performance evaluation; the use of genetic algorithms has been made in order to guide the search process and to converge the generation of design alternatives toward a set of well performing solutions. Further, the use of reconfigurable structures has been investigated to allow the design switching between different geometrical configurations of its components, aiming at embedding variable geometrical configurations each of which optimized for different contexts.

The process has been developed by specifically focusing on the design of modular large roofs. When focusing on large roofs, aesthetics, structural performances and economics often dominate the design process. However, the current increase in attention to energy-related aspects generates new challenges which require special attention. Particularly, the use of renewable energy resources needs to be confronted in the design. Based on this, structural morphology and solar energy transmittance have been selected as key research subjects. Within this context, special attention is given to the use of (eventually adjustable) components to make the envelope able to use on-site energy resources, like wind and solar energy. Focusing on passive thermal comfort (passive heating and cooling) and daylight, large modular structures are investigated with respect to the ability of being responsive to the daily and seasonal changing climate factors. The use of responsive geometries leads to investigations upon reconfigurable structures as systems responsive to different climatic conditions, including the possible integration of deployable and foldable modules.

The Vela Roof: an example of performance oriented parametric design

Though a first case study, the potentials of parametric modelling for performance oriented design have been explored. The case study is a large span roof (here called “Vela”), part of a project active in Bologna (Italy). Since the risk of summer thermal discomfort was expected under the roof, various strategies have been investigated considering passive systems and their effect on the thermal comfort. With respect to the investigated strategies, the geometry of the roof plays a key role and its exploration was integral part of the performance oriented process. In this context, parametric modelling was used in order to jointly investigate the overall shape, the structural morphology (with eventual integration of openable modules) and the cladding system of the roof. In particular, the models aim at parametrically generating three integrated families of geometric instances. The first one concerns alternatives of the overall free-form shape of the roof, to drive the airflow for cooling. This includes alternatives of the structural morphology, which were studied according to previous choices that favoured a space frame typology. The second one concerns the integration of openable modules in order to allow summer heat extraction. The third one concerns the sun shading properties of the cladding system, which play a fundamental role to prevent thermal discomfort. Specifically, this third investigation was based on ETFE pneumatic cushions with a north-south printed shading system aimed at reducing the direct solar radiation by allowing the income of indirect light. Figure 10 shows an example of performance evaluations for shadow effect (and direct solar exposure) and daylight of various parametric alternative solutions, generated to explore different opening angles of the printed shading.

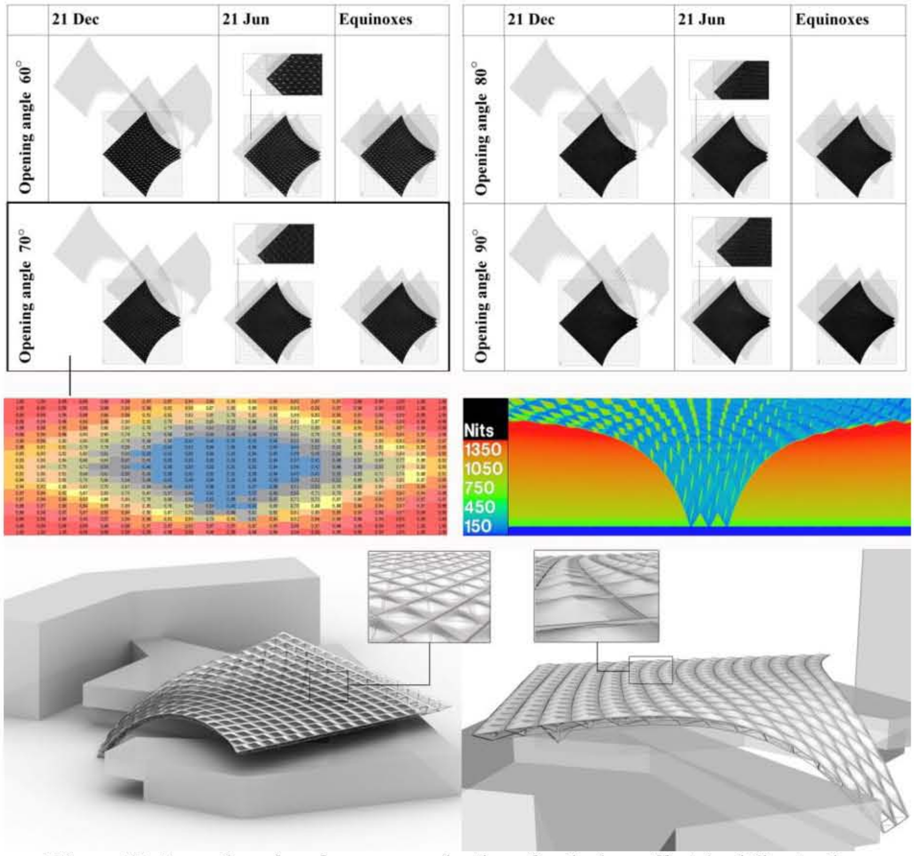
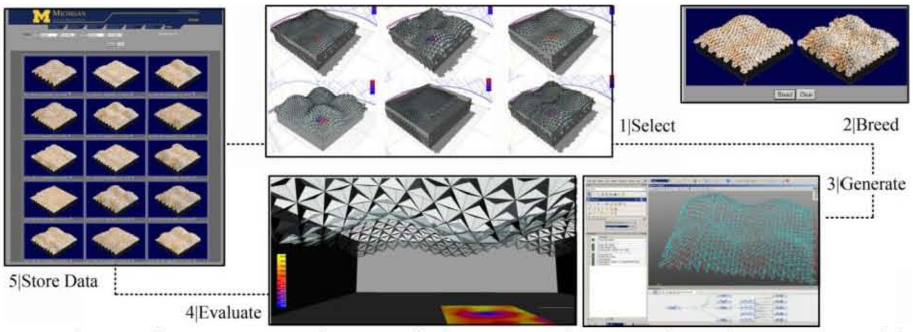


Figure 10. Examples of performance evaluations for shadow effect (and direct solar exposure) and daylight of alternative solutions parametrically generated.

SolSt: an example of performance oriented parametric design based on genetic algorithms

The Vela roof case study shown the potentials of parametric modelling in generating large range of design alternatives, which can be evaluated based on various performance criteria. The exploration of such a large design solution space remained however unsolved. In order to provide support in this phase, a tool (ParaGen) initially born for structural optimization was further developed to include energy related performances, based on a collaboration between TUDelft and Michigan University. ParaGen loops parametric modelers (at the moment Generative Components, Bentley Systems), performance evaluations software (at the moment STAAD for finite element analysis in structural design and Ecotect for energy related performances) and a genetic algorithm system. The tool is currently being tested on SolSt, a large span roof conceived for a location in Milan (Italy).



Note: The work on ParaGen is part of PhD research currently under way at Delft University of Technology and is performed in collaboration with the University of Michigan, where ParaGen was born on an idea of Peter von Buelow. As part of the same PhD research, the work on the Vela roof has been developed in close collaboration with Axel Kilian and Eric van der Ham.

- **José NUNO BEIRÃO**: City maker. Designing Grammars for Urban design

The main aim of the research was integrating information flow in the design process in order to support design decisions. For that purpose three main things were developed:
1- The integration of a parametric design platform with a geographic information system;
2- Urban design patterns, i.e., modular algorithms generating small design moves which combined may produce designs;
3- Embedding calculations in the design in order to obtain indicators on diverse properties of a design and in an interactive way.

The design environment above described allows designers to better deal with the complexity of the urban form and related information, thus strengthening design decisions. The platform also benefits strategies based on adaptable models with linked properties rather than definitive layouts.

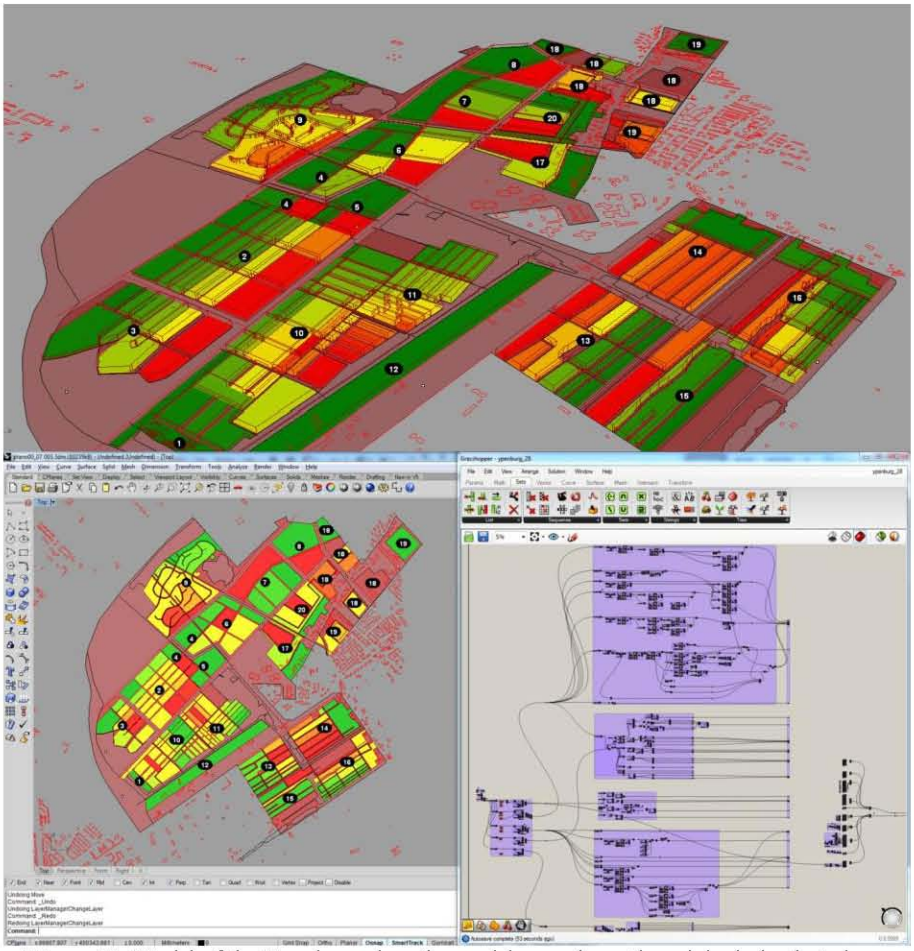


Figure 11. Model of the Ypenburg plan; the model reproduces the original plan but plays with density variations - colors show different building intensities determined at block level and also at district level. Districts are numbered. Different density variations will allow designers to visualize the impact on the plan appearance and to establish possible density regulations for the plan.

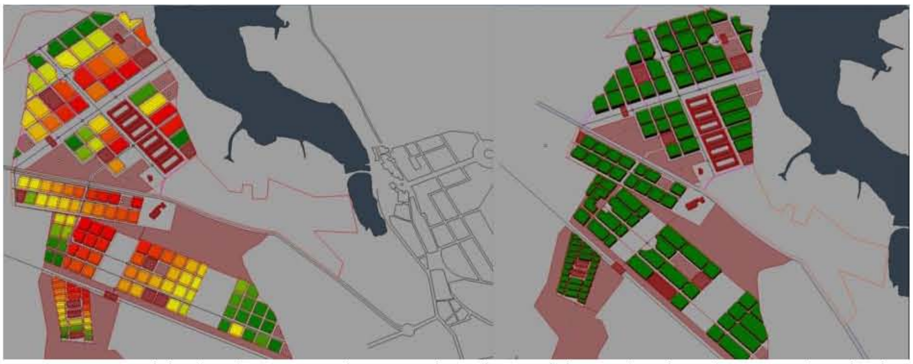


Figure 12. Model of Quinta Fonte da Prata plan; the model was developed more or less in the same fashion as Ypenburg but using a distribution of density defined as a function of proximity to selected elements of the design such as main streets or squares. We call this function attraction. The distribution calculations are done at district level but indicators defined at block level. Image on the left shows intense distribution and image on the right shows the situations when attraction is zero.

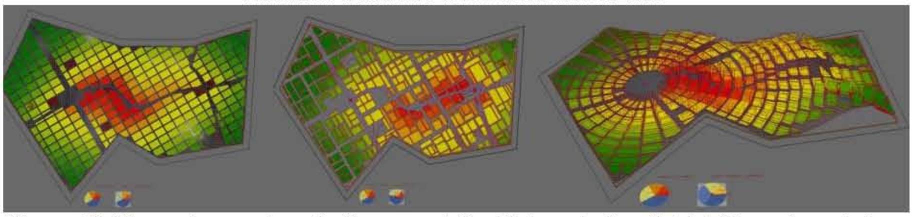


Figure 13. Shows three automatically generated grids in a similar district. The only variation is the input on grid type; the other variables (geometric and numerical) are the same. The grid on the right also shows the mapping of the plan into topography.

- **Pirouz NOURIAN**: Configurative Design Methodology and Technology.

A proposal for applied computational methods for built environment configuration Concisely, in this PhD research the main focus is on devising computational methods for configurative design: that is explicit design of spatial arrangements. This issue has three key aspects: Configuration, Computational Design and Design Methodology. Configuration here refers to the so called "hidden structure of space" or major aspects of spatial arrangements, including massing (density distribution), land-use allocation and topological relationships of spatial elements. Computational design methods and techniques are being used to make software applications for built environment design. These software applications are to support design and decision making processes in built environment design.

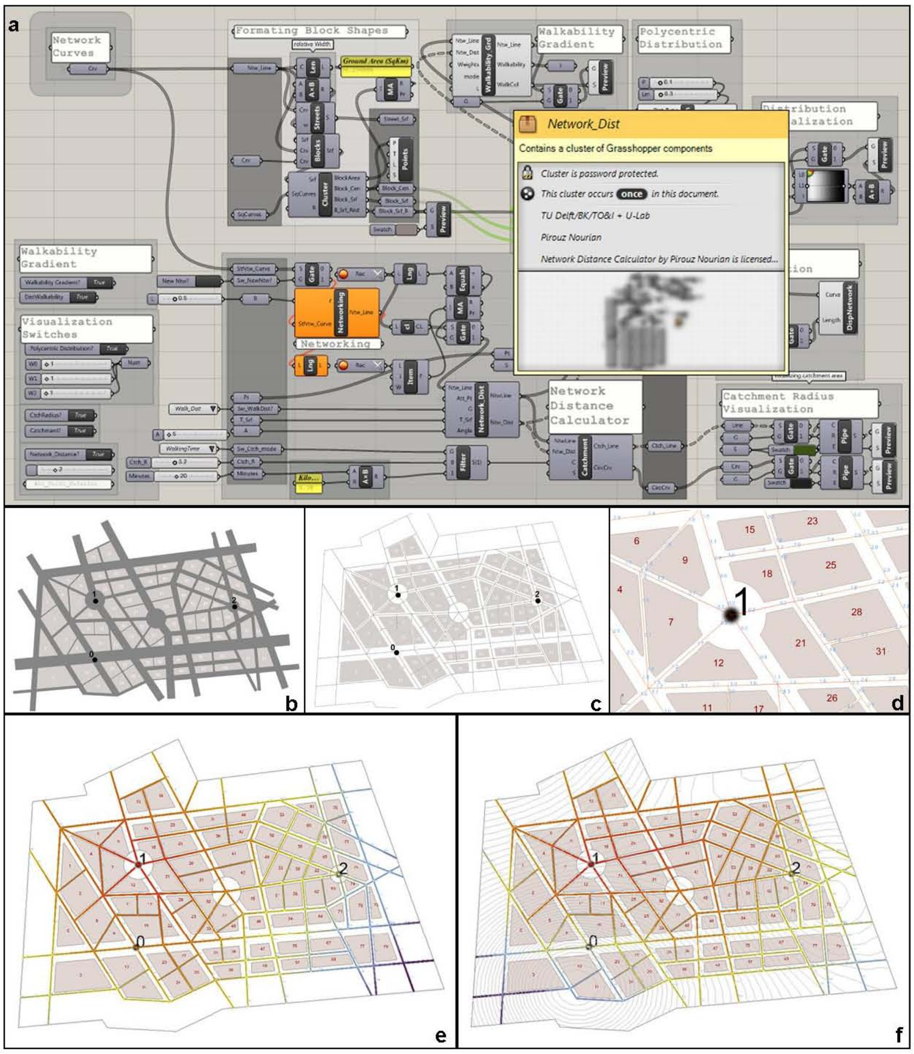


Figure 14. The computational design system made for Grasshopper® Visual Programming Interface. (b) a typical imaginary neighborhood; (c) street centerlines (d) network distances from an attraction point; (e) gradient of network distances from attraction point number one, considering a flat landscape; The bluer the colour the farther the distance (f) gradient of network distances from the same point considering a topographic landscape.

Sub topic: Computational Intelligence for Enhanced Decision Making in Engineering and Design

Human beings have the remarkable capability to make best decisions although the environmental information is ample, comprehending many obvious and hidden relationships among the detailed properties of an environment. Establishing computational models that simulate the human abstraction, reasoning and creation capabilities is the subject matter of the research presented here. This is important for two reasons. The first aspect is that the computational models permit to better understand the processes occurring via human mind, so that a deeper understanding of what design/decision-making is and how it works is gained. The second aspect is that it permits to support a human designer/decision-maker by means of powerful, 'wise' assistance during difficult tasks that are beyond human comprehension. In particular decisions in design and engineering are difficult to take due to increasing complexity that generally arises from the following three issues:

The first issue is the involvement of multiple decision criteria, which are conflicting and generally have a soft character, such as sustainability, operational certainty, financial certainty, or attractiveness. The softness stems from the need to represent many detailed features of an environment by means of a few quantities, so that models involve many non-linear relations among variables. The second issues is the involvement of multiple, stiff constraints that must be satisfied, such as time, money and space restrictions. The stiffness refers to large numerical difference among several constraints subject to minimization. And finally, the third source of complexity is the involvement of several independent variables constituting a solution, which implies an excessive amount of possible solutions to be investigated within limited time.

These issues make it formidably challenging to reach most suitable solutions. It is emphasized that this difficulty is alleviated when advanced computational methods are used to deal with the complexity, which is the subject matter of the computational intelligence-based work presented here. In particular methods from the domain of computational intelligence, such as evolutionary, neural and fuzzy computation, are employed to deal with soft and conflicting objectives, stiff constraints and vast solution domains. As result, solutions are guaranteed to satisfy the objectives at hand as much as possible, while they satisfy the constraints at the same time. This quality assurance is highly desirable in the face of depleting resources and increasing demands imposed on engineering and design products, and it will become more and more relevant in the future, in proportion with the increase in complexity of the real-world decision-making problems.

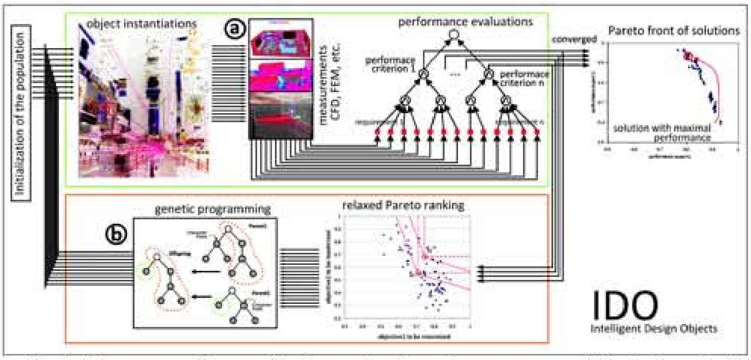


Figure 15. In this approach a multi-dimensional performance model is integrated into a computational search process.(PhD thesis M.Bittermann)

Energy-Neutral Neighborhood Engine (ENNE)
By the researchers Michael BITTERMANN, (post-doc) Ioannis CHATZIKONSTANTINOU (PhD,) Ozer CIFTCIOGLU (senior researcher-guest professor) recently completed project deals with the energy performance measurement of a buildings/series of buildings which can be use during the conceptual phase of the design.
Energy sources are scarce and therefore expensive. There is a necessity to use these sources as carefully as possible. Therefore we developed a tool that supports design and renovation of buildings, so they will have a low heat-energy demand. Using the Energy Neutral Neighbourhood Engine (ENNE) this can be achieved at minimal investment costs and without compromising the architectural quality. In ENNE the energy demand will be computed with satisfactory integrity throughout the early design stage.

Design-software with real-time energy computations
ENNE is a design software with real-time energy computations and a user friendly 3-D interface. It is a design tool for project developers, architects, and urban planners, who wish to know about the heat energy demand of their designs from on the first design stage. The computations are based on appropriate models of energy behavior. Therefore the annual heat energy demand and monthly costs for heat energy are computed with accuracy per house or for a whole building complex. This is considered an important feature for marketing a design, because house buyers are interested in the information on permanent costs of a property. Also municipalities may value the insight provided by ENNE regarding the implications of design decisions. Using the tool, the time required to accomplish an energy demand analysis with appropriate emphasis on integrity is significantly reduced. With ENNE the energy demand is computed in real-time throughout the design process.
In ENNE the following factors are taken into account:

Influence of the orientation	Influence of the location
U-values of walls, windows, roof, and floor	Dimensions
Percentage of windows	Different house types
Influence of the ventilation system	other influences

Further levels of computations
ENNE is an advanced design-software having three levels of computations that meet the demands of design complexity. *Level 1* is the basic heat energy and cost computations with minimal design input requirements as described above. *Level 2* considers additional soft design issues, like visual perception, environmental safety and comfort, and so on. *Level 3* provides optimization of the energy design aspects, with respect to the trade-offs among them. For example reaching low energy demand at maximum architectural quality.

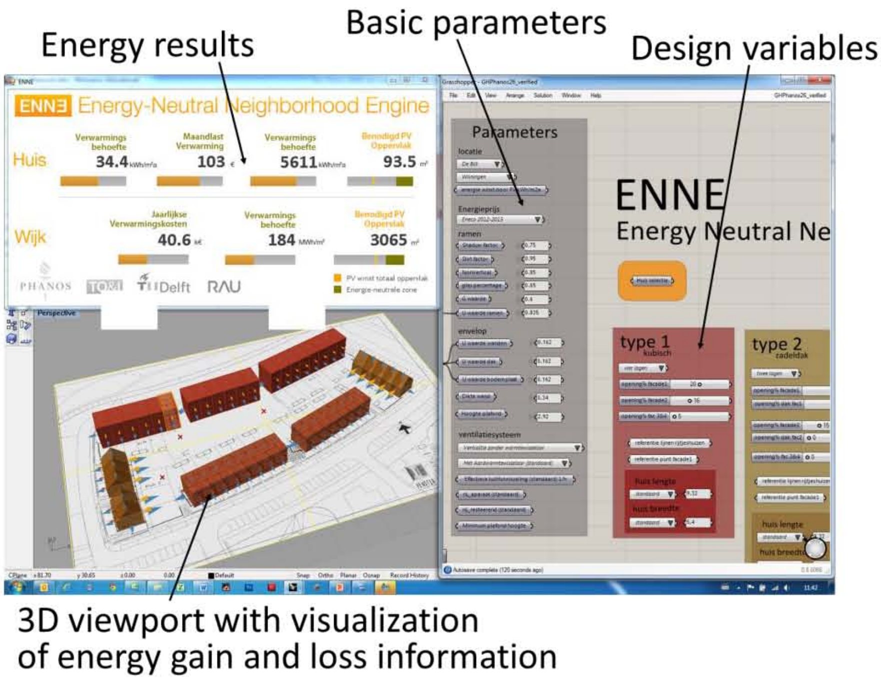
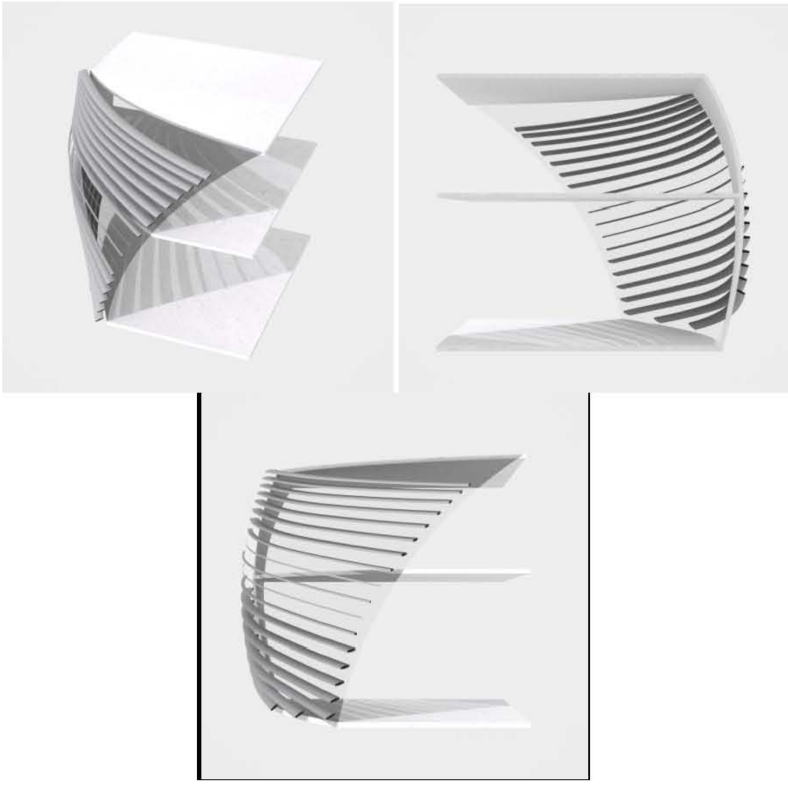


Figure 16. Components of the ENNE software interface

• **Ioannis CHATZIKONSTANTINOU:** Computational Comprehension for Treating Complexity in Architectural Design and Engineering.

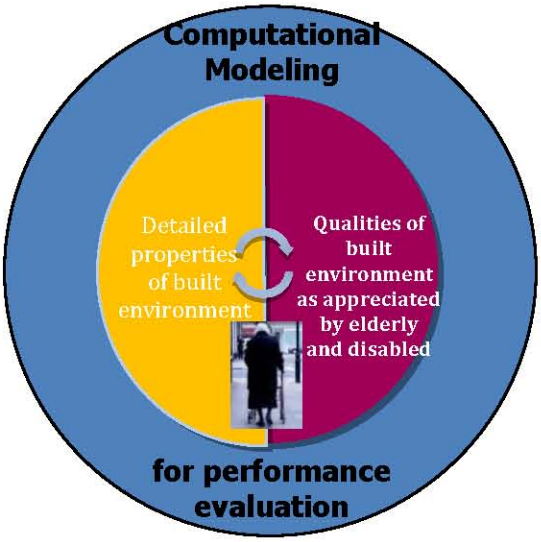
The task of architectural design is characterized by a large degree of complexity. The complexity comes as a result of the conflicting nature of the demands that the design is usually called to respond to, as well as the excessive amount of design decisions that it entails and which are related to design objectives in intricate ways.
The complexity comes from the fact that most real-world problems concern complex systems, which involve multiple, conflicting objectives, and multiple decision variables that are interrelated with the objectives in intricate ways. This generally gives rise to an excessive amount of possible solutions, so that identifying a most suitable solution among them is a formidable challenge. Such problems are encountered in all fields of science, ranging from the social sciences to engineering. In such cases human comprehension is not suitable to arrive at a best decision, and it should be supported with machine comprehension. Therefore machine cognition and consciousness is high on the modern scientific research agenda. The aim of the research is to investigate and develop a computational cognition and comprehension methodology in accordance to this demand, so that machine support can point to design decisions that reflect the at the same time the satisfaction of design demands as well as the preferences of the parties involved in the design.



The images are result of an investigation in the application of computational search (using evolutionary computation) for facade shading configurations that may provide shading for desired interior areas while minimizing material cost of the facade and subject to manufacturing constraints. The two different sets of images belong to solutions that are characterized by different performance in terms of shading efficiency and use of material.

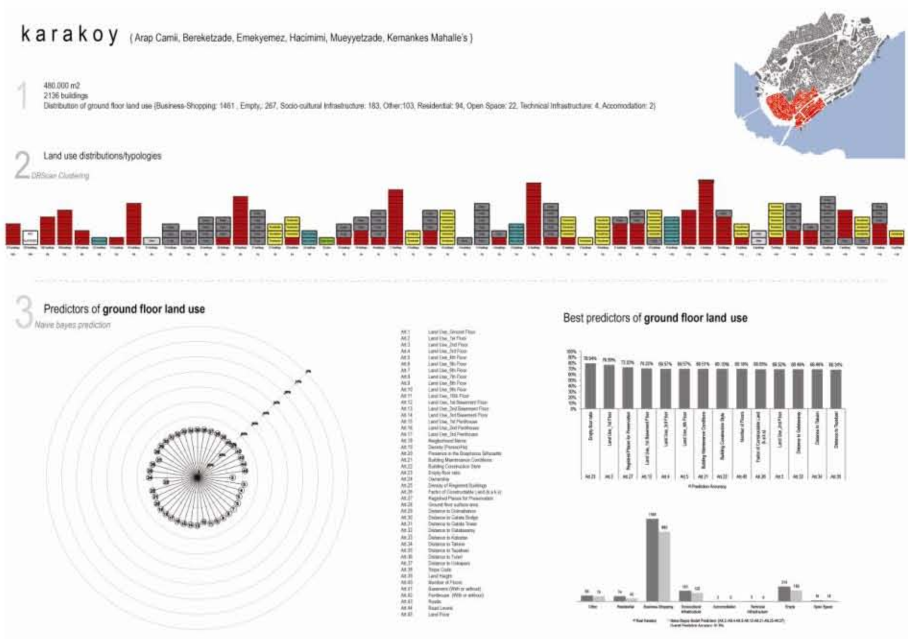
- **Tijjani ZUBAIRU:** Assessment of building Performance from the standpoint of elderly and disabled persons using neural computation.

Assessment of the performance of a building from the view point of its suitability for elderly and disabled is a complex matter, because it concerns not only measurements of detailed properties of a building, such as the width of doors, or the height of door steps, but it also involves psychological assessments in terms of security, safety, privacy, visual comfort etc. In order to deal with this complexity, assessment of experts, as it is conventionally exercised, without support by means of appropriate computational means is insufficient. Ageing and disability as used in this context refer to all forms of impairments limiting the functioning of both physical and mental attributes of human, that make the daily use and interaction with the built environment challenging. Developing a computational model for the precision assessment of the performance of institutional and public buildings is the objective of this research. The performance assessment concerns particularly the degree of suitability of a building for usage by elderly or disabled people. The methodology employed for this purpose is from the domain of computational intelligence, because it is uniquely able to deal with the complexity of the performance being assessed, namely the methodology emulates the ability of human to establish appropriate abstractions despite abundant information that contains many non-linear interrelations among multiple detailed attributes. This is in contrast to the methods from statistical analysis that presuppose independence among variables, which is a gross simplification in the present case, where a subject matter of great complexity is investigated. The result from the model being pursued will be an understanding as to the relative importance among the building features taking their simultaneous interrelation into account for the satisfaction of the demands of elderly and disabled. This way the information on performance being modelled is acquired by means of questionnaire supported where expedient by physical measurements, which will be integrated into a neural model.

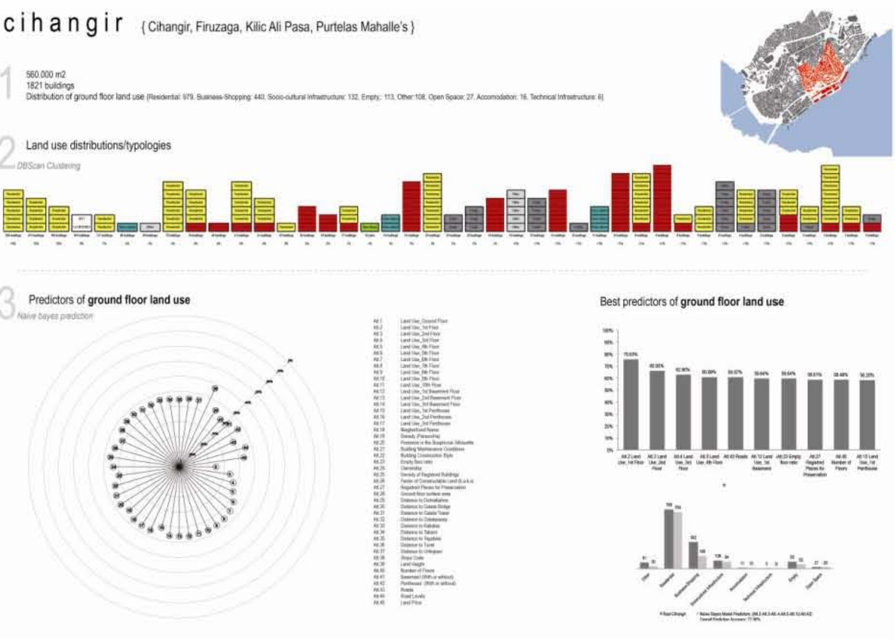


- **Ahu SÖKMENOĞLU**: Exploring patterns and relationships of a complex urban system; The case of Beyoglu (joint PhD with Istanbul Technical University-Turkey)

This research applies data mining methodologies in urban analysis to explore patterns and relationships of micro-scale data in Beyoglu-Istanbul and proposes a framework integrating data mining analysis results with evolutionary computation to demonstrate how these patterns and relationships can assist in decision-making in urban transformation.



These images depict the results of the analysis of buildings' attributes of two major districts in Beyoglu, Cihangir and Karakoy by means of data mining methodologies. Clustering analysis is done to detect how land-use of buildings is clustered within the districts, and Naive Bayes Prediction is applied to find the predictive power of different attributes of buildings over land-use of ground floor which indicates a certain probabilistic relationship among them. The patterns and relationships found in this step are further analyzed by means of Association rule analysis and integrated into evolutionary computation.



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• **Irem ERBAS**: Description of a decision support tool - based on Knowledge Modelling - for energy and comfort performance improvements of existing houses.

The main objective of this research is to contribute to energy efficient (re)design processes of the existing housing stock within the context of sustainability. The research aims to search for and present an approach to provide integrity to deal with the growing amount of information and processing of this information in energy efficiency and indoor climate relationship during a (re)design process of existing housing. The focus of this practical problem of energy efficiency is to ensure good indoor climate on several energy levels, from the less ambitious one till the most ambitious one. Based on these, two main questions are raised:
How can architects be better guided to achieve the ambitious energy goals without neglecting comfort? How to organize the complex and extensive information and how to present it to the architects in a meaningful way so that they are simultaneously informed about how their design choices affecting several performance criteria?
It is asserted that there is a need for a better support for architects in the process of energy and comfort upgrades of houses, particularly looking at early stage of (re)designing. In order to understand why one design performs better than another requires an integral approach looking closely to the interrelationships among the various aspects. Therefore there is a need both to better understand how conditions of good indoor climate are correlated with measures to improve the energy use of a building and to make this knowledge available to the architect in the design process in an integrated way.

According to findings, a knowledge model is established showing the interrelations between the performance criteria and their sub-aspects. This model has been considered to be a generic one which can be expanded with adding in further information. It is considered to be link to decision support tool development. By means of information/knowledge modelling and embedding such a model within an existing architectural tool, it is intended to make performance assessment an inherent part of design process.

7. CONCLUSIONS

Universities are the places where the *universal knowledge* is being discovered, developed and shared, without national borders. As Santiago Calatrava says; universities are the places where the *minds* collaborate and communicate. Therefore universities as scientific institutions besides preparing students for their professional life should educate and stimulate students to develop a critical, scientific, and innovative way of thinking. It is our aim to train young first-rate designers and researchers in order to upgrade the excellent reputation both nationally and internationally, also in the field of computational design, with the aim to be able to optimize the design performance to enhance the optimum building quality and built environment for the human wellbeing and prosperity of mankind.
As scientists and professionals concerned with built environment, from our professional ethics and social responsibility point of view, we are urged to develop new knowledge, and novel technologies which are able to capture this knowledge. This must systematically be disseminated to the new generations besides retraining the practicing professionals.
While doing this, next to the physical, material more attention should be paid to *human centred* immaterial values as well, such as social, cultural, moral and spiritual needs of the societies.
Integrating these soft issues with the environmental sustainability targets in the design process can be accomplished using the ICKT technologies. To make it happen we need to set up the appropriate strategy and policy for this goal.

ACKNOWLEDGEMENT

I would like to thank to all my PhD students, for providing me the text and the figures concerning their PhD work. They are all great, I am very grateful for them and at the same time very proud. They do the hard work and I am writing and talking about it!

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SESSION 6

16 November 2012 Friday, 13.30-14.30

Topic: Using computer software in architectural and urban design processes

Chairperson: Assoc. Prof. Christine THEODOROPOULOS

Res. Assist. Ahmet Emre DİNÇER, Instr. Dr. Hakan TONG, Prof. Dr. Gülen ÇAĞDAŞ
Role of Digital Tools in Housing Design by Mass Customization

Res. Assist. Emirhan COŞKUN
Considering Computer Games as a Learning Tool

Res. Assist. Ethem GÜRER, Res. Assist. Sema ALAÇAM, Prof. Dr. Gülen ÇAĞDAŞ
A Dynamic Methodology for Embedding Generative System Approaches in Architectural Design Education

PhD. Student Özgür ÖZTÜRK
A Digital Reconstruction of Visual Experience and the Sebasteion of Aphrodisias

ROLE OF DIGITAL TOOLS IN HOUSING DESIGN BY MASS CUSTOMIZATION

AHMET E. DİNÇER[1], HAKAN TONG[2], GÜLEN ÇAĞDAŞ[3]

ABSTRACT

The concept of housing has different meanings and values for each user. Until recently, this idea was ignored by design implementations done by logic of mass standardization to fulfill increasing needs of housing in mega cities. However, it has gained its popularity with new changing design approaches. This paper focuses on the potentials of digital design processes with support of generative tools and users' choices as an alternative to recent approaches of housing design. Accordingly, a new computational model based on the cellular automata and mass customization approaches is presented and its implementation, limitations and possibilities are discussed.

Key words: digital design, mass customization, cellular automata, form generation

1. INTRODUCTION

In recent years, in mega cities where a rapid population growth has been experienced and needs of housing have increased rapidly, in the same way the importance of 'housing' concept has increased, arguments based on it have also emerged. In this context, it is seen that practices of the past, which are based on short-term mass production techniques and evoke monotony, uniqueness, non-identity and the logic of standard user type, have been slowly abandoned. Instead, it is observed that an understanding of housing including concepts like collaboration, uniqueness, diversity and individuality in a certain level has started to take its place. In this change, mass customization techniques presented as an alternative for classic mass production have made a great contribution. However, there are also important effects of developments of digital technologies and design tools on the intensive choice of this method existing since 1970s.

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[2] Instr. Dr. İstanbul Technical University, Department of Architecture, ISTANBUL
[3] Prof. Dr. Istanbul Technical University, Department of Architecture, ISTANBUL

Through the support of developments in digital production, mass customization has been usually seen in industrial design fields (automobile, plane, shoes, furniture etc…). In these fields, mass customization defines a process which provides users' participation and accelerates interaction of user-designer-producer (Crayton, 2001). This concept needs modularity and configuration. Clearly, it includes products' properties of breaking into components and subsystems, which are re-composed, with modularity and qualifications like users' selection and method definition with configuration. In other words, mass customization is establishing equilibrium between choosing freedom and standardization for user.

In design works, mass customization differentiates as directional interaction with users (collaborative customization); constrained interaction with users in decision-making process of designs which are generally standardized (adaptive customization); and generalized user evaluations made without users' participation (transparent customization) (Niemeijer et al. 2010). Among them, approaches of adaptive customization are suitable for multi-residential buildings. When these approaches are realized in the form of users' material selection and choices of building components, their participation in spatial planning is ignored. Therefore, in these building samples, other approaches, especially transparent customization, are still preferred about spatial planning.

In our country, "Izmit New Housings Project" done by "United Architects" for worker families with low income is one of the original implementations where users' participation took place at early design stages (Cavdar 1978).These houses providing users' satisfaction, are a consequence of one to one and collective negotiations with householders. In the work, traditional processes were evaluated, need of a digital design tool was pointed out especially to manage the information coming from users.

In this work, it is presented that a digital design implementation incorporates interactive design processes with techniques of Cellular Automata (CA) approach. With its properties of simulating neighborhood interactions, samples of growth and social phenomenon, CA is used actively for conducting the structures from simplicity to complexity in context-sensitive and grid-based designs (Singh and Gu 1978). As a traditional process, Schön's approach of reflection in action gives a designer opportunity of one to one interaction with his/her work. It is considered that integration of these two approaches with each other contributes to both elimination of laborious practices of traditional process on information management and intervention to autonomous processes CA brings with.

With this work, developing cooperation of user, designer and design tools for design models comprising complex relationships and functions and requiring users' preference, and also indicating potentials of design models which may contribute to designer as design-decision tools are aimed. So, we define frameworks of a process where designers are able to evaluate sample model and alternatives with CA supported –simulation of spatial organizations in multi-residential buildings which are similar to a CA lattice and formed by users' data.

2. DIGITAL DESIGN TOOLS AND CELLULAR AUTOMATA

Generative design tools commonly used are listed as Shape grammars (SG), L-Systems (LS), Genetic Algorithms (GA), Swarm Intelligence (SI) and Agent Based Models (ABM) and Cellular Automata (CA). Design development fields of these tools, which are different from each other in terms of their properties, structures and solutions, are summarized as follows (Singh and Gu 2011):
BG and LS are interpreted as form-based design processes and used for form and style generation. CA, SI and ABM are seen as behavior-driven design processes. Among them, when CA is evaluated for context-sensitive design practices (urban design problems, zoning, block design etc…), SI and ABM are used for generating designs composed by self-organized structures, analyzing designs' usability and simulation of circulation and movement in design development samples. GA is applied to design optimization studies.
As a computational process, Cellular Automata (CA) simulates growth process by way of defining a complex system with simple individuals following simple rules. This process can be defined as an operating system and feedback mechanism used for division of issues and events in the form of cells and determination of each cell's position in the future based on other neighbor cells in a homogeny interactive work (Yuzer 2006). Its basic properties are as follows:

- Consisting of regular cell lattices
- Emerging in time stages
- Characterizing each cell with its state
- Development of each cell based on the same rule related TO THE numbers of state of the cell and finite neighbor cell
- Having relationships of neighborhood which are local and similar to each other

CA can be represented as different models like classic models (Wolfram's one dimensional, Conway and Ulam's two and three dimensional samples) and advanced models adapted to different disciplines (physique, biology, urbanism etc..). In architecture, CA practices have been usually made by using rule sets of existing classic systems like Conway's Game of life and interpreting their results as an architectural form.
In this field, early CA practices have started with Price's "Generator" and Frazer's "Universal Constructor" models (Herr and Kwan 2007). Price's "Generator" aimed at demonstrating variations of the physical form by replacements of architectural spaces like a CA system including volumetric units in functionalist perspective. Frazer's "Universal Constructor" was composed of hardware CA and based on logic states not including any architectural concept. With this model, Frazer intended to determinate an architectural manner with logic states in space and time.
With regard to different architectural states and environmental conditions, Coates and his team (1996) tried to develop an extended classic CA system more customized with more logic states. In addition, they exhibited CA's abilities of architectural form as an external data. Krawzcyk (2002 and 2003) researched architectural potentials of CA by changing formal representations, states and rule

sets of CA between implementation steps. As a result of his experiences, he stated that this CA-supported process was getting raw data from a generative method, finding a sample model and defining methods for interpretation of the sample due to additional architectural requirements (structural elements, horizontal relations etc…). Furthermore, Clarke and Anzalone (2003) studied on the development of structural models using one and two dimensional CA.

As opposed to other CA experiences, Herr and Kwan (2007) offered a hybrid model for using CA in architectural practices more effectively. This hybrid model was formed by integration of Shön's "Reflection in Action" approach with CA. In this manner, they considered that as an interactive way, Schön's approach was able to eliminate negative properties of CA incompatible with architecture. They evaluated its potentials with a sample model. Later, Herr (2008) also indicated advanced practices of this opinion in his doctorate thesis.

3. HOUSING DESIGN WITH CELLULAR AUTOMATA

Against identical residential buildings, with inspiration of natural processes, cell-like residential models have been developed. In these models, units constitute a whole on a skeleton which allows their development. In this way, it is considered to provide flexibility to satisfy inhabitants' changing requirements in time. There are very few constructed samples of these models, the majority of which have remained as a proposal so far and the best known of which was Safdie's project of Habitat 67. However, the numbers of the studies like Levent Loft in Istanbul, Mountain Dwellings and Lego Towers in Copenhagen have started to increase partially over the last decade.

In terms of the style of this approach, there are similarities between structure of CA and multi-residential buildings both logically and formally. CA with its properties of having bottom-up process, relations of neighborhood and logic of form following function supports the structure responding to time-dependent renewal requirements in housing buildings and changing user's preferences, and encourages innovative form alternatives. Besides, in such an approach, a digital design-decision tool is needed exceedingly owing to its complex content.

This tool can be CA itself, but it is not available to use with its autonomous structure and formal attributes in a design process effectively as it can be seen from the examples in the literature. For this reason, such a process supported with CA should be configured with comments in parallel with architectural purposes in a suitable design context.

Characteristics of Shön's theory of "Reflection in Action" are formed by concepts like "reflection in action", "indeterminate zones of practices", "framing-moving-reframing" and "practitoner's artistry". As a traditional process in this theory, a design process is fragmented with frame steps which can be interpreted, developed or reconfigured by a designer. In these steps, the phases which require automation and organizations of neighborhoods can be managed by a customized CA support.

3.1. Introduction of the protocol

In multi-residential housing implementations, design approaches can be evaluated from two different perspectives of urban context and building scale. In urban context, especially housing designs formed by separate building masses involve general concepts like aesthetics, transportation, common places, legal restrictions, natural lighting etc… However, in building scale as a small reflection of a city, there are spatial organizations where individuals meet their basic needs and common relationships among inhabitants develop. For both perspectives, they can be considered to be simulated and generated by a customized CA aided design. Accordingly, in this work, some scenarios based on them have been developed.

3.2. Housing Block Placement

In this stage, basic decisions of a site plan are interpreted by CA logic. To accomplish this, plot information (layouts of plot, rates of public spaces, and min/max heights of building masses) is primarily collected by user. Then, this information is evaluated in the framework of defined restrictions (distances of buildings from the layouts and positions of the building masses relative to each other) and sample generations are performed (Figure 1 and Figure 2). The progress adapted on principles of CA can be summarized as follows:

- Firstly, according to the restrictions, a building mass is placed randomly on the defined area.
- Secondly, building mass is generated similarly. However, if new generation is in the borders of first building mass which is defined by setback distances of buildings, death occurs and the generation is repeated. This process continues until it reaches to value of the parameter at startup.
- When total floor areas of the generated masses are equivalent to the construction area of the lot, during remaining generations, one of the generated masses are removed randomly and new mass is created.

Theory of "Reflection in Action" is applied taking designer reviews into consideration before and after generation. Accordingly, provided that the generated models are suitable for the designer's criteria, this stage is completed and the other stage is started. Otherwise, the designer has to go back to the beginning of the stage and the process is repeated by changing the parameters.

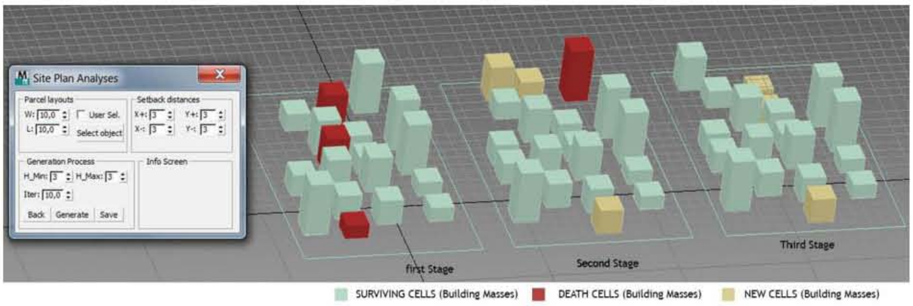


Figure 1. A sample interface and implementations of the site plan analyses.

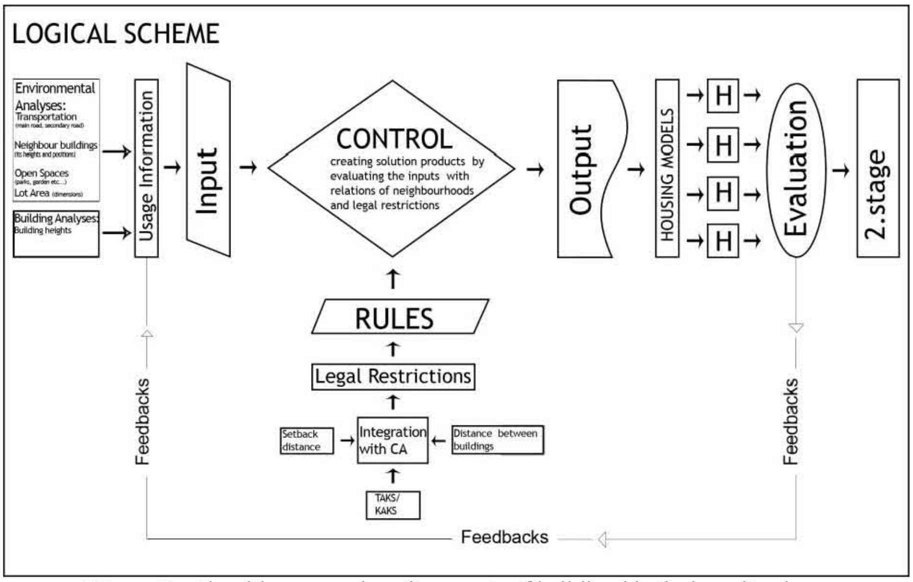


Figure 2. Algorithm managing placements of building blocks in a site plan.

After the placement of building masses in the first stage, for each block, reviews of floor plan organizations are initialized.

3.3. Organizations of Floor Plans

In modern housing plan understanding, users are given the right to choose partially by presenting samples of house including different sizes and amounts of room and a generalized user potential is presumed in design approaches. Proposal model also follows a similar route. However, open floor plan in this model has a feature that supports notions of more flexibility and more variation in housing designs with the aid of a parametric tool trying all possible alternatives. In other words, this model defines a mechanism where user preferences are transformed into a digital expression; each spatial unit affects and triggers generations of others; and innovative properties are involved.

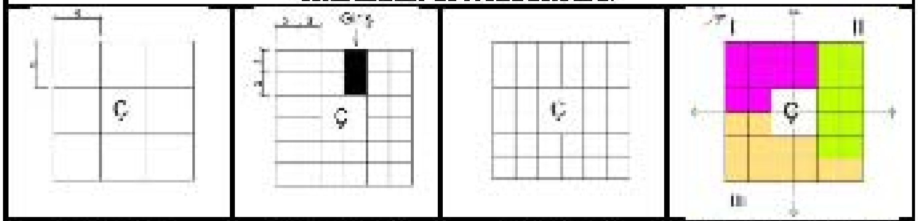
Proposal of open floor plan comprises a service core of building whose position never changes throughout all the floors and also changeable spatial units around it. With a structural system adapted to diversity and innovation, it has a feature that is able to grow and develop vertically.

The proposal is a skeleton structure including a plane of 18*18 m grid which can be subdivided by 6*6m and 3*3m smaller grids and squares on each floor. While the cells on the center of the plane define the service core, the remaining cells come together with their spatial descriptions to form different housing types grouped by examples of one (1+1), two (2+1), three bedrooms (3+1) and more (double flat).

The housing types on a floor depend on amounts of min and max spatial area determined for each. These amounts are seen as constraint criteria. So, a comparison is made between area of a housing type, a result of percentile values of user preferences, and these criteria. If the results match with one another, that housing type occurs on that floor. Otherwise, it is removed and its area is allocated among others. After this stage is completed, spatial analyses are started (Table 1).

Table 1: Logic of the process for housing types.

PROPERTIES OF A FLOOR PLAN

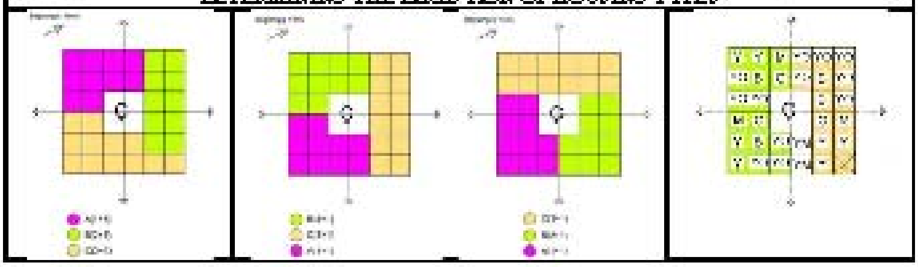


A floorplane	Ground Floor	Upper Floor	Allocation of dwellings

AREA ACCOUNT OF HOUSING TYPES

Total(m2)	Housing type		Min. (m2)	Max. (m2)	Rate of Pref.	Cal. of Area		Left	Num. of Cells	Num. of Housing
A unit cell: 6*6=36 m² A total of eight cells =36*8=288 m²	A	1+1	36	63	%30	288*0.3	86.4	5.4	10	2
	B	2+1	72	99	%30	288*0.3	86.4	14.4	10	1
	C	3+1	108	135	%40	288*0.4	115.2	7.2	12	1
	D	4+1	144	162	-	-	-	-	-	-

DETERMINING THE DIRECTION OF HOUSING TYPES



When interior spaces are designed for each housing type, with its customized structure, CA is seen as a tool whose duty is to run transition rules and the neighborhoods for them (Figure 3). The process is as follows:

- If the process is on the ground floor plan, entrance hall of the building is created. Additionally, a space of fire stair (YM) for all floors is defined arbitrarily. Both spaces are evaluated as constraints for other spaces. Otherwise, the settlement process of spatial units starts in the fields of defined housing types.
- First of all, according to the amount of housing types, cells of entry spaces (G) are added on the field of each housing type. These cells are close to service core of building. During the process "G" cells are primarily

positioned not to be adjacent with other "G" cells, but this rule can be changed in special cases.

- WC-Bath (B) cells are related to service core like "G" cells. Besides, at least one of them is expected to be adjacent to "G" cells. Furthermore, there is a criterion that maximum two "B" cells are adjacent to each other on the same floor, for the same housing type.
- Kitchen cells (M) must be adjacent to "G" cells. Except in special cases, they have at least one neighborhood with living spaces. The special cases are valid for kitchen cells related to the service core. Herein, "M" cell is primarily adjacent to open or semi-open spaces, called "Death cell", instead of living space cells. In this way, linking these spaces directly to the external environment is aimed.
- For the creation of a living cell (Y), there is a rule of having at least two or maximum three sequential neighborhoods with these cells. There is a difference for a housing type having one bedroom and minimum area. For this type, a living space having one cell can be created. Furthermore, on the same floor and for the same housing type, a living space can have up to four cells. For some cases, according to living cells, open or semi-open spaces may exist.
- Finally, cells called "bedroom" (YO) are generated. For them, if these cells are created in the region close to service core, a neighbor "YO" cell or an open/semi-open space is created automatically in the external region of the floor.

During spatial analyses, all progress is executed automatically. After each solution of an open floor plan, the results are evaluated by the architect's interpretation. When the results are acceptable, the information concerned with solution of this floor plan is saved and this process is repeated for solution of an upper floor plan. Otherwise, the feedbacks are made. In solution of an upper floor plan, a similar approach is followed. As a difference, during placement of spatial cells, the relationships of cells not only on the same floor but also lower floor are analyzed.

Finally, elevation analyses are performed simultaneously together with creation of floor plans. However, these are promoted by additional rules organizing adjustments of setbacks and cantilevers for diversity and dynamism on the facade with CA rules. Some of these rules are also exemplified as follows: in the vertical direction, if three spatial units having on a cantilever are ranked sequentially and an upper spatial unit following them in the same direction can't any cantilever, but a setback can exist on dimensions of that unit. Furthermore, in the horizontal direction, more than one cantilever does not exist on a space consisting of some units (like living rooms), but it can emerges sequentially on both spatial units defining different spaces and having a horizontal neighborhood with each other.

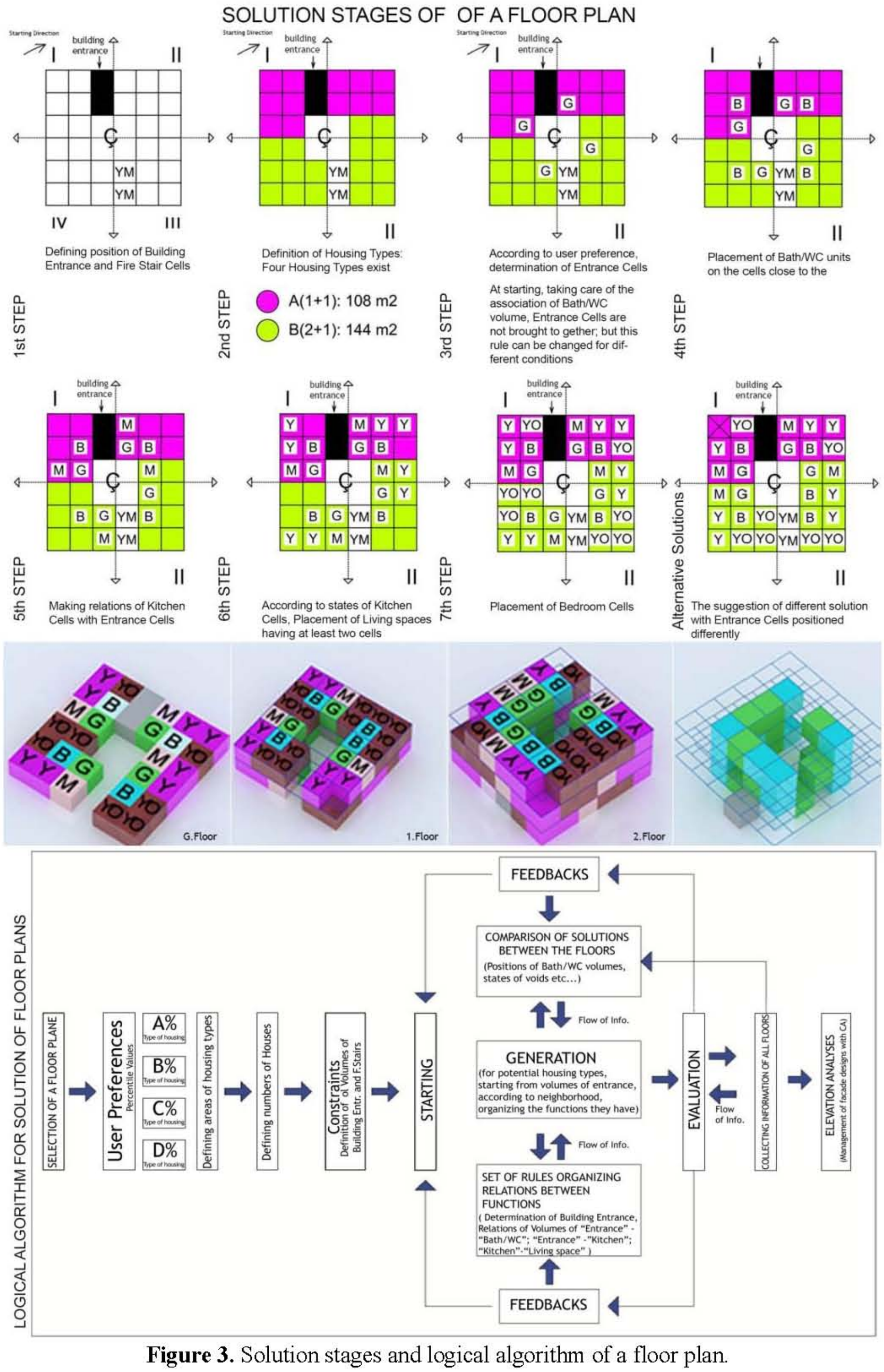


Figure 3. Solution stages and logical algorithm of a floor plan.

4. CONCLUSION

The basic findings and results which have been obtained from this ongoing study in the extent of PhD thesis together with the jury comments and individual evaluations so far are summarized as follows:
Firstly, it has been logically confirmed that the process of CA comprising relations of neighborhood has similarities with the framework where comprehension of open spaces can be organized flexibly by user preferences and does not depend on a form with its convenient structure. Accordingly, it is understood that CA can be adapted to this framework with designer' intermediate interventions during the process.
Secondly, when the suggestive scenario is completed, it is thought that the design process supported with CA is rather useful for considering the need of variety and uniqueness in terms of architectural logic; and the flexible functionality in terms of users' satisfaction. For, it is observed that integration of bottom-up structure of CA and emerging spaces with different user preferences is able to result in innovative and variable form generations, indispensable criteria for all design works.
Finally, owing to ill-defined structures of design problems, preparing changeable algorithms of CA for each stage repeatedly is usually seen as a compelling situation for these design models, but it is thought that this situation can also be an advantage as a technique evaluating all potentials having influences on the future of a design.

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CONSIDERING COMPUTER GAMES AS A LEARNING TOOL

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ABSTRACT

This paper describes several aspects of the growing research field interested in video games in education. The idea of reviewing computer games is derived from developing a framework of using games as cognitive tools and integrating into the classroom. In this paper three different fields related with the cognitive impact playing of video games are reviewed: abilities and skills, attitudes and motivation, knowledge and content learning. However, most studies use video games as new experimental materials and tasks to contribute to their specific field, and not as a scientific object of interest. Research on video games need a methodological framework in which results and effects can be compared, interpreted and generalized. Video games can have multiple effects on players and these effects can be used as educational potentials. An empirically-based classification of games, depending on their potential effects for an educational purpose, is strongly needed. Likewise, a unified research paradigm and methodologies to carry on reliable research on video games have to be developed.

Key words: Computer Games, Education, Learning Tool

1. INTRODUCTION

This paper reviews proposed benefits of using games as cognitive tools, and discusses the complexities of assessing those benefits. Use of educational games to supplement traditional classroom lectures is implicated by some researchers to increase interest, motivation, and retention, as well as to improve higher order thinking and reasoning skills. Assessment of the effectiveness of games as cognitive tools is a complex issue, and several variables, such as learner differences, assessment methods, and implicit knowledge, must be considered. This paper is divided into three main sections. The first section defines terminology, the second

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section describes game selection criteria and different kinds of computer games and their benefits. The last section discusses several factors which must be considered when attempting to measure computer games as a learning tool in education.

2. WHAT IS A GAME ? COMPUTER GAMES - A MATURING MEDIUM

A game is a set of activities involving one or more players. It has goals, constraints, payoffs, and consequences. A game is rule-guided and artificial in some respects. Finally, a game involves some aspect of competition, even if that competition is with oneself. Basically a computer game, in addition to the definition given above, is an electronic game that involves interaction with a user interface to generate visual feedback on a video device.

Computer and video games are a maturing medium and as a result of that it has caught the attention of many disciplines. In the last decades, video games have been increasingly appealing not only as an entertainment for children and adults, but also as an object of interest in academic research. A large body of studies investigated the potential of information technology as tools for learning, and particularly of games specifically designed for educational purposes. Recently, a growing interest has appeared for the potential of mainstream games in education (in or out of the classroom). The basic claim of this line of research is that videogames may have beneficial educational impacts (Prensky, 2005). Although computer and video games are most often thought of entertainment, it is important to understand that they can be powerful learning tools. Considering computer games as a tool for learning will create many opportunities. I believe that computer and video games can have multiple effects on players and that these effects can be used as educational potentials but in order to achieve that an empirically-based classification of games, depending on their potential effects for an educational purpose, is strongly needed. Also in my opinion it wouldn't be so wrong to claim that computer and video games is in need of a conceptual and methodological framework in which results and effects could be compared, interpreted and generalized. In order to achieve that framework we need a clear understanding on the cognitive and affective impacts of video games to make it clear which game has been shown to act on each specific dimension. Then the results should be empirically assessed through large-scales statistical studies and small-scale experiments. The large-scales studies will consist in investigating the level of abilities of regular players of the selected games on the specific dimensions and the small-scale experiments will evaluate the evolution of a given ability, skill or knowledge of participants that are asked to play the game regularly.

3. CRITERIA FOR COMPUTER GAMES

3.1. Game Selection

Most games are intended to be entertaining, not instructional. Often, the reason a person chooses to play a game is to experience the fun of engaging in the gaming activity. Learning is usually incidental or intentional only for the purposes of one becoming a better gamer. One aspect is to take the learning that does take place in game activities, such as exploring a route through a maze or improving a motor skill on a keyboard, and apply that incidental knowledge or ability to an intentional learning task (Rieber, Smith, & Noah, 1998). Educational games, especially those that are computer-based, are often designed in a drill and practice format, to the extent that some instructors grimly refer to them as "the old drill and kill." This format may be overused, but development of cognitive skills often requires long hours of practice with consistent feedback and it can be difficult to provide those conditions within a traditional classroom setting. Well designed computer games can be useful for consistent practice. However, games, like any other activity, require an interesting context to prevent students from losing interest and motivation (Wood & Stewart, 1987).

As a result of that, psychology and cognitive sciences have investigated the effect of video games on the players. The first thing to do is to decide what criteria were most likely to make a game a good candidate for study. According to Dempsey there are five criteria for choosing games that are more fitting to intentional instructional purposes : (1) The game must be relatively simple to play. This criterion arises from belief that gaming used for instructional purposes should not be overly complex. Complex rules and scoring require the learner to use limited learning time to understand the game (Jacobs & Dempsey, 1993). An exception would be a game that is intrinsically motivating and directly related to the intended learning outcome. It is defined that an intrinsically motivating instructional game as one in which game structure itself helps to teach the instructional content. (2) The game can be adapted and reprogrammed inexpensively. To maintain a reasonable cost-benefit ratio, the value of resources that must be sacrificed to gain benefits or effects must be comparatively less than the value of the benefits or effects themselves. (3) The game must have some identifiable potential for educational use, if adapted. It is necessary to have any reasonable possibility of applying the game to education or training. For example, card games require some arithmetic skills and therefore have some potential for intentional educational use and application to specific learning outcomes. (4) The game must be different from the other games in its category. This criterion was selected to study as many kinds of games as possible. (5) The game can be designed so that it can be played by a single player if needed. Most games could be played by either one or more than one player. One of the important factors is the integration of another player in game.

Computer games can be very complex, particularly simulation and adventure games. Arcade, card, and word games are based on a more simple structure. Each of game categories has potential for learning or instructional use (table 1). Whether verbal information, motor skills, or intellectual skills are the object of the instruction, computer games can be designed to address specific learning outcomes. Specific features displayed in a game are important. Players want challenging games with clear and concise instructions, help functions, and control over gaming options such as speed, difficulty, and timing. High-quality screen design, color, action, animation, and appropriate use of sound and feedback are desirable. In most of the games studied, participants indicated that these features were very important to sustain interest in the game. Games lacking the features listed above may not keep a player engaged for a sufficient amount of time for learning to occur. The majority of players in this, use trial and error as their game-playing strategy. This choice of strategy was due in part to several reasons related to what the participants themselves expressed as important concerns. Often, players would begin playing the game using trial and error and then would look for guidance by reading instructions or hint screens. As a result, computer games in an instructional setting should be constructed to allow for discovery learning, but clear and concise instructions and goals should be available for the player to access if needed. Likewise, a statement of goals and objectives is important to encourage engagement in a game.

Table 1. Different Games - Abilities

Adventure games	Survival skills Inventory Supply and demand Probability Consequences Problem solving Navigating History Purchasing Budgeting Higher order thinking skills Learning verbs/nouns Spelling/writing
Puzzles	Planning strategies Thinking ahead Spatial orientation Map reading Architectural design Problem solving Hand-eye coordination Pattern recognition Matching Assembly/disassembly
Arcade games	Hand-eye coordination Reflexive action Motor skills Speed simulations Multiple problems/priorities Timing Angles, trajectories Air current Planning Decision making
Miscellaneous games	Logic Pattern recognition Short-term memory Learning alphabet Probabilities Pattern matching Audio/visual discrimination
Word games	Vocabulary Spelling Problem solving Remediation Verbal information Drill and practice Reinforcement
Board games	Budget Logic strategy Counting Planning Problem solving Deductive reasoning Critical thinking Coordination Navigation

Simulations	Writing fiction Developing framing strategies Tactical and strategic planning Coordinates Velocity, speed, wind, angles Decision making Consequences Economics Stock projections	
Card games	Probabilities Developing strategies Pattern	Calculating risks Addition

4. COMPUTER GAMES AS A LEARNING TOOL

A tool is an instrument that a user may operate and manipulate to make a process easier or more productive. It may further be described as cognitive when the tool assists constructive thinking (Pea, 1985). Cognitive tools aid students in performing conceptual operations otherwise beyond their abilities. Learners become better, more independent thinkers when using effective cognitive tools, inasmuch as cognitive tools promote and cultivate higher order thinking skills (Salomon, 1993). Salomon (1993) lists the four attributes of a cognitive tool as: (a) an implement or device, such as a symbol system, mental strategy or computer program (b) which entails the purpose for which it is designed to serve, (c) serves functions beyond itself, and (d) is distinguished from machines by the need for skillful operation throughout its function. On the other hand when considering computer games as a learning tool it is important not to be overly complex. Levels of complexity should be based on the learner's experience (Jacobs & Dempsey, 1993). Providing examples, winning prototypes, of how to play the game can facilitate engagement in a game as well as incidental learning. Similarly, game players could acquire winning prototype learning strategies that would transfer to other learning tasks. Computer and video games may improve several types of cognitive learning strategies. These include: organizational strategies (paying attention, self-evaluating, and self-monitoring), affective strategies (anxiety reduction and self-encouragement), memory strategies (grouping, imagery, and structured review), and compensatory strategies (guessing meaning intelligently). These strategies are in direct relation with computer games.

Research aims at measuring the effect of playing video-games on cognitive abilities (perception, visual attention) and on development and personality (particularly on aggressive behaviors). A second body of research appeared recently within the theoretical framework of the multimedia learning community, in which video games are considered as a particular interactive multimedia instructional material. In both cases, the video game is used as a particular task or material but its specificities are not taken into consideration. The effects of playing video games on cognitive and perceptual abilities, emotional responses and knowledge acquisition emerged in the literature, but they remain very disparate and inconsistent. Studying the effects of video games, lead to ask what dimensions of the game experience can affect cognitive abilities. According to Gentile there are four independent dimensions: amount, content, form and mechanics. The amount refers to the time spent playing video games and the habits of play. This leads to considerations about video game addiction. Content, refers to effects of the messages carried by the video games as a media. Studies about games having an effect on behaviors, skills and attitudes typically are related with this dimension. Effects can be studied as negative, like violence and change of aggressiveness, or positive like health promotion. Form, refers to a kind of knowledge of the media. For example, the constant need to scan the screen in action games could improve some visual attention skills. Realism issues are also contained in this dimension. Mechanics refers to mechanical input-output devices used (Gentile, 2005). Another important issue could be the environments that games have. In the assessment of computer games as learning tools, games' environments can encourage the learning of implicit knowledge. Implicit learning occurs when a subject is not consciously intending to learn, is not aware of what they have learned, and yet they acquire new knowledge (Kihlstrom, 1994). Implicit knowledge is not necessarily reflected in people's ability to answer written questions, since they are not always consciously aware of what they have learned.

Is it possible to mix a game with a lesson and produce a valuable educational tool or is there any innovative way to use computer games for learning? Games marketed as being educational often seem to lack obvious cognitive value, while many educational toys are neither fun nor engaging. One of the most important things is to review proposed benefits of using games as cognitive tools, and to discuss the complexities in assessing those benefits. Researchers propose many benefits from the use of educational games, but the issue is complex, and several variables must be considered in assessing their effectiveness (Randel, Morris, Wetzel & Whitehill, 1992). After playing shareware entertainment games, adult players generated numerous ideas for instructional applications of computer games. Educational researchers and theorists ascribe to games a wide range of benefits that include improved practical reasoning skills (Wood & Stewart, 1987), higher levels of continuing motivation and reduced training time and instructor load. Diverse training applications, such as attention reduction or automaticity training (Jacobs & Dempsey, 1993) and complex problem solving (Hayes, 1981), are hypothesized to be prime candidates for gaming strategies. The limited amount of study in this area has led researchers to question many claims made on behalf of educational games because of insufficient empirical support. Even so, games, particularly computer games, are considered by many to be powerful tools to increase learning. Recognizing that educational computer gaming is a growth area and one worthy of exploration by applied researchers seems almost self-evident.

Common concerns from all qualitative sources were, first, the need for clear, concise instructions describing how to play the game. Second, the game should be challenging. Third, the player should have control over many gaming options such as speed, degree of difficulty, timing, sound effects, and feedback. Each of these concerns was listed in all eight of the gaming categories. It is asserted that learning potential is greatest when participants, rather than computers, have control over events. Aesthetic factors, specifically color, screen design, appropriate use of sound, and feedback, were considered very important in seven of the eight gaming categories. The need for opportunities for success was isolated as an area of concern in all gaming categories except adventure, arcade, and board games. Especially in simulations, adventure, board, and card games participants felt that clear goals and objectives were needed. Participants found certain features to be distracting. Lack of control, poor or no instructions, unsuitable levels of challenge, insufficient feedback, and intrusive sound across all game types were a main source of frustration for many of the players. Many of the games used in this study were shareware games lacking in three dimensional color graphics. This, no doubt, led to expressions of dissatisfaction with both color and graphic quality. Players often found the screen designs to be boring or unsophisticated. Bowman contrasts video gamers, who are engaged in states of flow, with students in traditional school environments. Students in traditional, teacher led classes have little control over what they learn, are passive recipients of material chosen by teachers, must conform to the pace and ability level of the group (group instruction), and are given shallow, imprecise, normative feedback on their work. Contrasting characteristics of video game playing and traditional schooling are expanded in Table 2 (1982). Bowman suggests that educators could use video games as a model for improving learning environments, by providing clear goals, challenging students, allowing for collaboration, using criterion based assessments, giving students more control over the learning process, and incorporating novelty into the environment. Bowman acknowledges that well designed learning environments use many of these design features in order to engage learners in states of flow; educational approaches such as problem-based learning environments, case based reasoning, learning through participation in communities of practice.

Table 2. Differences between video games and traditional school environment

Player controls how much she plays and when she plays.	Groups of students learn at one pace, and are given very little freedom to manage the content and pacing of their learning.
Students are actively engaged in quick and varied activity.	Students passively absorb information in routine activities, such as lecture
Players play and practice until they master the game; players can take all of the time they need to master Pac-Man.	Students must all go at the same pace, regardless of achievement. As Reigeluth (1992) describes, traditional schooling holds time constant, allowing achievement to vary, instead of holding achievement constant (ensuring that all students master material) and allowing time to vary.

Players have feeling of mastering the environment, becoming more powerful, knowledgeable and skillful in the environment.	Students learn knowledge abstracted by teachers and regurgitate this knowledge on pencil and paper tests, rarely applying it in any dynamic context.
Video game players work together, sharing tips and trading secrets.	Students perform in isolation, and cannot use one another as resources.
Performance is criterion based; each student competes against his/her ability to master the game, to reach new goals. Every student can reach a state of "mastery" over the game.	Students are graded normatively, graded against one another's performance and encouraged to compete against one another.
Games are played for the intrinsic reward of playing them, for the emotional state they produce (Herz, 1997).	Schools are structured around extrinsic rewards, such as good grades or a fear of failure (flunking).

Strategies in playing computer games included trial and error, reading instructions, relying on prior knowledge or experiences, and developing a personal game-playing strategy. Trial and error in computer gaming is defined as the absence of a systematic strategy in playing a game. This particular strategy involves actions and reactions to circumstances, consequences, and feedback within the game framework. Knowledge of how to play the game is accumulated through observation and active participation in the gaming process, not by reading rules and instructions. Trial and error was by far the predominant strategy across all game types. It is the predominant strategy used in games. This choice of strategy was due in part to several reasons related to what the participants themselves expressed as important concerns. Chief among these were lack of clear instructions, unclear goals of the game, and the participants' desire to discover the object of the game while playing the game. Often, participants would begin playing the game using trial and error and then would look for guidance by reading instructions or hint screens. As a result, computer games in an instructional setting should be constructed to allow for discovery learning, but clear and concise instructions and goals should be available for the player to access if needed.

5. CONCLUSION

Assessment methods are complex issues while measuring the value of computer games. A long list of questions have been raised about gaming assessment. Further study intends to develop a framework in order to integrate computer games into the design studios. Educational games may offer a wide variety of benefits. Increases in interest and motivation, as well as improvement of retention and higher order thinking skills are worthwhile goals for an instructional tool. However, several factors must be considered in the design of an educational game, and in the design of its assessment. Researchers must be careful with their methods, and administer the game as well as the assessment in an appropriate manner. Instructional objectives of the game must be clear, and matched to the assessment tool. Assessments should consider individual personality types and cognitive styles, and carefully consider how the learner can demonstrate what they may have gained from the activity.

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A DYNAMIC METHODOLOGY FOR EMBEDDING GENERATIVE SYSTEM APPROACHES IN ARCHITECTURAL DESIGN EDUCATION

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ABSTRACT

The generative systems have been discussed in many fields such as computer science, architecture, natural and social sciences over the last fifty years. Different approaches such as Cellular Automata (CA), Agent Based Design (ABD), Swarm Intelligence, Genetic Algorithms (GAs), L-Systems (Ls), Bio-Mimetics (B) within generative design paradigm show a potential to enrich way of thinking, particularly in architecture. However, generative design accompanied with computational thinking has not been embedded enough into the architectural curriculum. In this paper, we focus both on discussing how to introduce generative design theories to the students of architecture and how to observe the short term reflections via students' term projects.

Keywords: Generative design, generative systems, dynamic systems, architectural design education.

1. INTRODUCTION

Over the last fifty years, depending on the rapid changes both in production and in design technologies, new design approaches emerged in the field of architecture. The generative design approaches can be assumed as some of the new concepts which enrich way of thinking via their own potentials. While extending new methodologies, generative systems also require new points of view, new vocabularies and a new philosophy. McCormack et. al. (2004) consider generative systems as a new paradigm shift in terms of Kuhn's terminology.

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The inspiration of generative design system approaches is derived from the nature. The common dominator of the generative design approaches is that they are all related to the complexity theory. McCormack et. al. (2004) underline that generative systems are related to dynamic systems and their outcomes. Cellular Automata (CA), Agent Based Design (ABD), Swarm Intelligence, Genetic Algorithms (GAs), L-Systems (Ls), Bio-Mimetics (B), Shape Grammars (SG) are considered as a subset of generative design systems in the literature (Singh and Gu, 2011). Singh and Gu (2011) indicate that these subsets of generative design approaches have potential advantages for different phases of the design process (Singh and Gu, 2011). Knight (1999) highlights the potentials of shape grammars in architectural design education and practice. Oxman (2006) discusses the influence of new emerging technologies in the fields of architectural design.

The main aim of this paper is to discuss and to evaluate our own teaching methodologies within a master level compulsory course, titled "Generative Systems in Architectural Design" held in Istanbul Technical University, Graduate School of Science, Engineering and Technology, Department of Informatics, Architectural Design Computing Graduate Program, through the program of the course and the students' studies of the 2011-2012 spring semester.

2. GENERATIVE SYSTEMS IN ARCHITECTURAL DESIGN

2.1. Description of the Course

One MSc course including lectures, literature reviews, reflection writings and discussions about reviews and one term project were selected within the scope of this study *(Figure 1)*. In this course, students were first donated by lectures driven both by the instructors and by the guests having expert knowledge about the issue of the week. Readings relying on conventional generative design frameworks were also given in order to build up a direct support for theoretical explanations detailed during the lectures. The content of the lectures and literature reviews can be listed as below:

- Epistemological descriptions about Generative Systems,
- Practical descriptions concerning ways that Generative Systems are used in design field,
- Interpretation of Generative Systems related to the particular design problems chosen by students.

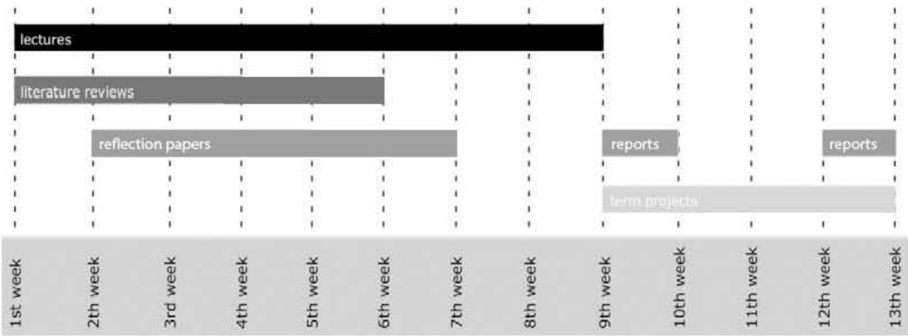

Figure 1. Timeline of the course

In order to be able to develop their own point of view, insight and ability of interpretation, students were oriented to keep a critical distance to examples and to theories via written reports. They were expected to submit 5 reflection papers based both on the detailed descriptions of different Generative Systems which are Cellular Automata (CA), Agent Based Design (ABD), Swarm Intelligence, Genetic Algorithms (GAs), L-Systems (Ls), Bio-Mimetics (B), Shape Grammars (SG) and on the examples including the integrated use of these systems. The main purpose was to encourage them to find out their own design strategies related to a particular design problem of various scales (urban, architectural, object scale) using one or more generative design approaches which were introduced them in lectures and readings. At this juncture, students were expected not only to solve specific problems given by the instructors but also to explore knowledge about problems they found out.

2.2. Methodology of the Course

As Watanabe (2002) underlined, to clarify the design process, you need to write down what was good about something, why you selected it, you need to exteriorize what went on in your mind so that other people "and also you" can understand it, to describe on white paper a fraction of what happened in the black box that is your brain. Therefore we asked students for retrospective decoding of their own projects revealing their strategies via written reports. With the reflection papers and the final retrospective reports we aimed first to build up a general awareness of the issue by re-experiencing it within a different domain and second to fill the gap between learning a theory and interpreting it. In reports, we examined the verbal similarity, discontinuity, conceptual matching and mismatching between theoretical feedback and design strategies of term projects. According to analysis, we explored how the theoretical instructions affected the way of both thinking and doing in design process. In this regard, we propose here a dynamic observation method concerning students' feedbacks in order to understand theory and praxis cycle.

3. METHODOLOGY AND EVALUATION

3.1. Methodology

The main data for evaluating the course were the reflection papers of the students, examples as midterm presentations, final design projects and their reports. Since the outputs were dominantly in verbal decoding, we filtered the specific terms/concepts both depending on literature and in relatively subjective manner. Afterwards we compared the terminology regarding (i) verbal similarity/discontinuity, (ii) conceptual matching/mismatching criteria.

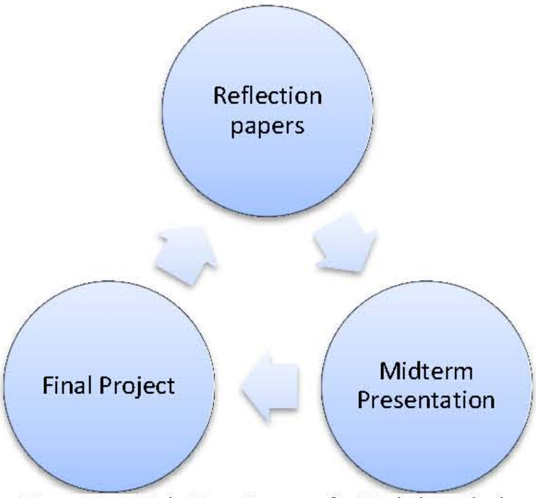

Figure 2. 3 Main Data Sources for Verbal Analysis

The interaction among the different data source is shown in *Figure 2* and *Figure 3.* The first two modules (reflection papers and midterm presentations) can be considered as more objective and comparable outputs; however the final report of the final projects were more subjective. On the other hand, reflection papers provided us subjective information about how and with which concepts the students interpreted the discussion topics related to the generative design approaches. In addition to the verbal data, design processes of final student projects and their preliminary outputs were also taken into consideration.

Reflection Papers	**Midterm Presentation**	**Final Report**
Term1 Term2 Term3 TermN…	TermA TermB TermC TermN…	TermX TermY TermZ TermN…

Figure 3. Comparison of the Verbal Data

3.2. Student Works and Evaluation

In this part, we focused on the studies of four out of eighteen students registered in 2011-2012 Spring Semester to the "Generative Systems in Architectural Design" course. We selected these students because firstly, they had worked in design problems (Term Projects) of various scales (sitting component, schools in city scale, structure design and nature inspired systems) and secondly, they both integrated computer programming into their work. In order to understand and to apply generative design rules, algorithmic thinking was encouraged. Students were coded as numbers such as 'student 1', 'student 2' in the figures. Five reflection papers were coded as symbols from a to e. The visual outputs with different phases of the design process belonging to 'student 1' and 'student 4' are shown below (*Figure 4 and Figure 5).*

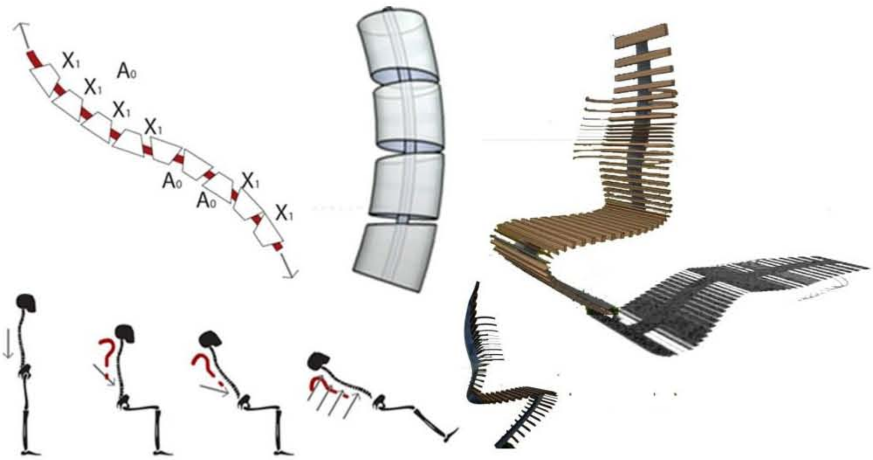

Figure 4. Diagram and renders of 'student 1'

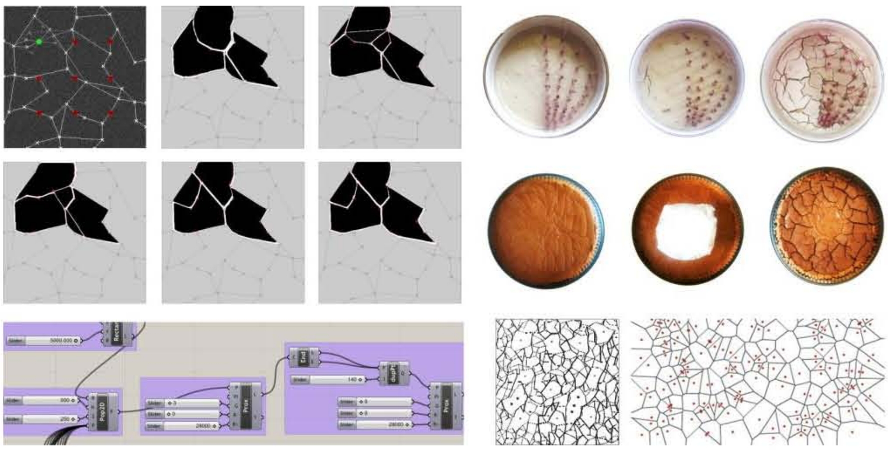

Figure 5. Images of 'student 4' belonging to the different phases of design process

One of our initial observations was that there were positive contributions of interpretation process of the theoretical aspects such as extending the conceptual terminology and understanding the semantics of existing vocabulary both in writing/reading exercises and in exploring by doing.

Besides that, it is possible to see in *Figure 6* that there is no one-to-one correlation between the vocabulary of midterm presentations and the other parts. In other words, the midterm presentations depending on the example review did not limit final projects' scope, therefore did not directly limit students' way of thinking.

Student	Reflection Papers	Midterm Presentation	The Term Project
1.a		shape grammar interpreter, parameter, shape, rule, geometry, space layout, rule based shape generation, geometric translation and union seperation addition, perception, creation transformation, scale, distance	interactive sitting component spinEAT, spinal system intelligent agents, user interaction, movement , nervous system, biologic and mechanic systems, sitting and lying, cellular automata, genetic algorithm, neighbourhood
1.b	digital media,digital design, formulas, mental interface, file-to-factory, productivity, rationality		
1.c	shape grammar, language, prototype, analyse- transformation-sythesis, paralel grammar		
1.d			
1.e			
2.a	classes of design, abstraction, vocabulary, syntax, semantics, context and style	procedural city modeling, algoritmic, shape grammar, virtual city	agent based models, swarm behaviour, patterns, parameters, dynamic shell, agent, algorithm, attraction point, array, route, pedestrian movemet simulation
2.b	performance, generation, representation, evalutaion, implicit explicit design,		
2.c	shape computation, grammar		
2.d	shape grammar, l-systems, cellular automata, genetic algorithhms, swarm behavior		
2.e	emergence, new materialism, morphogenesis, simulation,		
3.a		shape grammar, symmetry, parallelism, geometric representation, rule, addition, seed germ, transformation	rule based, digital design, parameter
3.b	digital design		
3.c			
3.d	dynamic system, digitalmedia generative systems,		
3.e			
4.a	reasoning, algorithmic flow, complexity, solution space	shape grammar, digital fabrication, manifacturing, rapid prototyping, computable construction, personalization.	crack, city, growing, voronoi, optimisation, algorithmic, partial control, iteration, pattern, transformation
4.b	performance, intergrated design, digital media,optimisation		
4.c	shape grammar, analytic, synthetic, implict, emergence		
4.d	transreality, algorithmic, symptom, digestion systems, circulatory system, respiratory system, subsystems		
4.e	digital design, simulation, vision, shape grammar, systems, fractals, algorithmic, cellular automata		

Figure 6. Comparison of verbal data of four MSc students

4. CONCLUSION

Many disciplines have long advocated the benefits of Generative Systems in different fields such as computer science, architecture, natural and social sciences etc. This study specially focuses on studies in Generative Design paradigm in a master level compulsory course titled "Generative Systems in Architectural Design" held in Istanbul Technical University, Architectural Design Computing Graduate Program in 2011-2012 spring semester.
We consider that each writing and/or doing process build up another interpretation layer. Therefore, we would like to indicate the importance of constructing a dynamic balance between learning by reading/writing and learning by doing. Moreover, we also underline the significance of literature and/example review in the field of generative design approaches.

ACKNOWLEDGEMENTS

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A DIGITAL RECONSTRUCTION OF VISUAL EXPERIENCE AND THE SEBASTEION OF APHRODISIAS

ÖZGÜR ÖZTÜRK[1]

ABSTRACT

Today, computers enabled architects to represent their ideas in a fast and more efficient way compared to making drawings by hand. It enabled architects to visualize their ideas in a way that hand drawings cannot. This paper is an attempt to make digital reconstructions to provide the visual experiences of the ancient city Aphrodisias in western Asia Minor and its temple dedicated to divine emperors known as the Sebasteion of Aphrodisias. Its aim is to show that by using common architectural softwares one can overcome the possible problems of graphic representations in the history of architecture. Moreover, this study focuses not only on the interpretations of the data at hand but also demonstrates how the missing information defines and shapes the digital models in order to convey the meaning of the buildings.

Key words: Digital Reconstruction, Visuality, Aphrodisias, the Sebasteion of Aphrodisias

1. INTRODUCTION

It is fascinating to see how architecture evolved in a decade in terms of graphic representation tools. When looked at real estate sections of the newspapers or advertisements of construction projects viewers mostly “convinced” with “breathtaking” animations and graphics where the projects take place in amazing landscapes, brand new buildings in perfect weather conditions and everyone is happy and content about their life. In short, it is possible for us to say that 3d visualization tools are offering a lot to its users in order to represent a prospected future not only for the architect and engineers but also to people who has no training at those fields at all. On the other hand, when looked at the possibilities to create spaces that does not exist in the physical space one might ask can we indeed reconstruct a building completely and give the observer an idea about how it looked

[1] PhD. Student

like originally, and demonstrate its transitions, evolutions to convey the meaning of the building in a convincing way?
In this paper other than trying to make digital reconstructions of the city of Aphrodisias and the Sebasteion of Aphrodisias, I will try to test and understand better both the advantages and problems of using such a strong graphic communication tool in coming closer to convey and understand how historical buildings were experienced by their users in the past. In doing so, I also hope to broach the pressing question: Can we really get the meaning of the building by making such a model considering the fact that the image can overwhelm the meaning?

2. APHRODISIAS, CITY OF APHRODITE

2.1. City of Aphrodisias

The city of Aphrodisias is located in the south-western part of the modern day Turkey. The area was identified as Caria in the known ancient geographical terms. According to the excavation reports, the first known settlements at the site date back to 5800 B.C. the late Neolithic and Chalcolithic periods (Joukowsky, 1986). In the Classical era, it was considered as a small size settlement rather than a city because the earliest public buildings, the Sanctuary of Aphrodite and the North Agora, are dated as late as the 1st century B.C.(Ratté, 2001) Until then, it is generally believed that the main building process was primarily limited to housing[2]
The city then draws the attention of Julius Caesar with its dedication to Aphrodite. Since Caesar's family claimed direct descent from Venus, this helped Aphrodisias to develop a privileged relationship with Rome herself [3](Erim, 1986). Additionally, a former slave of Gaius Julius Octavian, Zoilos, starts one of the most important construction phases of the city, the northern colonnade of the North Agora, the new Temple of Aphrodite and the stage building for the city theater. By the mid 2nd century the area between the North Agora and the Theater, which is known as the South Agora, was enclosed with colonnaded porticoes. On the west end of the South Agora, one can see one of the two baths of the city dated to the Early Hadrianic period due to the distinctive decoration of its time; it is known as the Baths of Hadrian in order to clarify any confusion among the two baths[4]. The civil basilica, a basilical hall thought to be used for administrative purposes was located in the SW corner of the South Agora. The Temple of Aphrodite underwent some modifications too. First, the temple was enclosed with a colonnaded court having an entrance from the east. Later, another walled-off area with porticoes and a large columnar gateway called the Tetrapylon was added to the east of the compound. In addition the Stadium, at the northern edge of the city (Ratté, 2001), and the Sebasteion, at the eastern end of the North Agora, were also built at the same time period (Smith,

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[2] Until the 2nd and early 1st century B.C. the population of the area was not enough to call the settlement a city.
[3] Based upon these connections, the city receives a senatorial decree *(senatus consultum)* which grants her freedom, a non-taxable status and increased asylum rights in Aphrodite's sanctuary.
[4] The other bathhouse is located south of the theater and called Theater Baths.

1987) In the mid-3rd century, as mentioned by Erim and Ratté, nobles of the city invested in their own private housing rather than commissioning new public buildings, except for repairs and restorations. the only notable progressive construction project one can see is the construction of the city walls on the late 4th century. In the 5th century A.D., the sanctuary of Aphrodite was converted into a church By dismantling and using almost every building component of the temple, literally turning the temple "inside out".
Although there is some dispute about what happened between the mid-5th and 7th century,[5] adding up the stage wall of the theater to build a fortress may show us that there was a dramatic change in the population of the city. The city shrunk back to the same population-size at the same spot where it had started out but with a church instead of a temple. Aphrodisias was now called Stavropolis, the city of the cross, rather than the city of Aphrodite.

2.2. The Sebasteion of Aphrodisias

By looking at the city plan retrieved with recent excavations and geophysical surveys in the city it is possible to say that the city of Aphrodisias had a grid plan. According to Ratté, the city centre was bordered by four major streets and the most important one was the street running at the N-S axis from the Tetrapylon to the Theater (Ratté, 2001). On this alignment one can see six important buildings of the city: The Sanctuary of Aphrodite, North and South Agoras, The Sebasteion, Theater and the Theater Baths. However the Sebasteion draws attention on this aligned orthogonal city pattern with its conspicuous angled position.
This building complex consisted of four components: a propylon, monumental gateway, two porticoes and a temple. The propylon is situated along the wide N-S oriented street facing the entrance of the North Agora. The existing situation of the propylon consists of podium blocks and three staircases where one can step up to a higher level than the street. Small segments of the North and South Porticoes also face the street and unify the propylon with the porticoes. Two porticoes located at the North and South of the building escort the viewers to a processional road which leads to a temple dedicated to *Sebastos*[6].
The Propylon consisted of two storeys, in the Ionic and Corinthian styles respectively, with sculptural additions in between the columnar axis. Thanks to the information gathered from the surviving sculpture bases, even though we do not have the sculptures themselves, we do have a fairly good idea about the location of the statues.
When looking at the two porticoes, even though they comprise similar components of the overall building, they stand quite apart from each other with their different architectural and sculptural features. Firstly, along the length of these almost 90m long porticoes, intercolumniations were different on both sides. In the North, the

[5]It is not known whether a change in the water level, earthquakes and invasions were instrumental.
[6] *Sebastos* is the Greek equivalent of the Latin Augustus. See Erim, K. T. (1986). Recent Discoveries. In K. T. Erim, *Aphrodisias, The City of Aphrodite* (pp. 103 - 126). London: Muller, Blond & White. see also Smith, R. (1987). The Imperial Reliefs from the Sebasteion at Aphrodisias. *The Journal of Roman Studies* , *77*, 88 - 138.

intercolumniation consisted of a single width, in contrast to the rhythmic system going on at the South Portico. In the latter, *a module of a room* consists of one wider intercolumniation in the middle and two narrower ones at the sides. Both porticoes were also at different heights and architectural detailing. Although very few reliefs of the North Portico have survived, we have an idea of the composition at the north. We know that there were a series of allegorical figures personifying elements of time and space(Smith, 1988), such as the personifications of the Day and the Ocean, and *ethnos* reliefs[7]. On the other hand, possibly because the South Portico collapsed at a later date and the fragments of the building were not used as *spolia*, we have a larger reflection of the South Portico in its entirety. On the second storey of the building, we can observe a sequence from Greek mythology like Leda and the Swan, Demeter and Triptolemus, Bellerophon and Pegasus... On the third storey of the building we see the Roman Emperors depicted with the themes of imperial victory, the divine emperors and the gods. As Ratté has pointed out (Ratté, 2002), in view of the fact that the first storeys of both the porticoes had no function with their small unconnected rooms, the users most probably did not have much to do inside the alley except walking up and down along *the street.*
As far as we know, the temple was a Roman style podium temple in the Corinthian order (Smith, 1987). During the conversion of the city to Christianity in the 5th century, the Temple lost its function with this new religion and it was dismantled to pieces and converted into workshops (Ratté, 2001).

3. MODELLING PROCESS

3.1. Decisions before Modeling Process

As previously stated, I will try to reconstruct the Sebasteion of Aphrodisias and the city itself via daily used architectural programs. Therefore we have to set up some parameters and basic notions even before modeling the city and the Sebasteion.
In order to understand the Sebasteion within its context and the urban pattern of Aphrodisias, we have to make a model of the whole city with its landscape. One of the purposes of making the model of the landscape of the city and its vicinity is to experience the city in an urban context. Additionally, a detailed digital reconstruction of the Sebasteion will be made in order to understand better or at least get closer to the meaning of the building.
In both of the models, one of the main concerns of the modeling procedure is the amount of detail needed on the buildings. In view of the fact that I was a member of the Anastylosis Team of the Sebasteion for seven years, I had the chance to draw almost every block type of the building which gives me a large amount of architectural data. As a result, this gives me a chance to show the architectural features of the building to the viewers. In addition, by adding the reliefs to their proposed locations on the building, we might be able to get much closer to generate the visual imagery of the building. As mentioned before, one of the main purposes

[7] These include the depiction of nations and provinces conquered by the Julio - Claudian family.

of the digital reconstruction is to create the effect of being there at that selected moment which faded away centuries ago, at least, in visual perception.
Additionally, one has to determine which time era of Aphrodisias is going to be modeled. Since the purpose of this is to experience the Sebasteion as a whole within the context of the city, the date of the city must be set to early 3rd century A.D. As a result there will be no city walls (Staebler, 2008) and the stadium would be higher than its current height (Welch, 1998) a model cannot contain both the city walls and the North Portico of the Sebasteion at the same time and be academically dependable.

3.2. Model of the City of Aphrodisias

In view of the fact that models generate the visual imagery of the buildings rather than the photorealistic experience of the city, the landscape also had to be presented in the same way. Therefore, a more figurative but comprehensive way of modeling was selected. For this reason, none of the architectural orders are recreated or remodeled on building models. Especially in a city-scale model, eggs and darts of the Doric order or volutes of the Ionic order would not help us to understand the importance of the Sebasteion in the city scale.
Even though the details of the buildings are *"sticks and boxes"* due to difference of scale this model helps us to visualize how Aphrodisias looked like in its heyday in the 3rd century A.D.
In the process of modeling buildings, one of the decisions was about whether to show the roof tiles on the buildings or not. Even though it is known that buildings were painted in antiquity, it is hard to find complete data about the use of colors on the buildings of Aphrodisias with the exception of studies made by Mark Abbe on polychromy.(Smith and Lenaghan, 2008) and (Smith and Ratté, 2006) [8] On the other hand, highlighting the heights of the buildings would give the viewer's eyes the sense of height and three dimensions among all the different shades of grey. As a result, only the roof tiles of the buildings are put in their places to show the edges of the buildings.
Even though there is evidence for an ongoing urban grid pattern one cannot simply recreate whole houses of the city for practical reasons. The city lived on and its people modified their environment according to their needs which made it impossible to figure out how houses looked like in 3rd century A.D. However it is crucial to give the effect of the housing pattern of the city in order to bind the monumental buildings of the city to each other in re-creating the urban setting. Consequently, instead of modeling houses, only big boxes are modeled to define prospected areas of housing in 3rd century A.D. By doing so, the model gave the chance to perceive the streets and their role in order to understand the role of the Sebasteion in the urban context.

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[8] see also Abbe, Mark B. "Polychromy of Roman Marble Sculpture". In *Heilbrunn Timeline of Art History*. New York: The Metropolitan Museum of Art, 2000–.
http://www.metmuseum.org/toah/hd/prms/hd_prms.htm (August, 2012)

3.3. Model of the Sebasteion

In order to make a 3D model of the Sebasteion every known block type was drawn, studied and documented in the field during the anastylosis project. Moreover, besides the actual reconstruction of the SE corner of the building, the Propylon and some fragments of the temple were studied for future projects. As a result, block typologies, detailed drawings and more importantly, some reconstruction drawings were already made in order to understand the structure of the Sebasteion at Aphrodisias. The model of the Sebasteion had to have more architectural details in contrast to the city model and its *"boxes and sticks"* approach. Some basic elements of the architectural orders such as; triglyphs of the Doric order, dentils on the Ionic cornices, lion heads on all cornice blocks, acroteria of the South Portico and the flutings on column shafts were added.

Modeling the reliefs and bases of the Sebasteion was rather a challenge when compared to modeling the architectural components of the building. First of all, every architectural component of the Sebasteion was drawn in the field. Even though there might be missing blocks, in view of the fact that the building had a repetitive tempo, which helped to replace the missing parts of the building, it was modeled without any technical difficulties. On the other hand, when looking at the reliefs, it is almost impossible to find a common repetitive pattern. Additionally, none of the reliefs has any information at all about how the missing ones could be. Therefore, the models of the reliefs could only be as real as the existing information at hand could offer. Moreover, there are 51 (fifty one) possible spaces where a relief can be put between the columns of the North Portico on the Ionic and Corinthian stories which gives us the total number of 102 (a hundred and two). Unfortunately, the surviving reliefs of the North Portico are just a handful and most of them are just relief bases which give us information about the placement of the particular relief but not its visual imagery (Smith, 1988).

Secondly, the original locations of the reliefs are in debate. Even though there is a drawing at the new wing of the Museum of Aphrodisias with the reliefs on their projected and prospected locations on the building, there is one important detail about the reliefs. As mentioned by Smith, the reliefs of the South portico have clamp holes on their sides which help the reliefs to connect to architectural pieces and thus the structural system (Smith, 1987). Therefore in order to verify the original locations of the reliefs all of the original architectural pieces must be tested with the reliefs so that we can have a solid verification about the position of the relief on the building. As mentioned by Jones, arranging reliefs according to context and find spot plans might give an idea about the visuality of the building but it is really important to keep in mind that this visual image might not be the original state of the building and the reliefs (Jones, 2000). Therefore, even before modeling the reliefs on the building, it is important to keep in mind that existing data is not very solid about the positions of the reliefs which basis a very doubtful base for the modeling process. Making a reconstruction of the building with reliefs based on this data might create an image of the building in a state which it had never been, causing some serious problem of perception.

4.PROBLEMS WITH VISUALITY AND MISINTERPRETATION

4.1. New Museum Wing to the Museum of Aphrodisias

A new museum wing was built for the Aphrodisias Museum in 2007. The main intention of this project was to create enough space to make a new exhibition space for the reliefs of the Sebasteion. The reliefs are currently in a perfectly illuminated and clean exhibition hall where all visitors can reach and even though they should not, touch them.

A significant argument about the museum exhibition is that it does not get close to the visual reality of the building in terms of understanding the impact of the building or the possible experience that their long gone users had. It may help to examine the details on reliefs more closely and give us some clue about the possible production methods. However by doing so, it might be faulty in terms of understanding the building as a whole and might even create a wrong perception about the building.

In addition to this *change of perception* due to presentation in a museum, it would help to ask the question of how much we can understand the entire building from a component of it. How much can a viewer understand the whole with a photo of a relief or a single sculpture of a façade? The technology employed in the study helped us to perceive the Sebasteion in two models. The main concern of both of the models was to put every bit of information on the models so that the models could be "real" as much as possible. Unfortunately some information was always missing and this absent information affected the final result of the models. Starting with colors of the components, missing reliefs and unexcavated areas around the Sebasteion or the site caused problems in the modeling process.

4.2. Color and the Sebasteion

The neo-classical premise assumed that the ancient Greek and Roman sculpture and architecture were monochromatic and sought to represent the figures in terms of such aesthetics. Recent studies have shown that antiquity was not monochromatic as previously assumed. Color was an important aspect of architecture and applied in a wide variety (Brinkmann, 2006).

There are few publications about the use of color on the components of the Sebasteion (Smith and Ratté, 2006). Unfortunately, due to the different scale and viewpoints, color detail would not be visible to the viewer's eye and the whole composition would still be seen as different shades of gray with light and shading effects. Even though there is a vast amount of missing information about the color use in the Sebasteion, it does not mean that if any data is found, this information cannot be applied to the model. In contrast, this kind of monochromatic model will help us to visualize a possible colored version of the building if the data at hand is solid and reliable. By modeling possible varieties of the Sebasteion with colors on architectural components and reliefs, based on a solid and scientific study, can get us one step closer to understanding the overall impact of the building and the possible visual experience that an Aphrodisian would have had in the 3rd century A.D.

4.3. Data That Built the City Walls

Another problem occurs regarding the whereabouts of the missing blocks of the Sebasteion. The North Portico collapsed around the 3rd century and its components were re-used as *spolia* for the city walls. Dramatically a considerable part of the Temple and the sculptures of the Propylon shared the same fate. Moreover the temple was converted into workshops in the 5th century.Yet the existing building blocks of these components give the viewers enough information about the whole of the building in terms of architectural composition. However one cannot say the same for the reliefs and the sculptures of the North Portico. As seen in Smith's article (Smith,1988) a handful of reliefs and relief bases have survived from the North Portico. Sadly, the amount of information about the North portico reliefs has made it impossible to model the whole with reliefs. As a result, one can only have an idea of what the buildings were like when they were intact but did not have enough information for a massive photorealistic reconstruction.

In addition to *spolia* use and conversions of the building itself, another major problem occurred during the modeling process. Albeit the information about the interior and the possible visual effects at the alley of the Sebasteion, it is really hard to visualize the exterior of the building. The existing information suggests that the back walls of the Sebasteion were masonry walls without any cladding or ornaments. Moreover if there was any cladding or ornamentations on the building, the possible area that these blocks might have fallen has not been excavated yet or may still be lying just under the excavation compound.

4.4. It is always Sunny in Renderland

Despite all the missing factors and detailed information about the components of the building, a digital reconstruction study could still get us closer to understand the impact of the Sebasteion because there some factors that can still be tested. In view of the fact that it is not possible to make a photorealistic image of the Sebasteion in terms of architectural details and reliefs does not mean that realism can be achieved only by these details.

As mentioned before when looked at architectural presentations about predicted future it is always sunny in this digital environment. On the other hand, when people actually start to use the building, they add or take away something from the building and due to usage some deterioration occurs inevitably. In other words, nothing stays the same. Unless it is intended in the design dirt never looks good on a new building and it never was a desired object for the design community. On the contrary Favro points out that:

"…visitors to the physical sites recall not only the monuments seen, but, with equal force, the weather, crowding, mood, sounds, and other sensorial responses. These vibrant aspects of the human-architecture connection need to be evaluated for historical environments." (Favro, 2006)

In addition to various weather conditions and the dirt effects to enhance the perspective images it is important to put human figures on them. By doing so, perspective images will help the viewer's eye to scale every detail on presentations. In addition to enhancing visuality and reality it is important to visualize the same perspectives with a different user population. Therefore it is important to visualize the Sebasteion in different times of the day, in different weather conditions and in different user numbers. Experiencing different numbers of visitors on different days is quite expected in a city which was devoted to Aphrodite. In view of the fact that the Julio-Claudian dynasty traced their roots to Aphrodite, a building dedicated to the Imperial cult in Aphrodisias would have drawn a lot of attention during a festival of Aphrodite. As a result, there will be a big collection of similar images during different times of the day, weather conditions and different user population, but this bombardment of information will help the viewer's eye to perceive the Sebasteion one step closer to reality.

4.5. Neither Fantasy nor Reality

The Tetrapylon of Aphrodisias is the monumental gateway to the temple of Aphrodite. It was built around 3rd century A.D. and except for a renovation in the 7th century; it stayed intact until it collapsed. In the 1980s the building was re-erected back to its original place with an extensive anastylosis project and since then the Tetrapylon of Aphrodisias has welcomed all visitors to the site with its strong visuality.[9] After a small village square, which resembles the old days of its village days just before Kenan Erim started his expedition, visitors who choose the North path first encounter the Tetrapylon. However, this first visual encounter is rather different than what an Aphrodisian might have had because the tourist path is higher than the prospected street floor of the 1st century.

Moreover this kind of wide perspective view where the tourists can perceive the Tetrapylon is from the inside of a building and possibly through a wall. When looking from the street level of the city, one can see that the Tetrapylon is hard to perceive because the other side of the street is filled with shops and colonnades. In addition, the Tetrapylon was only the monumental entrance of a processional courtyard which means that there were walls on the North-South axis of the building and it was never visual as it is today. Therefore the image of the Tetrapylon which is experienced so focally during a visit to the site is a *romantic image of a wrong perception* rather than the reality. Digital modeling techniques and presentations in architecture may have a similar tendency when it comes to representing ideas and spaces. These drawings are mostly to give the viewers' eyes an idea about how the project might look or feel like when they are completed. The *possible* visual experience of a user will not be the reality itself but it might give an idea.

In view of the fact that the Sebasteion had a similar problem of presentation on the site due to tourist paths, unexcavated areas and the presentation of building components in the new museum wing, images created by a digital model of the Sebasteion has to cover what the site experience could not in terms *of visual experience*. For example, Smith criticizes the work of Aphrodisian sculptors as the models were redesigned according to local concepts and simplified the work on

[9] As a sign of respect after his death, Kenan T. Erim's tomb is also located very close to the Tetrapylon.

detail[10]. On the other hand, when the reliefs are put into their projected locations one might wonder how these abbreviated depictions would have been perceived. Looking at the same relief in a perfectly illuminated museum and on its projected location on the building two stories up from the ground have different effects to the viewer's eye. Consequently the amount of the perceived detail would be different from each other.

4.6. Replacing the Actual Past with an Imagined Past

Images had to be a product of an extensive study of the building and its surroundings. All the known data that might affect the result of the model should be applied to it carefully and all the known users should be aware of advantages and disadvantages of such studies. In view of the fact that a tool that is used to represent a building in an imaged future is turned in a way to visualize a past based on scientific information, it is really important to draw a line that separates the actual past and the imagined past (Arnold and Bending, 2003).

Representing the imagined past to viewers in a very strong but faulty communication language will end up in misinterpretation of history which will make the whole modeling process less worthy, if not worthless. For instance; the example of Paestum engravings might give an idea of how a pretentious action might lead one to another and end up in a skewed perception with or without intention. The first engravings we know about the temples in Paestum were made by Bartozolli and these engravings became standard views for the following fifty years. These engravings were long accepted as the real depiction of the buildings despite the fact that they were in conflict with verbal descriptions of the buildings (Arnold and Bending, 2003) Therefore by creating an imagined past based on assumptions and missing information alone, the whole study would be another subject of an academic work in the future on how an erroneous digital reconstruction may lead into fantasy rather than reality. Such complications can arise with any academic work, but digital reconstructions are more prone to it, since they are visual tools viewed by the masses as well as academics. As a result while working with such strong graphic communication tools it is important to keep in mind that the image is a wolf with puppy eyes.

5. CONCLUSION

The aim of this study was getting closer to understanding the impact of the Sebasteion within the city context by using architectural visualization tools.

With the help of such strong graphic tool which helps to create an *imagined future* helps us to visualize the *past* in a way that their architects, builders and users would have done was applied to the city of Aphrodisias and the Sebasteion, difficulties were encountered and decisions had to be made. Starting with the missing

[10] For a criticism of R. Smith's approach see Öztürk, O. *Temples of Divine Rulers and the Urban Transformation in Roman-Asia, The Cases of Aphrodisias, Ephesos and Pergamon.* Unpublished dissertation project, University of Texas at Austin.

information about the studied area, extensive studies were made not only to gather information but also to represent that merged information at hand. Even though bringing various disciplines together to achieve the kind of result presented in the study is a real challenge, this will hopefully help us to understand or get closer to understanding the impact of buildings such as the Sebasteion and the mind of their users and builders. Although the result of the models created for Aphrodisias in this paper are eye appealing to the viewers in a way that has never been possible before with other visualization techniques, it is really important to emphasize what kind of information was used in this procedure and more importantly, how the missing information was represented, since the amount of missing information defined the accountability of the result.

This paper shows that every reliable model will help us to ask new questions - that were not possible before - in order to get closer to understanding the impact of the ancient settings and the procedures of design, these new questions will in turn generate new knowledge which creates an indefinite loop between modeling and research for the modeling process that will help us to understand these urban settings in a better way.

As a final word, one must stress that digital reconstructions are not time machines that will take the viewers back in time. They are an alternative way to experience and explain the dynamics of architecture which has to be handled with care. If not, they might end in a dramatic but disastrous result that will echo in the future. As a result, any pretentious action based on assumptions rather than scientific proofs during the modeling process will not get us closer to understand this impact. On the contrary it will create a diversion that will lead to misunderstanding and misinterpretation of the building and its components and it will echo in the future in a brutally straightforward way.

5.1. Figures, Graphics, Photographs and Tables

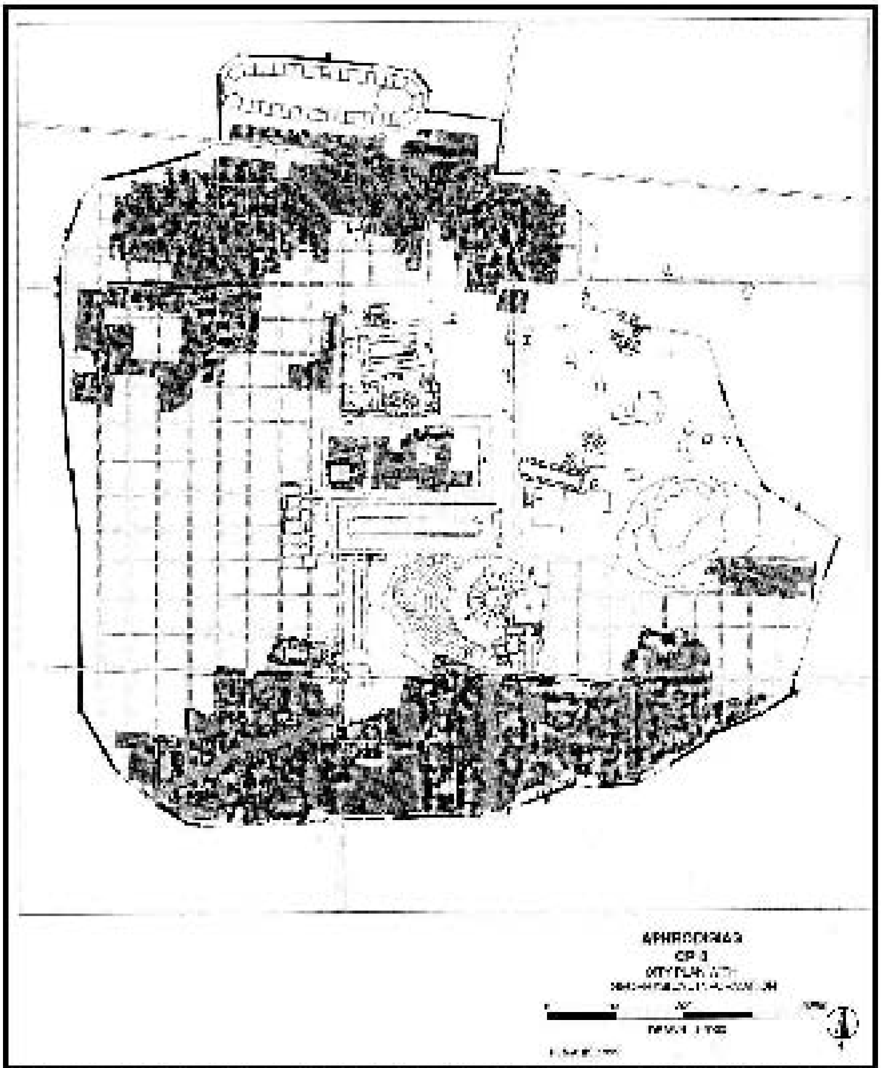

Figure 1. City plan of Aphrodisias with geophysical information. Source: Ratté, C. (2001). New Research on the Urban Development of Aphrodisias in the Late Antiquity. (D. Parrish, Ed.) *Journal of Roman Archaeology Supplementary Series* (45), pp.118.

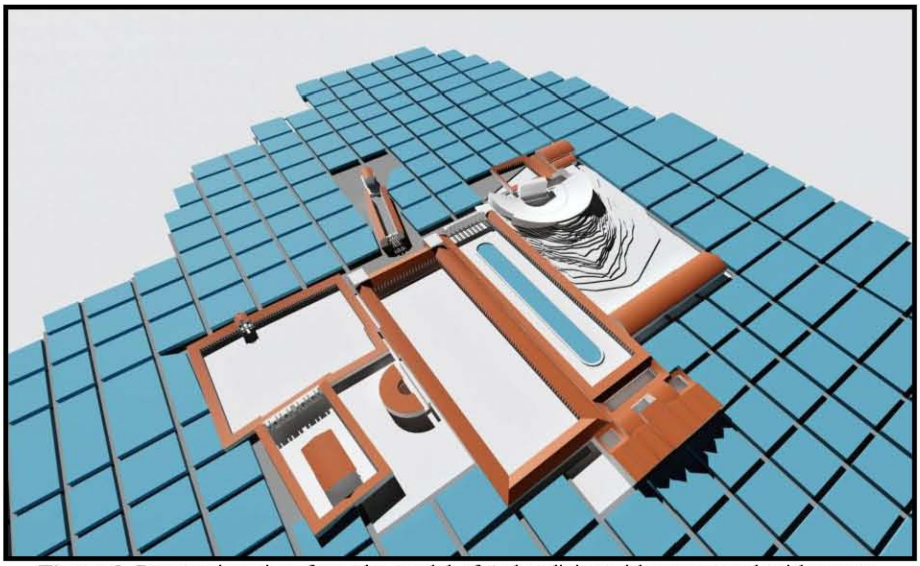

Figure 2. Perspective view from the model of Aphrodisias with prospected grid pattern

Figure 3. Perspective view from the model of the Sebasteion

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KEYNOTE SPEECH

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New Technologies for Cultural Heritage Documentation and Conservation: The Role of Geomatics

NEW TECHNOLOGIES FOR CULTURAL HERITAGE DOCUMENTATION AND CONSERVATION: THE ROLE OF GEOMATICS

GRAZIA TUCCI[1], VALENTINA BONORA[2]

ABSTRACT

The concept of Cultural Heritage is rapidly evolving, connoting the union of an intrinsic and an extrinsic value that includes several economic, territorial, environmental, academic and social aspects. The terrible natural disasters (cyclones, cloudbursts, floods, landslides, volcanic eruptions and earthquakes) that periodically occur weaken our fragile cultural heritage, which is constantly exposed to risk factors. Failing to protect it has negative effects on the sectors mentioned above, as we know that for some of these phenomena the anthropic action (i.e. pollution, improper use) actively contributed to their occurrence. In compliance with this wider view, the scientific and technological research is acting in different fields: from chemical, physical and biological sciences to nanosciences, from the methods of spatial positioning to info sciences.

Key words: Documentation, Conservation, Geomatics, Metric Survey, Cultural Heritage

1. INTRODUCTION

The concept of Cultural Heritage is rapidly evolving, connoting the union of an intrinsic and an extrinsic value that includes several economic, territorial, environmental, academic and social aspects.
The terrible natural disasters (cyclones, cloudbursts, floods, landslides, volcanic eruptions and earthquakes) that periodically occur weaken our fragile cultural heritage, which is constantly exposed to risk factors. Failing to protect it has negative effects on the sectors mentioned above, as we know that for some of these

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phenomena the anthropic action (i.e. pollution, improper use) actively contributed to their occurrence.
In compliance with this wider view, the scientific and technological research is acting in different fields: from chemical, physical and biological sciences to nanosciences, from the methods of spatial positioning to info sciences.

2. FACING THE RISK WITH MAINTENANCE MANAGEMENT

"Understanding the physical fabric of a site is an important first step in finding the right conservation strategy, and documentation is the first step in understanding" (Clark 2007).
This sentence highlights the primary role of documentation and the interdependence between knowledge and conservation strategy: you should know the object surveyed as well as the risk factors to which it is exposed, in order to plan the conservation works and the maintenance programmes useful to prevent risks and to avoid facing emergency situations.
The only possible way to hand over "heritage documentation" to future generations in modern times is through - as permanent as possible - digital records.
Digital tools and media offer new opportunities for collecting, analyzing and disseminating information about heritage sites. For the approach presented here, careful attention has been paid to the suitable role that geomatics should play to implement a thorough prevention policy, in compliance with the recent scientific approach adopted for heritage obsolescence, which aims at optimizing preventive (rather than corrective) maintenance on buildings. This method has apparently higher investment costs, but they will be amortized over the long term. This is briefly the logic at the basis of the strategy and methods of "Building maintenance management" (Lee 1993). This revolution in the philosophy and tasks of restoration, which has always been limited to repairing or renovating existing damage, emphasized the strategic importance of adopting suitable survey tools and methods to support the prevention of "expected damage". This kind of activity is based on timely detection of deterioration phenomena (as well as their mechanisms and possible causes) in order to limit their development and assess their incidence on the artefact's life cycle.
The decay curve of its "performance quality", from the very beginning up to the minimum threshold allowed for the function carried out, allows assessing its "useful life" and planning maintenance works, leaving any possible unexpected failure aside. Without preventive maintenance, small problems with monuments and buildings can quickly grow into critical issues.
If in the building industry these works normally include modification and replacement of damaged parts, in the cultural heritage sector they should not undermine the values (authenticity, artistic value, historical interest, etc.) of every artefact. The model of information required to inform conservation action is already established in the Venice Charter (Article 16) (ICOMOS 1964) and expanded in the ICOMOS Sophia Principles (ICOMOS 1996). The conservation of built heritage is developed following a series of work phases, involving analysis to establish value

and significance in order to understand the priority of action and allocation of resource, diagnosis to identify the causes of damage and decay, therapy to choose the remedial measures and controls or monitoring to review and assess the efficiency of the intervention or conservation regime (Santana Quintero et al. 2007). The contribution of Geomatics is fundamental in all the four phases described above, which should not be considered as part of a linear process with a beginning and an end, but rather than as a cycle (Figure 1): each phase requires thorough, correct and up-to-date metric knowledge of the object surveyed, even according to different levels of detail and accuracy.

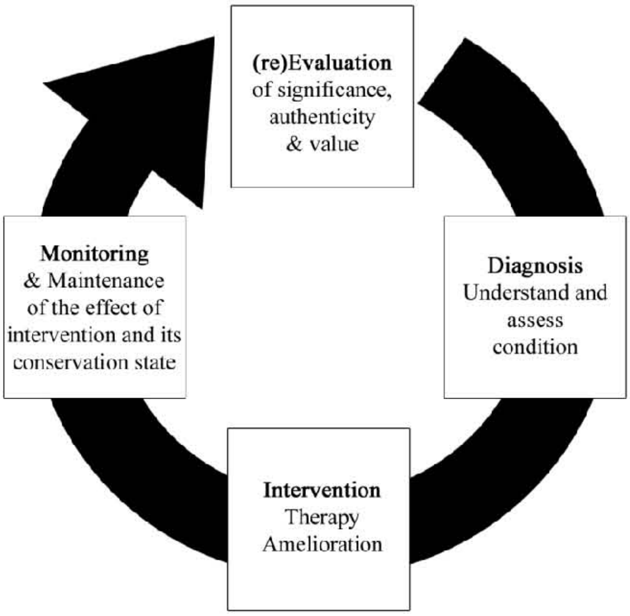


Figure 1. The Conservation cycle (from Santana Quintero et al. 2007)

3. DIGITAL RECORDS FOR HERITAGE DOCUMENTATION

Metric survey is the reference base for all types of documents required during analysis, diagnosis, intervention and monitoring. According to English Heritage, metric survey is “The measurement and pictorial presentation of land and buildings to a specified standard, supplying reliable and repeatable base data without specific thematic input” (English Heritage 2003).

The output of the contemporary metric survey is an information system where information can be structured according to geometry, materials, pathology, and so on, and linked to a database. It is thus possible to provide graphic representations responding to specific queries from time to time. That is why metric survey should

become an aggregation element of multidisciplinary contributions, a common platform hosting every kind of knowledge and not only a simple "service" activity.
The information coming from diagnostic tests and the manifold multidisciplinary contributions should be gathered to form an information system, which will be used from time to time to extract important outputs for the assessment of the "useful life" of artefacts or elements, evaluating their vulnerability in case of natural or anthropic risks.
Good conservation of our cultural heritage is based on informed decisions. The first and effective step towards prevention is an up-to-date documentation of what needs to be pre-emptively defended: the Heritage itself and not documentation for documentation's sake. Documentation is expensive, but contributing towards a better knowledge of the building and its problems brings the conservation costs down as low as possible.

3.1 Level of detail pyramid

Survey should be planned and carried out to reach a level of detail that can provide helpful information by optimizing the invested resources. The frequent need to have data with different scales underlines the importance of integrating various levels of detail into a single documentation project. On top of the pyramid scheme (Figure 2) there are catalogues and inventories, which are the most basic form of knowledge, as they require only "identification" and recording of data. Therefore, each element belonging to Cultural Heritage must first be identified, then geo-referenced and finally stored, associating its position to other basic information, if necessary. At the base of the pyramid there are high-resolution 3D models, whose level of detail allows describing the materials and conservation status by means of a texture. In the middle there are all other types of 2D or 3D representations, carried out with metric data.

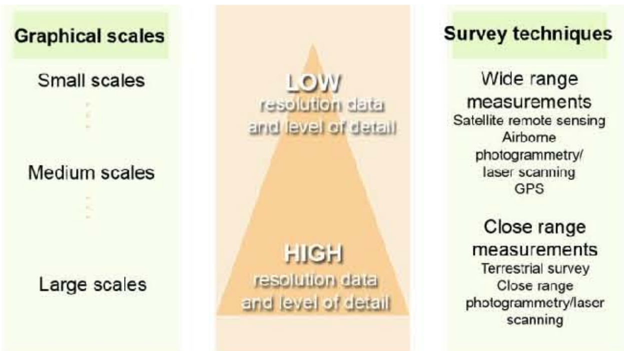


Figure 2. Level of detail pyramid

4. DIGITAL TOOLS FOR HERITAGE DOCUMENTATION

Currently, a wide range of digital sensors for documenting cultural heritage is available. Survey tools can be divided into "direct" and "indirect". The former

require the operator to first build a mental model (and then a virtual one) of the object by selecting all the measures necessary for its construction one after the other, while the latter can postpone modelling according to the density of the object sampled.
In the last decay we have seen the final digital transposition of photography and photogrammetry, the development of scanning systems based on different technologies, electronic total stations and satellite receivers. Except for the natural progressive optimization of these tools, no new kind of sensors has been introduced recently (and this trend will probably continue in the future).
We are instead witnessing the birth of “hybrid” sensors, such as total stations with GPS antennas or laser scanners with cameras, sometimes placed on supports that can acquire data on the move, such as those cameras mounted on drones or UAV, mobile mapping systems, digital cameras on rotating heads, range cameras, which integrate distance measurements and imaging aspects.
After the development of sensors that can acquire high quality data, we are now witness to a process aiming at optimising productivity. Only a few years ago, in 2007 we spent entire nights surveying the Basilica of the Holy Sepulchre in Jerusalem, which required approximately three hours for each scan. With the scanner we use now in our laboratory the whole work would take only ten minutes. We are presently working on a system mounted on a motor vehicle integrating laser scanner, GPS, IMU and digital camera.

5. APPEAL AND RISKS OF VIRTUAL WORLDS

The higher and higher resolution of data and their more and more rapid acquisition risk leading to a separation between the surveyor and the object surveyed. The time spent in the past to observe and draw an object before writing measures down was the first step of a knowledge process in which measurement was often the element confirming or denying a hypothesis (concerning shape, construction, structure and so on) put forward by the surveyor “while” observing the object. Nowadays the shorter time spent on site postpones interpretation. Therefore, the acquisition of very high resolution data is often linked to the possibility of considering the digital reference sufficient to represent the real object rather than to the need for describing tiny variations during the representation phase of the object surveyed.
As Carlo Monti pointed out, even though the situation has changed, the “problem of measurement” still remains “a central element in the issue of scientific knowledge applied to real life. [...] It is an uninterrupted alternation of analysis and synthesis of the object detected, where size measurement is the analysis and model is the synthesis and they can hardly be separated because they are always present at the same time.” The survey tools and methods available today allow, according to Monti, “passing from the monument to a realistic model, where geometries are real within the measurement uncertainty and ‘shapes’ are not interpreted according to historical and stylistic experience, but according to the positioning of several points belonging to architectural elements within a suitable reference system”. (Monti et al.

2004) In any case, it is clear that the transposition of analyses from the real world to the virtual one is both fascinating and potentially dangerous.
Roberto Pane's remark stating that "Briefly, we need to understand that the only real and complete representation of a monument is… the monument itself" (Pane 1948) seems to be questioned by the unstoppable technological progress. But if we consider a documentation project as a series of investigations looking for a series of answers, the only thing we can do is acknowledging the fact that the choice of the questions is the fundamental moment and confirming the leading role of the person operating the tool. Even though we use objective tools to quantify information, its recording is still a selection and interpretation operation influenced by the experience, the cultural context and the time in which the surveyor works.
The degree of "automation" reached by some tools should be considered as the possibility of managing repetitive and complex processes and operations requiring limited human intervention, but we should not confuse it with "autonomy", which is the capacity of choosing among different alternatives without the direct intervention of the user. According to this definition, therefore, an "autonomous" system would be able to work without any specific parameter, which could be inferred from the past knowledge.

6. MODERN SURVEY SYSTEMS FOR CLOSE RANGE APPLICATIONS

Even though it is essential to remember that the materials used for buildings and their virtual representation should not be considered completely interchangeable, the digital representation of a building can originate from different survey systems. A possible classification of the most widespread tools is divided into "image-based" systems and "range-based" systems.
Range-based systems directly provide 3D coordinates. They are based on the measurement of sensor to target distance, having the *a priori* knowledge of angles through the controller orientation of the range measurement device, or on triangulation (with laser light or stripe projection).
Image-based systems refer to photogrammetry and computer vision, paying higher attention to the metric value in the first case and to the efficiency and effectiveness of the vision in the second. In both cases 3D measurements are acquired from multiple views. In image-based systems, field acquisition is limited to shooting a series of frames and recording some measures of elements that can be clearly identified in images. (Remondino and El-Hakim 2006)
Close range applications have specific problems that generally require case by case planning, as well as the integrated use of different tools, as one single system is often unable to satisfy all requirements. (Beraldin 2004)
The diagram below (Figure 3), derived from Böhler presentation CIPA symposium 2001, Potsdam (Böhler 2001), summarises different techniques in terms of scale and object complexity.

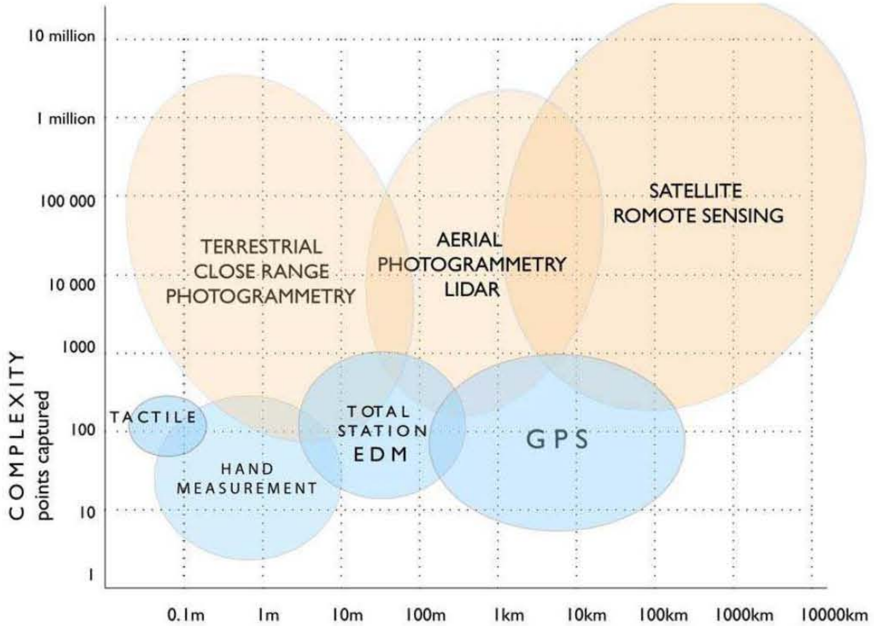


Figure 3. Metric survey techniques related to object complexity and scale of analisys

Finally, it is important to bear in mind that there is a close relation between hardware and software, because the electronic parts of a scanner require a parameter setting monitoring system, which is also useful to carry out a first visual check of the surveyed data. The software used to control the scanner is often the same used to carry out the first processing operations (data cleaning, scan alignment and referentiation, etc.). It is difficult to choose the software to be used for subsequent graphic processing without taking into consideration the acquisition system, because of strictly commercial logics: unfortunately, data are often stored in a closed file format and sometimes long conversion operations become necessary.

7. CHARACTERISTICS OF THE SURVEYED DATA

A 3D reconstruction of an object derives more and more frequently from high resolution point data: they are called range maps, point clouds, scans, and so on, with slight differences in meaning that are not worth taking into account in this work.

Range map is a metric representation of an object from a specific point of view through a set of 3D points properly spaced apart, according to the complexity of the imaged surface. (Guidi and Remondino 2012)

Irrespective of the specific technological solutions implemented in the various measurement systems, the surveyed data present some common characteristics:

- They are always digital data (real-world information is converted to and stored as binary numeric form), with several advantages regarding flexibility, transmissibility, sharing, possible automatic storage of metadata, etc. We should bear in mind that the documentary heritage created in digital form will remain at risk of digital obsolescence and also of the fragilities inherent to digital media.
- They are 3D. A metric survey records the position, size and shape of every part of the object analysed; even though the need for plans, sections and profiles plotted on hardcopy is still strong (e.g. for direct use on site), the modern survey techniques always generate three-dimensional survey information.
- At the moment of acquisition, they are undifferentiated. In fact, they come from a sampling carried out directly on the surface of the object (in case of range-based systems) or on photographs (image-based systems). Automatic systems of segmentation and classification give good results on urban and local scales, while at the moment they are hardly used for the semantic structuring of models in close range applications.
- The time required for their on-site acquisition is very short. The most recent scanning systems work at a higher and higher speed: it takes only a few minutes to survey a room or the façade of a building. In the image-based systems the only activity to perform on site is to take photographs. In both cases you should not underestimate the time needed for the planning of essential operations. Furthermore, if we can consider acquisition as "near real time", the subsequent processing carried out to meet various needs will require pretty long time.
- Survey is always carried out without touching the object.
- The object is sampled at high resolution. The concept of resolution during acquisition (resolution is "the smallest change in a quantity being measured that causes a perceptible change in the corresponding indication", VIM 2008) is directly linked to the concept of "level of detail" during restitution: the higher the resolution, the smaller the geometric detail documented by the model.
- Geometric data are often associated to information on texture coming from photographic images: raster and vector data can be combined in 3D modelling software.

Finally, as far as data are concerned, we need to point out that the efficiency with which they can represent the real world should not be confused with the accuracy of the representation itself, defined by VIM as "the closeness of agreement between the average of an infinite number of replicate measured quantity values and a reference quantity value." (VIM 2008)

8. GRAPHIC PROCESSING: SOME EXPERIENCES FROM GECO LAB.

Various types of processing can be performed starting from the surveyed data. The most suitable ones should be detected from time to time according to the main purposes of the project under way. Many design activities require conventional representations such as plans, views and sections as basic drawings. Vector drawings can incorporate raster images to integrate the description of geometry into the description of materials and their conservation status.

For all the section planes the rules and exceptions typical of the technical drawing hold true, such as the need to pass through openings, avoid structural elements such as pillars and columns, and cross vaults next to the keystone. On the 3D reference too, i.e. the model of the real building, you should act in a similar way, with careful translations of the section plane and the graphic restitution of only the important elements from time to time.

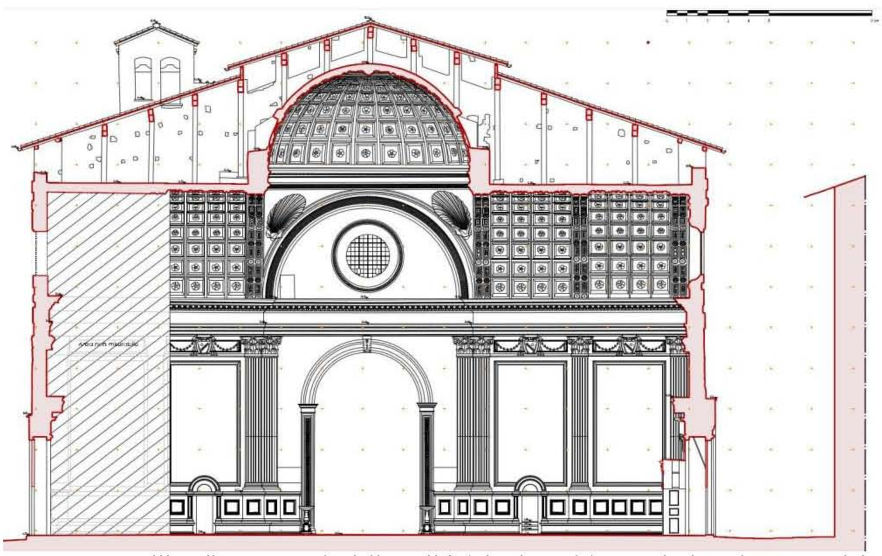


Figure 4. Basilica di Santa Maria dell'Umiltà (Pistoia, Italy) – vertical section, vectorial drawing (graphical elaboration from a laser scanner survey)

The orthogonal views can be integrated with the photographic information coming directly from the model (in case of scanners with integrated cameras or image-based systems), or applied afterwards, as it generally happens when good resolution and high photographic quality of the texture are required.

Figure 5. Frieze of the Ospedale del Ceppo (Pistoia, Italy) – orthoimage and DSM model

Figure 6. Arezzo Fortress (Italy) – Elevation, vectorial drawing integrated with rectified image. In the small image, a view of the 3D model

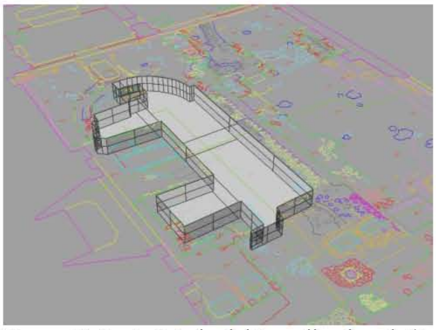
The texture representing the status of a surface during its survey can be overlapped with maps thematising the different materials that compose it, the pathologies detected and the treatments planned.

Figure 7. Pisa (Italy), walls of the city – 3D model texturized with the deterioration mapping

Other representations keep the three-dimensionality of the initial data and allow exploring the model interactively, an activity that proves to be very useful to communicate complex spatial realities and materials, as well as to forecast the outcomes of design works.

Figure 8. Certaldo Alto (Florence, Italy), video shoving the results of a 3D city modelling project

The metric validity of the model allows obtaining linear and angular measurements, as well as surface and volume measurements even in real time, which are useful to check similarities and differences in terms of costs, works to be performed and materials



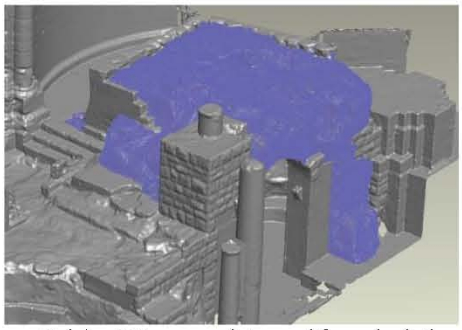


Figure 9. Santa Maria del Lavello church (Lecco, Italy) – 3D survey data used for calculation of the volume of land to be removed in the next step of an archaeological excavation
Figure 10. The Grotto of the Annunciation (Nazareth, Palestine) – calculation of the surface to be treated in restauration works on the 3D model

Additive manufacturing systems allow giving physicality to 3D models and reproduce small objects or whole architectural complex in full or reduced scale.

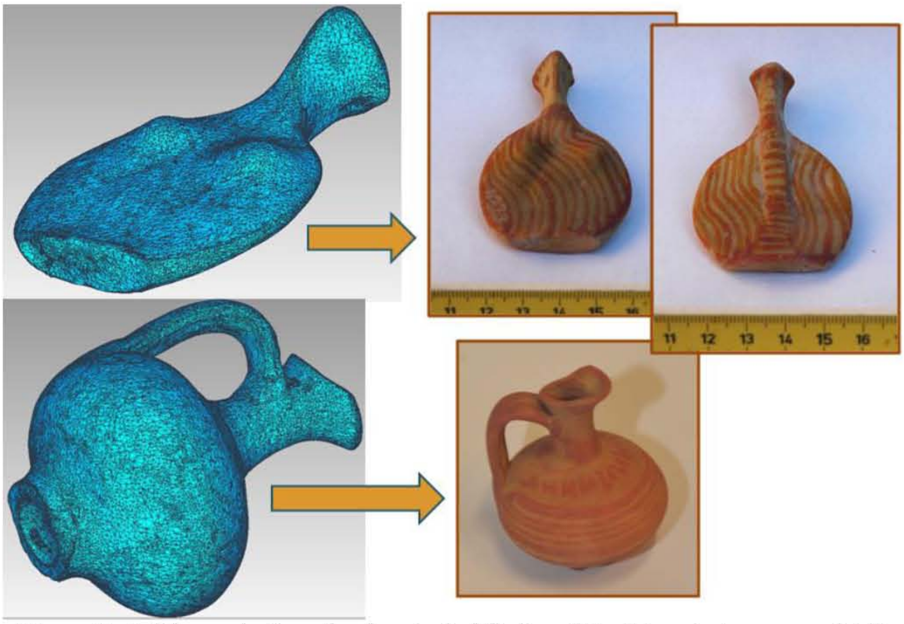


Figure 11. Solid reproduction of archaeological findings (Mus.Int project, www.musint.it)

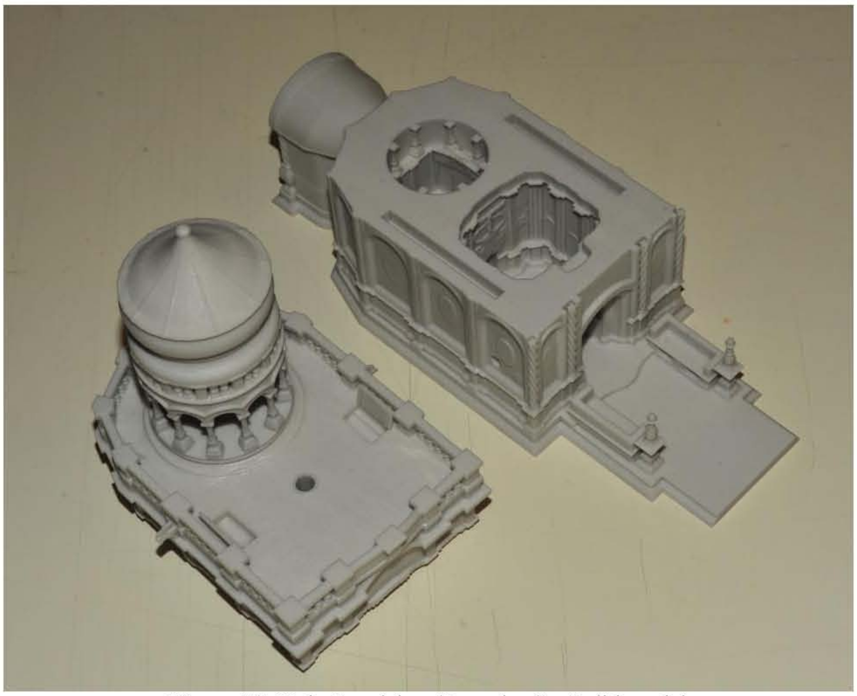


Figure 12. Holy Sepulcher (Jerusalem) – Solid model

Keeping in mind that "the preservation of the historical memory should be entrusted to accurate recording systems of the events involving the building, as well as to the works performed on it" (Torsello 2005), it is possible to coherently record survey campaigns over time, providing a diachronic reading of the building - let's think about, for example, the inevitably destructive progress of an archaeological excavation.

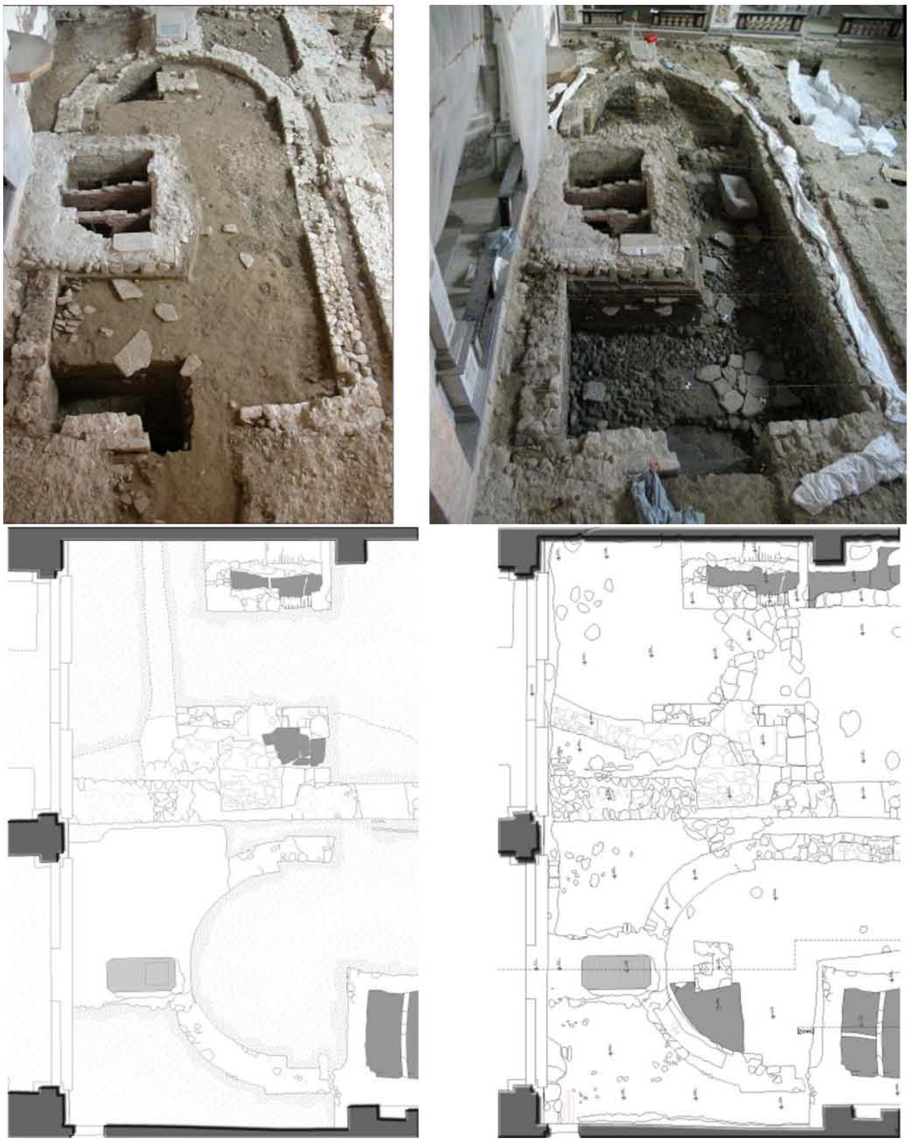


Figure 13. Archaeological survey update

Static, perspective or orthogonal images can represent space from unusual or unreachable points of view, increasing the knowledge of the object and even putting forward interpretations never taken into consideration before.

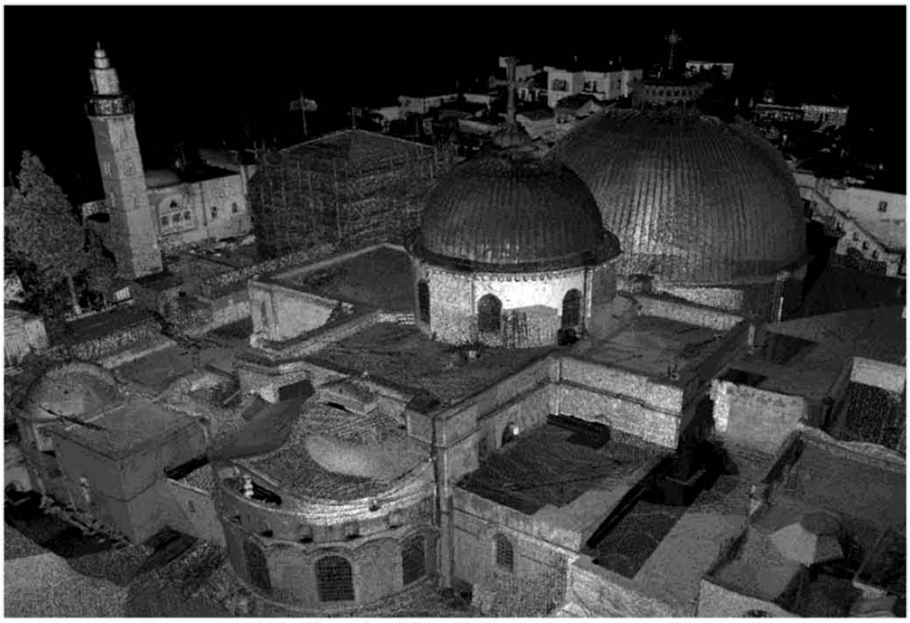


Figure 14. Holy Sepucher Church (Jerusalem), view of the roofs

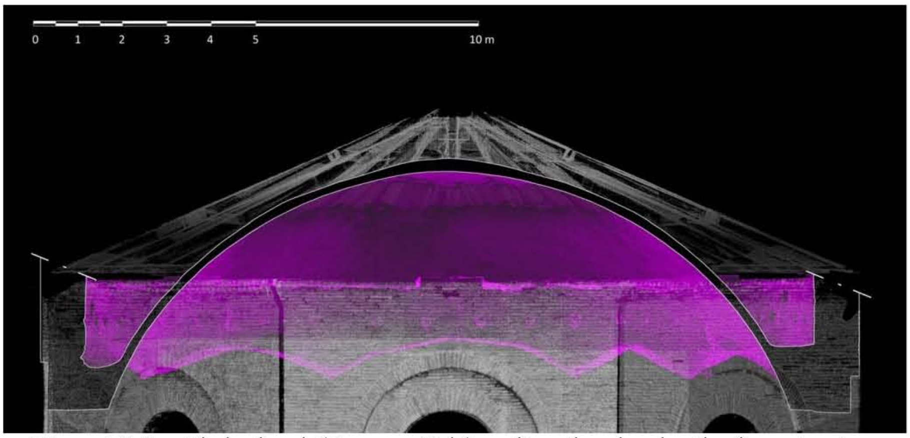


Figure 15. San Vitale church (Ravenna, Italy) vault section showing the dome structure

The common structure of the data required to represent both the current condition (i.e. the survey) and the project allows considering the virtual model as a "true research 'laboratory', where you can test and analyse hypotheses concerning historical reconstructions, integrations, releases, completions and such" [Torsello 2005], up to anastylosis operations that can now be accepted only for the virtual reference of a building.

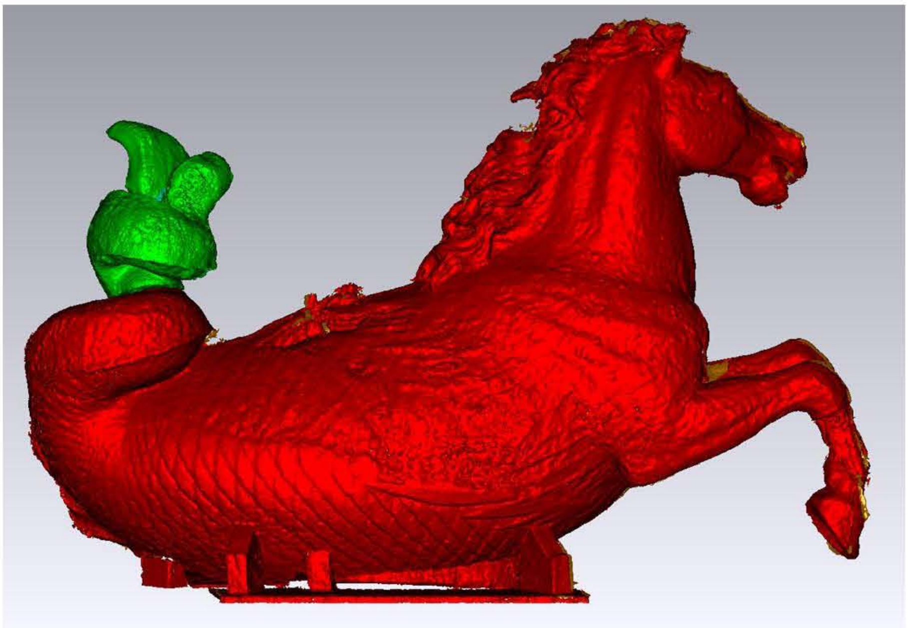


Figure 16. Pegasus statue, reconstruction of the tail

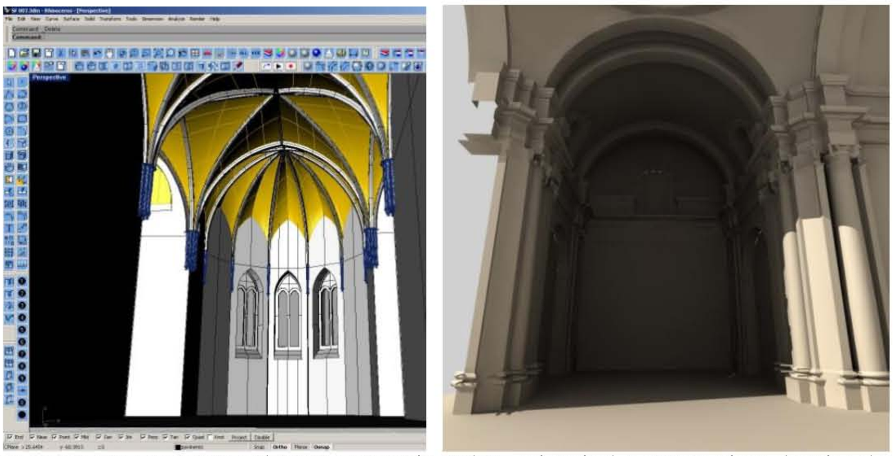


Figure 17. San Francesco al Campo (Perugia, Italy) – Historical reconstructions showing the building in different periods (3D modelling software and render)

9. MENAGEMENT, COMMUNICATION, DISSEMINATION

Thanks to the union between range map and digital images it is now possible to "follow three different and complementary directions: the first pushes architectural analysis to the limits of materials and the transformation processes involving them; the second provides us with powerful means of calculation and orientation to make design choices and the third opens the doors of virtual reality, allowing us to forecast the outcomes of our design choices and the consequences that they will have on future transformations."
In fact, survey is not only an effective means to describe the built-up space, but it also "imposes some forms of transcription and communication… Indeed, the ability of turning the critical or scientific acquisitions of the survey into a message is the guarantee that surveying will not become a mere descriptive act with the aim of generating only useless graphic representations." (Torsello 2005)
At the same time, the digital information and communications technologies (ICT) have produced a wide range of applications for collecting and processing historical data, documenting and monitoring the physical conservation of objects and monuments, visualising historic structures and environments, and creating interactive information networks that can link professionals and scholars with students, museum-goers, and interested amateurs. The integration of Heritage with digital technology has already shown the potential for greatly enhancing many aspects of the research, management, and public involvement in the material remains of the past. However, it is important to understand that ICT is a complex field whose contribution to cultural heritage can only be realised if it is utilised in effective, sustainable ways. It cannot be considered an immediate or magical cure-all. Cultural heritage professionals must understand what ICT can do, and in which situations or contexts it is most effective. With the rapid development of digital applications for historical research and public heritage presentation, the integration of digital technologies into the field of cultural heritage must be undertaken with the full awareness of their potential uses and effects. (Brizard et al. 2007)

10. FUTURE PROSPECTS OF DEVELOPMENT

In these years we are witnessing widespread dissemination of geo-referenced data; notwithstanding the way they are produced, they could prove to be a decisive contribution for the realisation of that recurring dream (i.e. comprehensive heritage documentation), which in 1858 led Albrecht Meydenbauer (Albertz and Meydenbauer 2001), a young German architect, to use photographic images for the first time to document buildings with the aim of creating an Archive of Cultural Heritage (Denkmälerarchiv). He knew the risks that Cultural Heritage was running and he was sure that this kind of documentation would have even allowed reconstruction, if necessary. Between 1885 and 1920 2,600 buildings were filed through approximately 20,000 photographic images on plates.
To establish a parallelism with the urban and land scale, where "alternative" solutions for the production and sharing of data have been testing for a long time

and where collective participation suggests the idea of «citizen cartography», while Google calls its maps "geospatial applications", we should launch a sharing and networking process of all the outputs coming from cultural heritage surveys.
According to Mark Graham, researcher of the Oxford Internet Institute at the Oxford University, the projects carried out by digital neocartographers can be organised into three categories: virtual globes, applications and sites belonging to Web giants that allow users to virtually explore any place in the world; wiki-locals, such as Wikitravel and WikiMapia, where users actively participate in the representation of the places that can be shown in different scales, and OpenStreetMap, where maps are drawn by volunteers who pick up the GPS signals of our devices, rather than using private or government data.
How about creating a data community for Cultural Heritage? Images, drawings, models, range maps could be accessible and integrated. After all data, if suitably validated, are a common good with an extremely high value that short-sighted administrators and red tape rarely make available, entailing additional measurement operations and higher costs.(Graham 2009)
Some projects to make available geographic data concerning the territory have been launched successfully: thanks to the incredible results of the first pilot experiences, "portability" and "interoperability" have become watchwords for an ever increasing number of public administrations.
The information regarding cultural heritage is still fragmented and dispersive: similar analyses and surveys are sometimes carried out on the same object by different subjects and within separate research activities, proving to be unnecessarily expensive and redundant.
Just as cataloguing represents the lowest level of documentation, which attests only the "existence" of a good, similarly the first step could be the creation of a digital repository of Cultural Heritage resources (possibly based on open-source software, at least in theory), to prevent the fragmentation and duplication of information.
The already existing "digital repositories are often unable to guarantee affordable features in the management of 3D models and their metadata [...]. The nature of most of the available data formats for 3D encoding seems to be insufficient for the necessary portability required nowadays by 3D information across different systems." (Felicetti and Lorenzini 2011) The following aspects relating to large scale documentation are still to be taken into account or unsolved:

- Definition of a common vocabulary and identification of effective metadata concerning the digitization of cultural heritage.
- Sharing of procedural standards, even through the preparation and dissemination of specifications aiming at overcoming the outdated prescriptive approaches and adopting a more contemporary technical approach.
- Definition of open file formats for both raw data filing and subsequent processing operations.
- Need to define validation and test procedures to ensure the quality of data and the resulting information.

Training must become the key element to support this proposal, and it should embrace vocational update of qualified professionals, promotion of the scientific culture linked to 3D technologies (even among public and private customers) and awareness of heritage users in general. In fact, only an increase in the awareness towards heritage can support and improve promotion and valorisation. New technologies are the right tool to make knowledge "available", at last. In 1964 the Venice Charter (ICOMOS 1964) already stressed the importance of documentation and publication in article 16, a concept taken up in several subsequent recommendations, including the London Charter and its more recent updates (www.londoncharter.org).

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SESSION 7

Topic: New Technologies for Cultural Heritage

Chairperson: Prof. Dr. N.Gül ASATEKİN (Bahçeşehir University, Turkey)

Assoc. Prof. Gianluca BELLI, Postdoctoral Research Fellow Valentina BONORA, Phd. Student Nadia GUARDINI, Phd. Student Armağan GÜLEÇ KORUMAZ, Assoc. Prof. Grazia TUCCI
Architectural Survey of The Vaults of Sangallo's House in Florence

Assoc. Prof. Grazia TUCCI, Architect Alessandro CONTI, Architect Lidia FIORINI
Geomatics for Knowledge and Conservation of Cultural Heritage: The Pratolino Park Case-Study

PhD. Student Daniela CINI, Postdoctoral Research Fellow Valentina BONORA, Assoc. Prof. Grazia TUCCI
ICT Project for The Museum of Casa Martelli in Florence, Italy: For a Virtual Tour of Today's and Yesterday's Collections

ARCHITECTURAL SURVEY OF THE VAULTS OF SANGALLO'S HOUSE IN FLORENCE

GIANLUCA BELLI[1], VALENTINA BONORA[2], NADIA GUARDINI[3], ARMAGAN GULEC KORUMAZ[4], GRAZIA TUCCI[5]

ABSTRACT

Many technologies have been used in cultural heritage conservation and documentation in recent years. One of these techniques, laser scanning which is increasingly becoming popular in late years is used for various purposes like surveying, modelling, archiving and visualization in the field of cultural heritage. Plenty of works have been done in heritage documentation with laser scanning technique allowing the user to achieve different information from a 3D model and helping to investigate the shape and components of heritage. This paper deals with how a 3D model can be used to identify the construction technique of heritage and the application of laser scanning for the generation of 3D models of the vaults in Sangallo's House in Firenze. The aim of this study is to compare the shape and the constructive techniques of surveyed vaults. To achieve this aim, we needed to obtain the thickness and the morphology of the vaults, and this information was provided by laser scanner survey. The paper presents applied technology and instruments used, steps of graphical evaluation and 3D, comparisons between the vaults. In order to make comparison, detailed surface modelling was needed to understand them and to be able to see the differences between construction techniques of the vaults. Leica HDS 6000 laser scanner was used for the generation of 3D model of the vaults. Then point clouds were registered in Cyclone. After that, cross sections were extracted from 3D model to understand vault thickness, shape and to have an idea about how they were built. The results will be displayed and evaluations will be made as conclusion.

Key words: Constructive Techniques, 3D Scanning, 3D modelling, Vaults, Sangallo

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1. THE SANGALLO'S HOUSE IN FLORENCE

The house that Giuliano and Antonio da Sangallo built for them in Borgo Pinti, Florence, is now known as Palazzo Ximenes-Panciatichi and it has never been studied systematically. In 1902 Cornelius von Fabriczy (von Fabriczy 1902) published some documents on it, but since that moment no other further research has been carried out on the history of the building or its material structure. Recent document researches and detail recordings concerning some rooms allow shining a new light on the history of the house and the techniques used to build it.

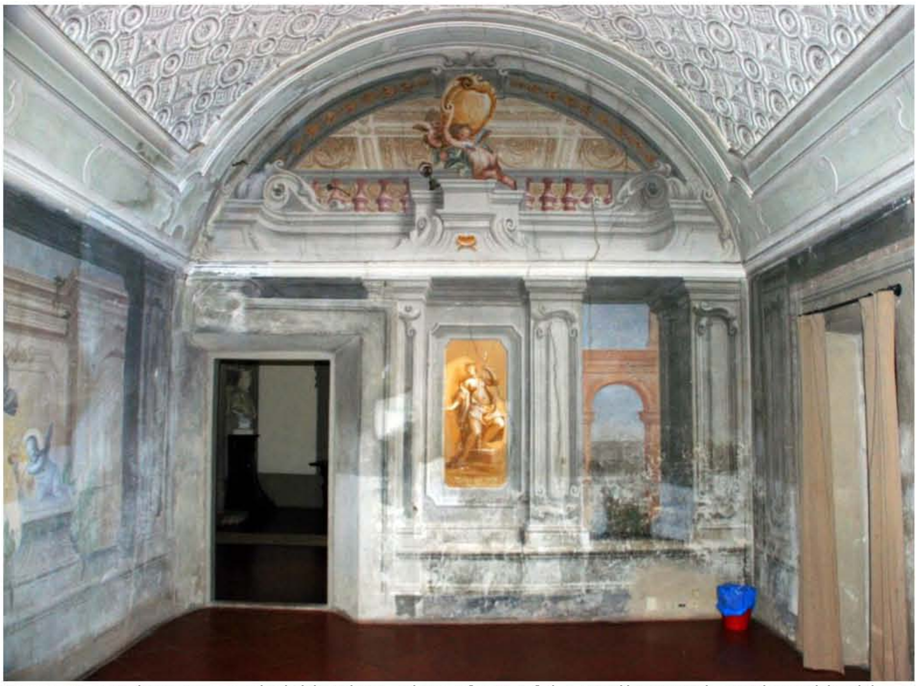

Figure 1. Ximenes-Panciatichi Palace, view of one of the small rooms investigated in this study.

The land was purchased by Giuliano and Antonio between 1490 and 1491, but the progress of the building works was slow. When the two brothers wrote their last wills, the building was still unfinished. After Giuliano's death in 1516 and Antonio's death in 1534, the property of the house passed from one member of the family to the other, and in 1603 it was sold to Sebastiano Ximenes, a Portuguese merchant linked to the Grand Duke's court. He restored the building and started its enlargement. Further enlargements and modifications were made during the 17th century and above all the 18th and 19th century (Belli 2012). These work campaigns transformed the original building - enclosed in a square area with a side of 40 *braccia fiorentine* (a unit of measurement equal to approx. 58 cm, that means a side of approx. 23 m) and built up on just two floors – into a wide stately palace, enriched with a big garden and built up on four main floors.

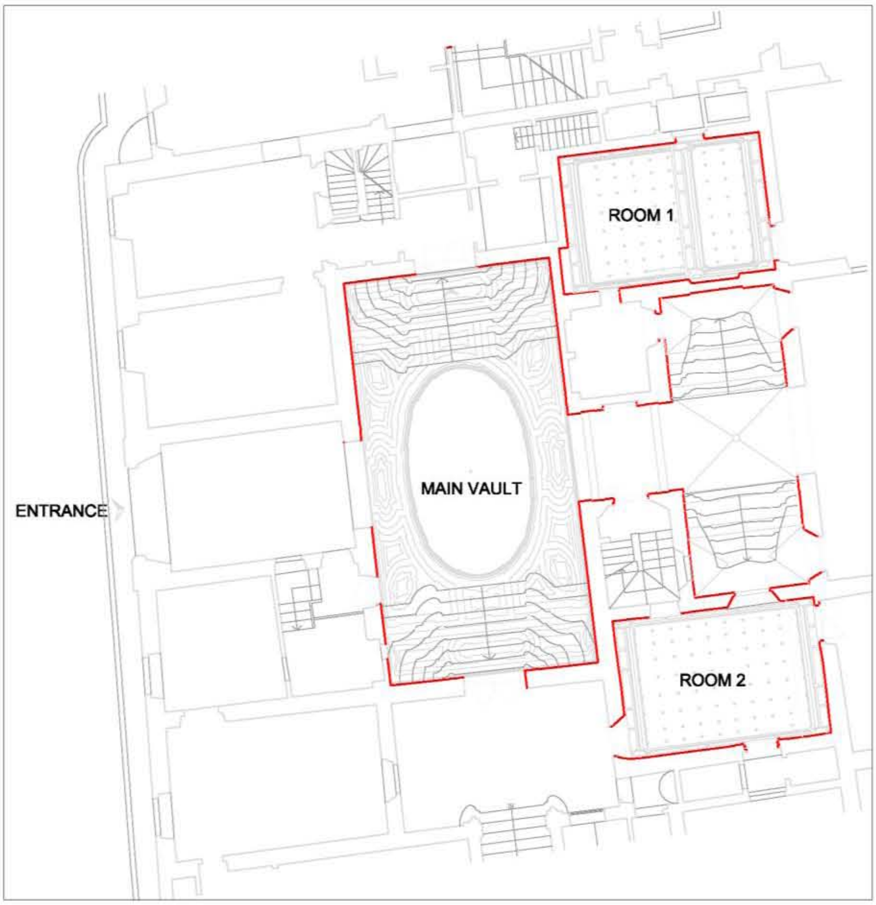

Figure 2. Plan of the original nucleus of the Sangallo's House in Florence. In red you can see the rooms subject to the survey campaign with laser scanner described in this report, while the representation of the adjacent rooms has been inferred by a previous survey (by Arch. Ilaria Filippini).

2. THE VAULTS STUDIED

Despite the alterations, the most ancient nucleus of the palace is even today easy to be detected. It is characterised by a perfectly symmetric U structure, which develops around a wide cross double-height room. On the back, on the sides of the loggia facing the garden, there are two equal rooms, covered by stuccoed barrel vaults. The kind of decoration and the technique used are typical of Sangallo, and in fact these vaults have always been considered as the few original elements that survived transformations. Instead, not enough attention has been paid to the big barrel vault covering the central room.

2.1. The vault of the central room

Altered by 18th-century banded decorations, the vault has been considered as an intervention occurring later than the first building phase (Marchini 1942). But the strict analogies between the plan of the house in Borgo Pinti and the plan of the villa in Poggio a Caiano, designed by Giuliano da Sangallo for Lorenzo de' Medici in the same years, lead us to believe that the vault had always been there. In Poggio a Caiano too, in fact, the most important room is made up of a big transverse room, covered by an impressive barrel vault. The Sangallo origin of the vault in Borgo Pinti is supported also by another evidence. In the *Life* of Giuliano da Sangallo, in fact, Vasari included an anecdote according to which to convince Lorenzo to build a big barrel vault in the room of Poggio a Caiano, the architect built a similar vault in his own house (Vasari 1878-1881). So, when Vasari wrote the *Lives* (published for the first time in 1550), the vault should have already been built and noticed by him, as he surely knew the Sangallo's house being a friend of Francesco, Giuliano's son.

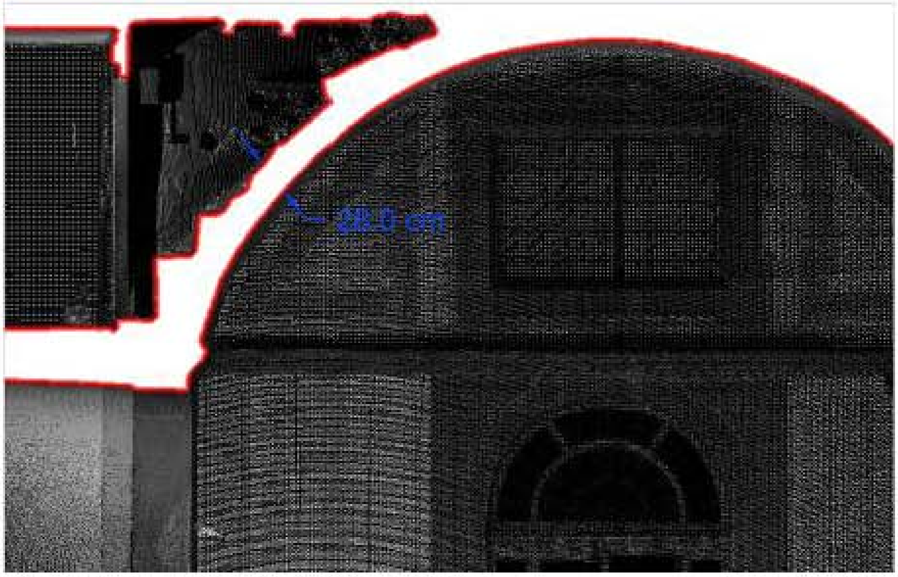

Figure 3. The survey of some rooms on the first floor allowed establishing the thickness of the vault of the big access area: approx. 28 cm.

The vault is smaller in size, but it can be compared to the one in Poggio a Caiano (approx. 13.50 x 6.90 m against 19.80 x 10. 50 m), and additionally they seem to have been built through a single concrete casting, as you can see by inspecting the extrados. It is an ancient technique, which has been brought from Rome to Florence by Giuliano da Sangallo, according to Vasari (Vasari 1878-1881).

2.1. The vaults of the minor rooms

The direct surveys on the vault covering the minor room at south, which were carried out inside a hole in decoration, proved that this structure too is made of concrete and the material used to built it is similar to the one of the bigger vault. The vault seems to bear no load, as over the casting (whose keystone is 11 cm thick) we noticed a wooden element, probably the joist of a slab. Instead, it was not possible to carry out a similar inspection on the vault of the room at north, as the decoration there has no holes and it is impossible to access the extrados (unlike the previous case). However, we can reasonably assume that in this case too the same technique has been used.

3. THE NEED FOR A HIGH RESOLUTION SURVEY

To have further data on the two smaller vaults and on the one in the central room we thought about carrying out their survey with suitable tools to ensure extremely precise results. We needed some information on the exact geometry of the vaults to confirm the hypothetical building techniques. We also considered it appropriate to compare some particular sections of the two small vaults, as well as their profile with the one of the bigger vault. In the first case, the aim was checking the possibility that the same rib had been used for both structures, while in the second case the aim was understanding if the shape and the structure of the big vault reproduce on a bigger scale those of the minor vaults, to further support the hypothesis that the coverage of the central space too dates back to the first (Sangallo-style) phase of the works. Finally, we analysed the stucco decoration of the two minor vaults. On their intrados we always noticed a decoration module made up of a circular crown containing four small figures, which is crossed by four smaller circles. This motif was made by impressing in succession a square mould (maybe of wood) with a side of one *braccio* (approx. 58.6 cm) onto a very thin layer of gypsum mortar. The particularly detailed 3D survey of the intrados available suggested the possibility of comparing (by overlapping them) a couple of modules extracted from the two vaults, in order to check whether the same mould was used and thus have another useful element to date these structures.

3.1. 3D scanning systems

To survey the rooms we used the 3D scanner Leica HDS6000 of the GeCo Laboratory (University of Florence).
A 3D scanner is a tool that can automatically record 3D coordinates of points evenly distributed on a portion of the surface of an object. The surveyed points have a high resolution.
The choice of using 3D scanning systems is related to their ability to make higher sampling of the space compared to traditional topographic instruments. After some data processing, a complete database of geometric information is provided and it is possible to display a full 3D model, which can be explored in real time.

3.2. Topographic survey

Each range map is initially formulated within a reference system built in the scanner. Common reference points were needed to link all the data acquired from different positions: for this purpose we used points of known coordinates in a single reference system, materialized by means of specific targets, which were measured topographically starting from the vertexes of a topographic framework. The design of this framework was carried out to meet the specific needs of the project, i.e. defining the correct mutual position of rooms that are not directly connected. In particular, we needed to connect the rooms on the first floor with the ground floor to assess the thickness of the vault covering it and to position the minor room at north (room 1), whose access door from the loggia has been infilled. The topographic connection was thus made by carrying out measurements through a small window and by positioning a vertex in the small adjacent room.

3.3. Quantification of the data acquired through 3D scanning

The number of 3D acquisitions required depends on the range of 3D scanners and on the complexity of the object being surveyed. In this case we carried out 6 scans for the minor rooms, 4 scans in the big room, 2 scans for the portion of extrados on the upper floor and 4 scans in the connecting rooms, for a total of 14 scanpositions.
The scanning was carried out with a field of view of 360 degrees horizontally and 155 degrees vertically (excluding only the shadow cone projected by the tripod), with resolutions defined according to the level of detail of the surfaces surveyed. To document the stucco decorations of the minor rooms we used the “highest resolution” (that means about 3 mm spacing between points at a range of 10 m), while for the adjacent rooms a “medium resolution” was sufficient (that means about 1 cm spacing between points at a range of 10 m). In total we acquired over 740 million points.

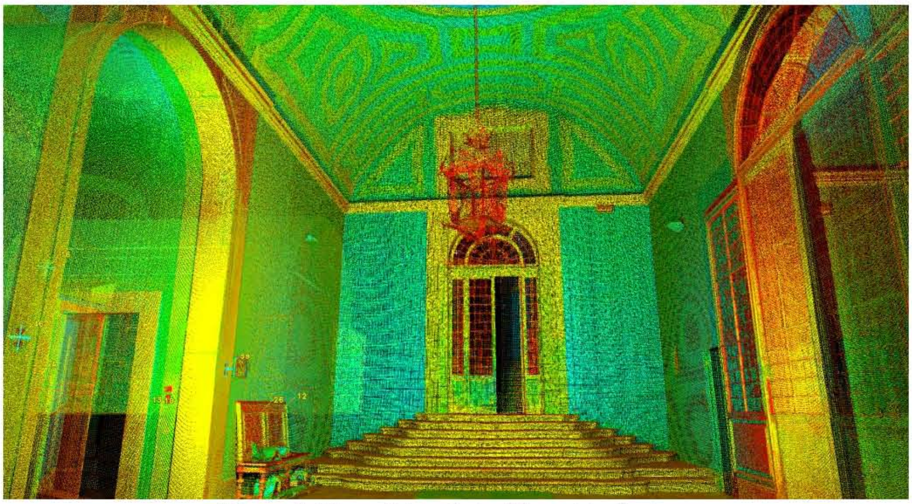

Figure 4. View of the whole 3D model of points

4. GRAPHICAL ELABORATIONS ON ACQUIRED DATA

The database is the starting point from which it is possible to extract different kinds of information required for documenting the building: raster (orthoimages), vectorial representations and three-dimensional models.
The representation of the plans, views and section profiles has been performed through the geometric interpretation of the subtle lines of the clouds of points. All the graphic representations are two dimensional, but they keep their referential three dimensional homogeneity: every processing belongs to a plane where both the position and the lying position in the defined space of the adopted reference system are known.

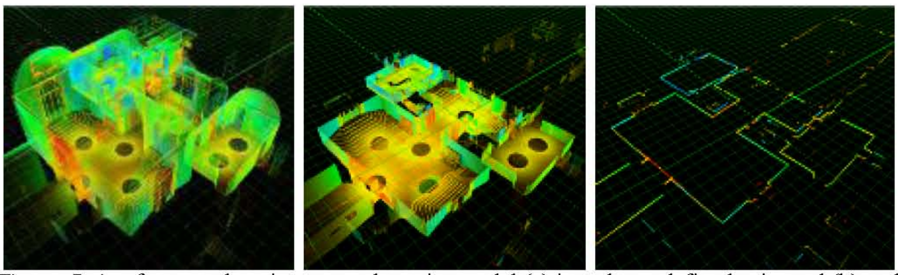

Figure 5. A reference plane intersects the point model (a) in order to define horizontal (b) and vertical sections; a "slice" of the point model (c) is the base for vector drawings.

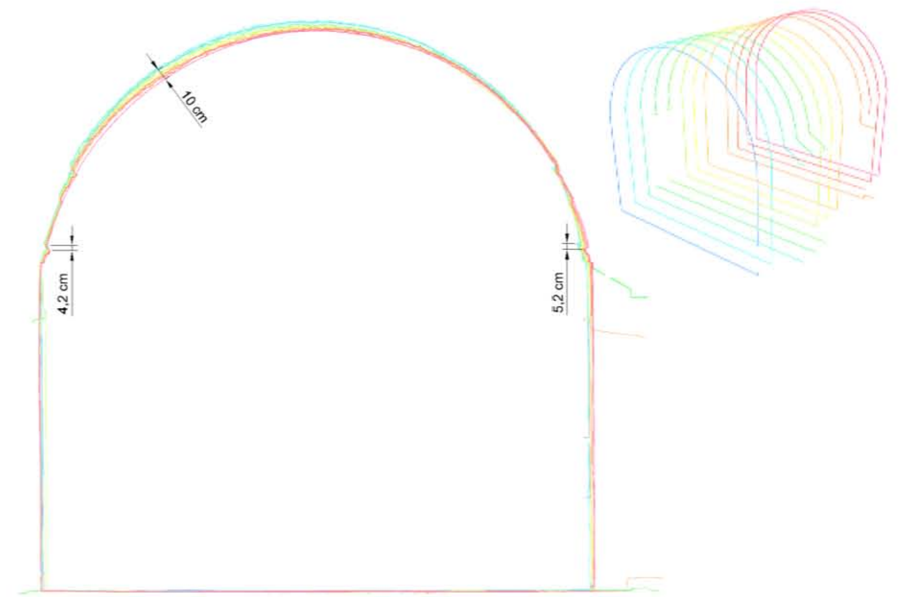

Figure 6. A series of cross sections of room 2, with a distance of 50 cm (the reference plane fits one of the short walls). They allow quantifying the deformation of the structure.

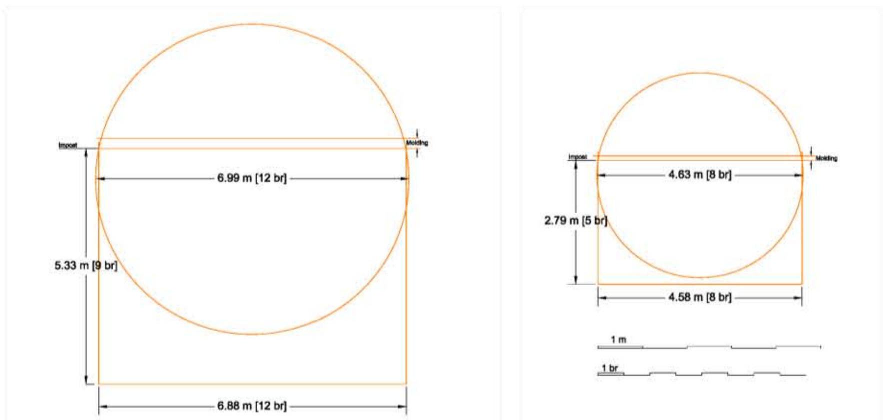

Figure 7. The sections of the vaults in the big room and of the minor vaults are formed by round arches and they are all connected to the wall through a vertical tangent, except for minimum deviations, which cannot be perceived directly as it is hidden by cornices.

The high resolution adopted during the acquisition phase allows obtaining some ortho images of the point model: these are raster data in which the metric value is ensured by the definition of an orthogonal viewpoint and a prefixed plane, and the chromatic information comes from the intensity with which the laser signal is reflected by the surface hit. Starting from these drawings it is therefore possible to represent the elements in sight, such as the projection of the vault decorations.

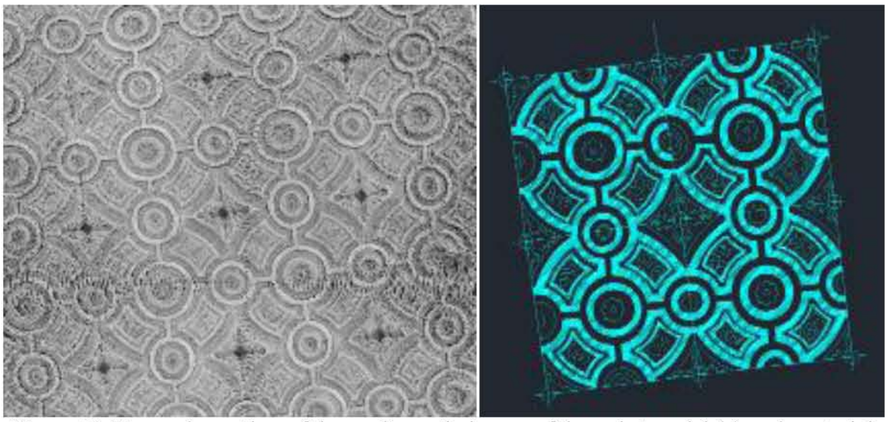

Figure 8. Stucco decoration of the vaults: orthoimage of the point model (a) and vectorial representation (b).

The point model surveyed through scanning represents an extremely detailed (even though discrete) description of the surfaces of the object. To reconstruct their continuity we need to calculate a mesh, i.e. a continuous surface made up of triangular faces sharing an adjacent side. Further processing is thus required to optimize the mesh, close any possible hole, and simplify it with the aim of improving its usability.

Figure 9. Surface models of the vault in room 1 (a) and room 2 (b).

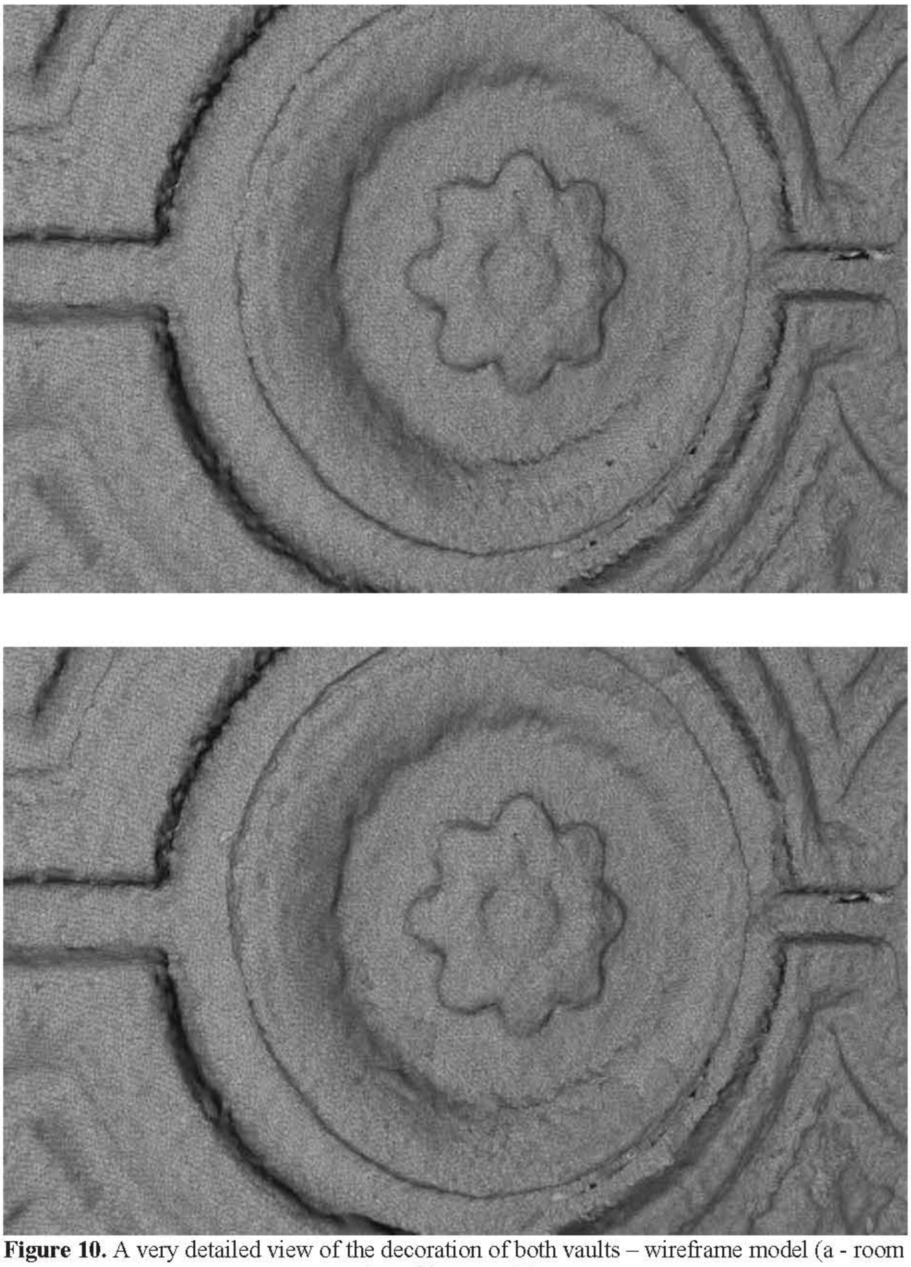

Figure 10. A very detailed view of the decoration of both vaults – wireframe model (a - room 1, and b - room 2).

5. CONCLUSIONS AND FUTURE POSSIBILITIES

The completeness and resolution of the data surveyed in the vaulted rooms allowed carrying out drawings useful to interpret historical-building aspects, as well as quantifying the size that characterises the vaults in terms of structure (span, curvature and thickness) and decoration.
To study the geometry of the vaults we needed to assess their size expressed in *braccia fiorentine da panno* (58.36 cm), i.e. the unit of measurement used at the time of their construction. Moreover, the aim of reconstructing their design geometry, which can be directly compared with what is described in coeval manuals, required space geometrization. The irregularities and deformations due to the building of the architecture have thus been neglected, paying more attention to an "ideal geometry" of the vaulted rooms. In particular, the following aspects have been neglected: out-of-plumb, out-of-line and bowing of the walls, the difference in height of the cornices on the opposite sides of the room, and the presence of stucco decorations. Thanks to the high resolution of the laser scanner survey we managed to compare the real building with its geometrization and thus quantify what we can call the "tolerance of the architecture". In the case of the surveyed rooms, this value is approximately 5 cm and it represents a limit to be taken into consideration while studying the geometries and their proportions.
The sections of the vaults in all the three rooms have a perfectly semicircular profile, with a diameter equal to 4.63 m (8 *braccia*) for the minor rooms and 6.99 m (12 *braccia*) for the central room, values that correspond to the design dimensions. In every room the vault springer is next to the lower level of the cornice.
The small dimensional differences between the vault diameter and the room width generate a slightly depressed arch.
The other drawings presented to describe the development of the cross section and the type of springer highlight the compliance among the three vaults analysed.
We can notice that the plan proportions of the rooms seem to be calculated according to the size of the ribs: for the bigger room the plan sides (13.50 m x 6.90 m) approximate a ratio of 1:2 (12 x 24 *braccia*), while for the two minor rooms (6.80 m x 4.60 m) they approximate a ratio of 2:3 (8 x 12 *braccia*).
For the larger vault it was also possible to determine the thickness of the reins, equal to approx. 28 cm. Thanks to the data obtained on the extrados, the thickness of the vault could be even throughout its whole width. These data confirm the direct observation of a small portion of accessible extrados and the fact that the vault was built entirely through casting and not with bricks. We can notice that the keystone thickness of the vault in one of the minor rooms, which has been directly verified, is proportionally lower compared to the one of the big vault (11 cm).
With the aim of hypothesizing a date for the two smaller rooms, we analysed the stucco decoration by means of surface models and high resolution. The analogy between the decorations shown in the figures above confirm the hypothetical reuse of the same mould, even if in one of the rooms small stucco pyramids have been added to the corners of the square tiles to mask the junction of the adjacent impressions. Even though it is not possible to date the construction or decoration of

the vaults, they can be considered as coeval or built within a relatively short period of time.
We have shown here the first results of a reserch that will continue with further processing of the data acquired to compare thoroughly the two minor rooms and further verify their building technique. Moreover, we wish to assess the possibility of an original continuation of the decoration impressed under the 18th-century bands currently present next to the springer of both smaller vaults, by using a digital model of the general conditions as the basis of a hypothetical virtual reconstruction of the look of the rooms at Sangallo's time.

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GEOMATICS FOR KNOWLEDGE AND CONSERVATION OF CULTURAL HERITAGE: THE PRATOLINO PARK CASE STUDY

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ABSTRACT

The project concerns the achievement of multi-resolution and multi-sensor 3D surveys of the main buildings of Pratolino Park, based on laser scanner and photogrammetric technologies, spread to surrounding land and environment and geo-referenced using GNSS.
The case studies presented concern both true architectures as the Chapel by Buontalenti and the Paggeria and other buildings as the Fountain of Jupiter and the giant statue of the Appennino by Jean de Boulogne. These first case studies show the wide range of artefacts present in the Park; each one of them requests appropriate techniques for their surveying and representation because of their different sizes, geometries and materials.
The project gave the chance to define, improve and check the best practices for surveying a wide range of heritage buildings. The drawings and models of the artefacts were used both for research purposes and as a support for conservation projects.

Key words: Geomatics, Survey, Laser scanning, Conservation, Gardens

1. INTRODUCTION

Survey, which has always been considered a tool of knowledge and communication for architecture, has been chosen by Venice Charter too as the essential element for heritage documentation and conservation. Carrying out an accurate direct metric survey for a complex architecture is a long and burdensome task. This is clear in the Pratolino Park, where you can find many examples of irregular and organic structures typical of the Italian 16th-century gardens.
The authors of the previous survey campaigns, carried out around 1985 with traditional techniques, highlighted the inadequacy of those tools, even though they

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followed a rigorous methodology. In fact, these shapes cannot be related to easily identifiable geometric models; therefore, when during the survey recognizable reference points were missing (Dezzi Bardeschi and Zangheri 1988), the adoption of a blurred and evocative drawing technique became essential (Conforti 1987), as sometimes interpretation prevailed over objectivity. In 1985 they already adopted photogrammetric survey for the statue of the Appennino with good results (Ippolito 1988), but the presence of trees and plants allowed surveying only the main elevation. Paradoxically, sometimes the environment hinders the survey of garden architectures, in such an extent that its representation is often omitted.
Instead, the use of automated technologies for survey, in particular laser scanner, means acquiring a huge quantity of non-selected data in a short period of time. This allows measuring complex shapes with the desired sampling resolution, without making a distinction between the scanned object and the environment in which it is inserted. The database obtained is thus proof of the geometry of the object at the moment of survey, which can be compared with similar later surveys to highlight the changes occurred.
On the other hand, surveying means interpreting architecture; therefore, such a survey includes also the detection of the most effective representation techniques for every situation (Balletti et al.2005).

2. THE PRATOLINO PARK

In 1568, the Grand Duke Francesco I de' Medici started the project of the Pratolino Park, the result of the lucky union between the Prince and Bernardo Buontalenti, to which the most talented artists working in Florence at the end of the 16th century contributed.

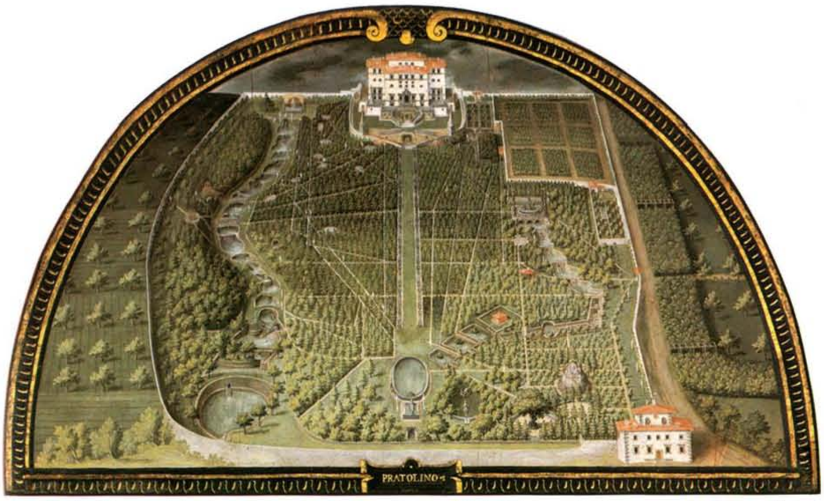

Figure 1. G. Utens, The lower part of Pratolino, 1599. Museo di Firenze com'era, Florence

Pratolino became immediately a milestone for travellers, because of its many wonders. The excellence of this complex originated from its elegant architectures, but above all from the incomparable originality of its water works, water-driven statues, grottoes and fountains. All these mechanisms were driven by hydraulic energy, transforming Pratolino into a spectacular technology exhibition (Battisti 1962). Water was also at the main element of the allegorical meaning of the Park, which had been developed along an axis crossing the whole garden from north to south. The main path started from the Fountain of Jupiter, then moved to the Appennino by Jean de Boulogne up to the Villa, continued along Viale degli zampilli (Fountain Avenue) and ended at the Fontana della Lavandaia (Fountain of the Laundress). In the following centuries, the changes in fashion and the resulting machine deterioration led to the almost total disappearance of the original Pratolino, and the remaining constructions look now like independent works that do not belong to an organic system anymore. The Park then became property of the House of Lorraine and in the 19th century it was purchased by the Demidoff family. In 1969 the already deteriorated complex was auctioned and finally abandoned until 1981, when the Province of Florence bought it (Zangheri 1987, Brunon 2001).

2.1. The Chapel

The Chapel was built in 1580 and is one of the last constructions made in Pratolino by Bernardo Buontalenti. Erected on the margins of the Park behind the Villa on an artificial earthwork mound, it can be reached by climbing up a staircase. It covers a total surface of 300 m^2. Initially delimited by high firs, it is now surrounded by a broadleaf forest.

Figure 2. Cross section of the Chapel. CAD drawing and views from point clouds.

The central-plan building was originally composed of a hexagonal room with a side of 4.20 m, surrounded by an ring-shaped porch of eighteen columns made of *pietra serena* (a grey Tuscan sandstone); four of them were later included in the walls

forming the sacristy. Inside there are some pieces of furniture, among which the wooden stalls and the altar, with a big altarpiece and other decoration elements.
The survey enabled to study the geometry of the dome (Arenga and Velatta 2012), coated with lead sheets and ending with a lantern, for a total height of 15.60 m., which in the previous surveys had been drawn only through patent approximations (Passaniti 2008).

2.2. The façades and garden of the Paggeria

In the original design of the Park, the *Paggeria* (or Pages' lodgings) was part of a complex for the staff and the service activities of the Medici villa, the present garden of which formed the courtyard.

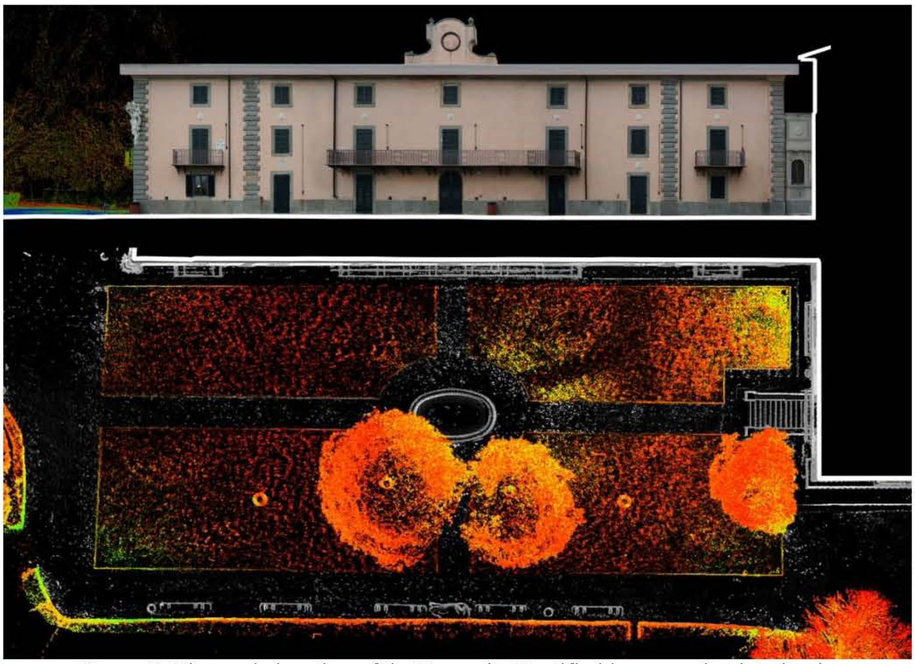

Figure 3. Plan and elevation of the Paggeria. Rectified image and point cloud.

The Demidoff family refurbished the building and transformed it into a villa, adding a new hall perpendicularly to the main body. This latter, divided into three floors, kept essentially the original structure, while the simple façades were reorganised without prejudice: the new iron balconies and the watch on the façade casually combine with both real and fake bas-reliefs. The building overlooks a 57 x 27 m garden including in a geometric layout natural elements and furnishings, among which a central oval marble basin and in particular the original hand and foot of the Appennino statue, replaced during the 1877 renovation works.

2.3. The Fountain of Jupiter

The Fountain of Jupiter was centred on the statue of Jupiter Pluvius by Baccio Bandinelli, later removed and placed in the Boboli gardens in 1834. The Demidoffs gave to the fountain its current aspect, with a modern reinterpretation of the statue of Jupiter. On its side was added a sculpted eagle too, that has no head now, but appeared intact at the time (or reintegrated).

Being in the highest part of the park, the fountain had a precise technical explanation. In fact, the pool acted like a surge tank, a reserve to pressurize the lower pipelines and to operate mechanisms and water works.

The fountain covers an area of approx. 27.00 x 18.50 m, with a difference of altitude of approx. 24.00 m. At the top of a staircase with grass steps, demarcated by kerbstones, there is an oval pool with a brick structure, 12.70 x 8.70 m, 3.50 m. deep. Inside the pool, a double row of pillars holds five vaults on which a stonework mound is laid. The sculptures are placed on top of it. The survey highlighted the hydraulic systems, such as the supply pipe under the central vault, the bottom outlet and the two intake pipes located at different heights (Tucci et al. 2011). It also recorded the deterioration of the last remains of the decoration system made of *spugne* (sponge-like rocks) that can now only be found around the arches.

2.4. The Giant of the Appennino

The giant statue of the Appennino is the most famous and original artefact of the Pratolino Park: the huge "sculpture/architecture" has been transformed and re-invented many times, so we will give here only a brief summary of its story.

The statue was built from 1579 to 1583 by Jean de Boulogne on a foundation structure designed by Buontalenti; originally it was placed inside a huge vaulted rockwork niche and contained several rooms decorated like artificial caves with fountains, paintings, statues and automata. Around 1690 the niche was demolished and Giovan Battista Foggini reorganised the back area and created the statue of the dragon. Some important modifications were carried out in the Romantic age and later by the Demidoff family, but the first studies and restoration in modern sense date back to the eighties (Vezzosi 1990).

Currently, the big statue covers an area of approx. 12 x 14 m (back area excluded) and is 10 m. high, while the base makes it 5 metres higher than the level of the lake. The survey well documented the condition of the surfaces and the complex relations among the internal spaces that are placed on three non-communicating levels. The lower one (corresponding to the underground structure by Buontalenti) looks like a cave and rises from the level of the lake to the space behind the sculpture. Here there is a small hexagonal room where the vault and walls show the remains of the 17^{th}-century rustic mosaics of stones and shells. In the back of the giant, behind the Foggini's dragon there is another room, leading to a small vaulted space inside the head, where you can see the remarkable iron structure that holds it.

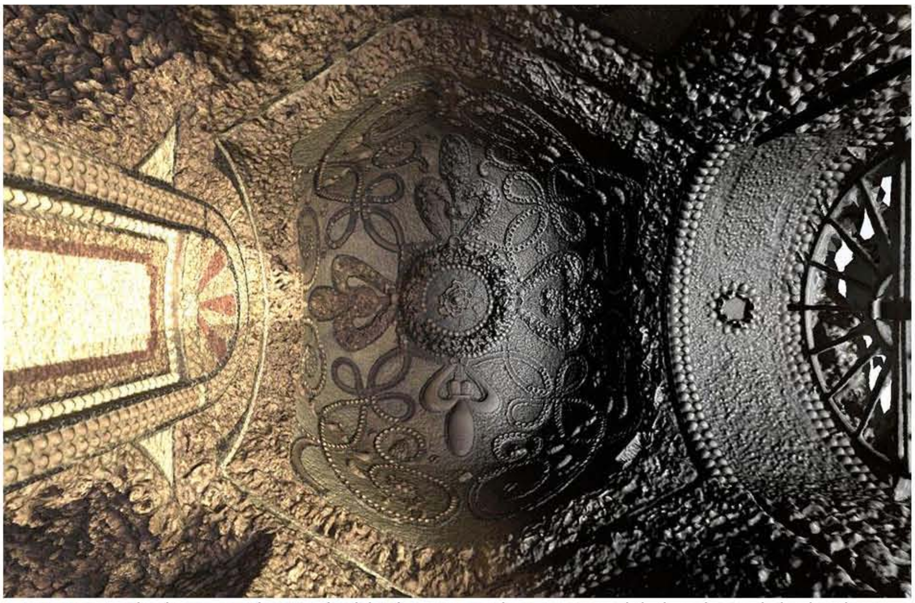

Figure 4. The hexagonal room inside the Appennino. 3-D model showing original colour attributes (on left side).

3. THE SURVEY: PURPOSES, TOOLS AND METHODS. FINAL DRAWINGS

Surveys have been carried out with different purposes and methods. In particular, the surveys on the Chapel and façades of the Paggeria were the subject of the final workshop of the First Training Course in "Geomatics for Conservation of Cultural Heritage" (Tucci et al. 2010, Conti et al. 2010). In compliance with the didactic purpose, the operations carried out (which sometimes exceeded the normal operating needs for such surveys) allowed comparing different techniques and provided all the students with the possibility of testing the available instruments. In the case of the Fountain of Jupiter and the Giant of the Appennino, however, the surveys were ordered by the Property in view of the maintenance works and the June 2011 restoration campaign on the external surface of the giant statue. These two artefacts, characterised by a complex and irregular geometry, were built with rough and carved materials, as well as rockworks encrusted with stalactites, sponge-like rocks and rustic mosaics formed by shells and polychrome lithotypes. These conditions generate several undercuts leaving shadow areas and holes in point clouds. The GeCO laboratory had thus to define specific best practices for the acquisition and modelling of this type of artefacts, later used in the surveys of the Grotta di Cupido (Cupid's grotto) inside the same park and the Grotta degli Animali (Cave of the Animals) in Villa Reale di Castello, which are still under way.

3.1. Topographic and laser scanner survey

We performed a topographic framework within a local reference system for all works, except for the case of the Fountain of Jupiter for its modest size. Targets for range maps alignment and registering were measured using total station. Scans were later modulated by position and number according to the land morphology, construction geometry and limited visibility due to thick vegetation. In some cases, in the same position we carried out many scans at different resolutions to have both a low-resolution environmental survey and a detailed range map of the building. We commonly used a phase-based laser scanner, but in the case of the Giant of the Appennino it was necessary to perform long-distance scans due to the presence of a pond in front of it. We therefore used a time-of-flight scanner with a higher range, which allowed acquiring the chromatic values of the surfaces too. Scanning was always performed during daylight hours and when the park was closed to avoid the presence of visitors who would have become unwanted elements to be eliminated from scans during editing. To acquire the back and the top of the Giant, some scans were performed from an aerial platform.

As each scan position is defined in a scanner coordinate system, for registration it's necessary to know the exact position and orientation of these scanner coordinate systems according to a local or global coordinate system. This can be obtained detecting in every scan at least three correspondences between targets surveyed by total station or any other similar natural points. The whole model is then optimized with an iterative algorithm (Iterative Closest Point). The alignment is followed by the editing of the point cloud (Santana Quintero et al. 2008).

3.2. Integration between rectified images and laser scanning

In the case of the Paggeria, the different geometric and material characteristics of the building (with typical flat façades) proved to be particularly suitable for the representation through rectified images integrated with scans. A survey planning was drawn up to detect the number of images required to represent the elevations in the desired scale, targets and natural points were surveyed topographically, further control points were extracted from the scans carried out for land survey. Images were roto-translated for the image rectification and expressed in the same local reference system used for scanning. As the geometry of some elements, such as the access staircase, could not be represented with rectified images, we integrated the drawings with ortho-images from point clouds.

3.3. Alignment and referencing

Every single topographic survey was performed initially in local reference systems due to the lack of intervisibility between the surveying stations and the distance between the different constructions. The referentiation of a single reference system was obtained by surveying with a GPS some surveying stations and other significant points that were not screened by the thick vegetation.

	Chapel	**Paggeria**	**Fountain of Jupiter**	**Giant of the Appennino**
Acquisition date	March 2010	March 2010	January 2011	May 2011
Number of people involved	9 students + 2 tutors	9 students + 2 tutors	2	7
Acquisition time (days)	2	2	1	3
Total surface (flat projection in m²)	5,400	2,280	500	2,000
Main closed traverses (no.)	1			1
Secondary open traverses (no.)	1	1		1
Traverse stations (no.)	6	2		9
3D laser scanner stations (no.)	25 (12HL-24ML)	6 (ML)	15 (3ML-12HL)	48 resol. m. 0.01 at 10 m
Acquired targets (no.)	47	32	14	35
Acquired space coordinates (no.)	321.778.445	40.779.575	497.077.644	361.698.330
Mean absolute error of alignment	mm 5	mm 3	mm 6	mm 4
Instruments (no., model)	1 Leica Total Station TCR 303; 1 Leica Total Station TCR 705; 1 Leica Laser Scanner HDS 6000; 1 Leica Laser Scanner C10 (Giant of the Appennino) 1 Leica GPS SR530; 1 reflex Nikon D700			
Software	Star-Net (topographic data processing), Leica LGO (GPS data processing), Leica Cyclone (range maps processing), Meshlab (mesh modelling), Geomagic Studio (mesh modelling) Bentley Systems Microstation (vectorialization) Adobe Photoshop (graphic editing)			

3.4. Final deliverables: 2-D drawings and 3-D modelling

While drawing up the final drawings, two aims have been pursued: providing the designers with drawings that comply with the conservation project and fully exploiting the quantity of data acquired with the most suitable representation techniques to describe – briefly but accurately – the geometry, the environmental context and the materials of each artefact.

For the Chapel and the Paggeria we did drawing by means of traditional orthogonal representations in 1:50 scale for architectures and 1:200 scale for general layouts. By using the point cloud of the Chapel we determined the suitable section planes, extracted thin point sections and obtained orthoimages of the building and context. The integration and processing of these images produced both contour lines maps of the whole area and vector drawings of the vertical and horizontal sections of the building.

The nature of the Fountain of Jupiter, characterised by the coexistence of strictly connected natural and artificial elements, suggested the opportunity of executing an overall surface model of the architectural elements, to be used to automatically extract all the desired orthogonal representations. As it was not possible to conceive a single surface model (due to its complexity), in the point cloud we segmented small homogenous portions in terms of morphology and level of detail required for their correct description. In fact, if for natural elements (lawn of the staircase, tree) a brief description of the volumetry is enough, for built parts (pool, statues, etc.) a more accurate definition is required.

Figure 5. Fountain of Jupiter. 3-D surface model of the mound and the statues.

Each single portion was decimated differently according to the planned definition and then triangulated to obtain an overall initial surface formed by 11,334,006 triangles. The following phases involving cleaning and processing gave a final model of 5,815,538 triangles. This model allows obtaining automatically all the desired 2-D representations. The natural environment surrounding the artefact, which is not included in the surface model, was synthetically represented with orthoimages of the point cloud used as the background of the sectional elevations.
In June 2011 a new survey campaign of the giant statue of the Appennino became necessary to carry out the restoration and maintenance works. Besides the complete 3-D representation, we also asked for 2-D drawings in order to compare them with the ones did during the surveys and restoration works carried out in the eighties. On that occasion a reference grid was drawn and used as reference for photos and documents concerning the survey of the artefact complex surface (Pozzana 1988). However, the Giant of the Appennino has different characteristics compared to an architectural artefact, whose representation planes can be generally and easily detected in plans and elevations. Therefore, we needed to obtain the projection planes of the orthogonal views from the pre-existing drawings. This trend proved to be positive for the main elevation, already surveyed through photogrammetry, while it could be applied only by approximation to the other elevations and plans previously surveyed with direct measurements, which showed remarkable deviations compared to the new measures. However, the 2-D representation of the elevations according to prefixed planes with the conventional criteria of the architectural drawing highlights only a tiny part of such a complex artefact, so further drawings were planned.

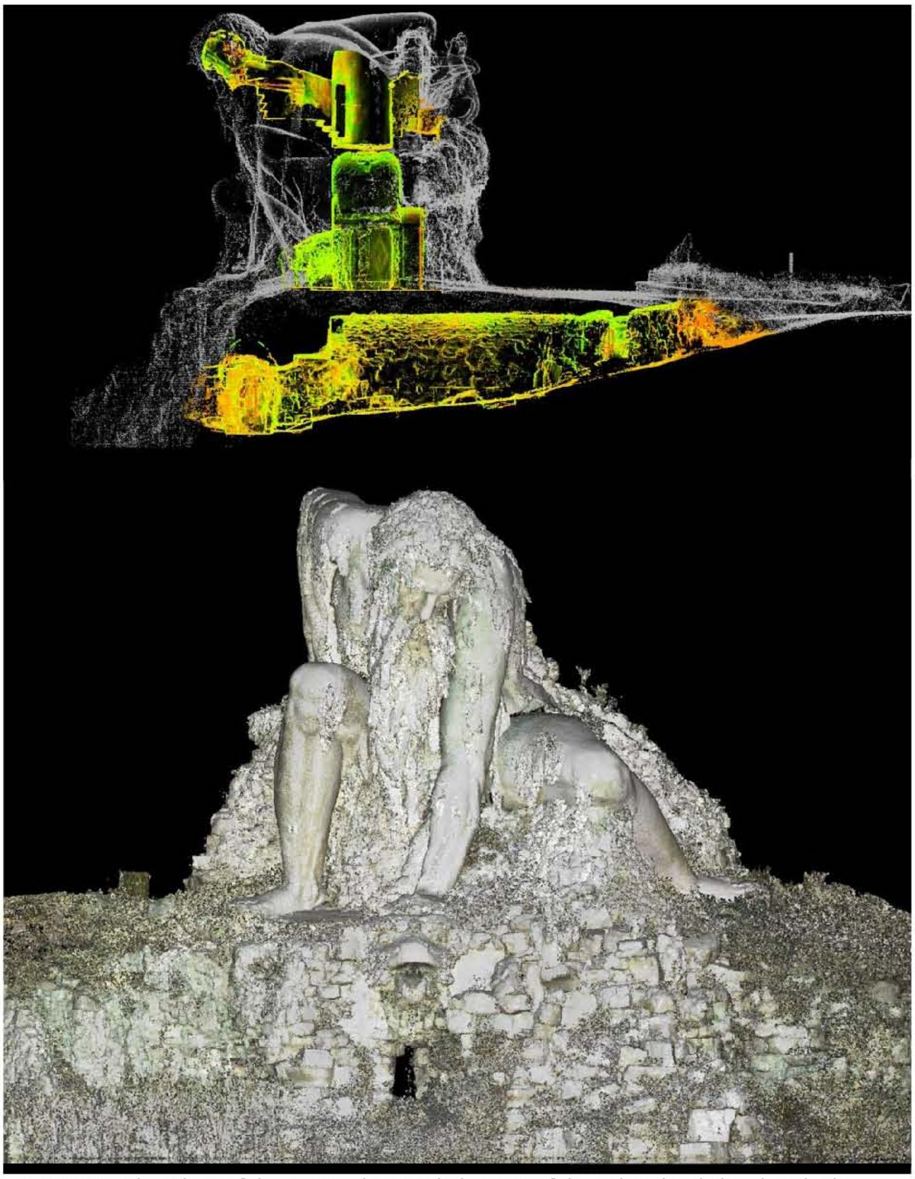

Figure 6. The Giant of the Appennino. Orthoimages of the point cloud showing the inner rooms and the main elevation.

These drawings, by differentiating the representation of the points of the external surfaces from the internal ones, allowed instant representation of the relations among the spaces. In this case too we drew up a surface model (presently only for internal spaces), which allows displaying in real time the geometry and inner articulation, as well as the chromatic values of the surfaces.

Figure 7. A comparison between a photo of the Appenino and the 3-D model (with texture on right)

4. CONCLUSION

The report showed how, by using the Geomatics techniques in an integrated way, it is possible to represent complex and organic shapes with metric precision which otherwise would be difficult to survey through traditional techniques.
However, there is still an open issue: to manage the data obtained suitable IT tools and technical skills are necessary; therefore, it is even more important to detect the most effective ways to communicate the results to non-specialised users too. On the other hand, the best potentialities lie in the production of 3D models that can be used for several functions.
Furthermore, as some in-depth studies have already been carried out on the Pratolino Park within different sectors (history of art, archaeology, botany, etc.), it is possible to use the database holding the surveyed metric data to relate the geometry of the buildings and the environment with the results coming from this multidisciplinary researches.
This way we can link knowledge and dissemination requirements with administrative requirements for better management and conservation of the Park.

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ICT PROJECT FOR THE MUSEUM OF *CASA MARTELLI* IN FLORENCE, ITALY: FOR A VIRTUAL TOUR OF TODAY'S AND YESTERDAY'S COLLECTIONS

DANIELA CINI, VALENTINA BONORA, GRAZIA TUCCI[1]

ABSTRACT

Through the use of multimedia centered on imaging technology, three-dimensional survey and customized educational itineraries, a noble ancient palace with its relevant art collection becomes a very communicative museum. This paper presents the project plan and first achievements, featuring the objectives, the explorative tools and impacts on visitors and users.
The purposes of the project are to reconnect threads between artworks and documentary sources, which have been cut or forgotten, and to reveal to the museum's visitors the lost evidence of these links, either attested to by direct figurative references or by art-historical reconstructions.
The technical aspects of the planned paths for different kinds of visitors are meant to engage the users and make their cultural experience unique and personal: both the applications on site and through the Web will broaden the visitor's perspective providing information, suggestions and stimuli for an integrated and accurate perception of all elements related to the family's collections and home.

Key words: Information and Communication Technologies, Virtual Tour, 3D models, interactive interfaces, House-museum

1. INTRODUCTION

Casa Martelli, an ancient palace owned for centuries by this Florentine noble family, has been recently restored and transformed in a National museum, limitedly accessible just a few hours per week by reservation since 2009. Even if partially refurbished, especially to adapt the building to public safety regulations, it maintains the peculiar quality of an elegant "house-museum" with exceptional 18^{th}-19^{th} century *trompe-l'oeil* wall and ceiling paintings (Fig. 1), original doors, draperies and pieces

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of furniture still adorning ceremonial rooms and a fine and valuable collection of artworks, dating back up to the 15th century and gathered through time by different members of the family. The last Martelli kept the majority of the paintings belonging to the family arranged in a suite of rooms especially designed for them in the 18th century, preserving the late-baroque taste for art viewing and enjoyment (Figs. 2, 6).

Figure 1. The frescoed "winter garden" on the ground floor.

The curatorial choices of display, lighting and communication that have been made by the museum curators are oriented to save the sense of a domestic and private environment, even if noble and full of historical values. These should not appear invasive or unnatural. Captions have not been affixed near the works, and there are no cases containing information sheets in the rooms. Visitors, so far, have been guided by art-historians or museum attendants through the open rooms, receiving directly from them the interpretative keys to the historical owners, the place and the main pieces of the collection. Moreover, artificial lighting is diffused and reinforces the pre-existing chandeliers, not focusing on each painting or object as generally is done for exhibit arrangements.
However, the museum has been recently suffering from a lack of highly qualified personnel permanently available for groups or individual visitors, which are increasing and variously characterized.
This is one of the reasons why the curators of the museum intend to convey the unique essence of these spaces in a new didactic tool, accessible also on the Web, and in addition reveal, through it, to all visitors what is not immediately visible

walking through the rooms: the changes in display and the renovations according to the cultural taste of the exponents of the household; the valuable artworks which have been inherited by other branches of the family or sold in a time of decline and are held today by important museums, in and outside Italy; the cross-references between visual and textual documents related to the Martelli's art patronage, commissions and purchases (as in Fig. 3, the statue is attested to be in the gallery).

Figure 2. A detail of the entering room of *Casa Martelli*'s picture gallery on the first floor.

Figure 3. *The Martelli Family* by G.B. Benigni, 1777-1783 (Museum of Casa Martelli), and the statue of *Saint John the Baptist* by Desiderio da Settignano (Bargello National Museum).

When the palace, with its contents, passed into public hands, an extensive archival research on the family, the property and the collections was indeed undertaken, in order to orient the choices on how to reuse the old building. The present project creators intend to exploit this material complementing it with educational activities to develop the visitor's trails based on specific topics.

2. THE PROJECT

2.1. Objectives

On the basis of a common agreement aimed to expand the communication channels of the distinctive "home-museum" and of the collecting history of the Martelli family, art-historical objectives and technological engagement modalities were developed together by the Directors of the museum and the Geomatics for Conservation and Communication of Cultural Heritage Laboratory (GeCo Lab) of the University of Florence.

Since 2006 GeCo Lab collaborates with public and private entities on projects which need to correlate metrics and spatial three-dimensional data with specific concerns and results of other kinds of survey. GeCo Lab applies techniques and tools created within the cartographic sciences to enhance knowledge and representation of Cultural Heritage at various scales, from the urban/territorial one to the decorative elements and movable objects field (in particular, for the developed experience on medium and small sized objects see Tucci et al. 2012). The Lab develops modern and integrated surveying methods (3D scanning systems, digital photogrammetry, topography, etc.) testing advanced hardware/software instrumentation in contexts of significant interest, as it is the case of the *Casa Martelli* museum, to obtain 3D models and make use of the output for scientific or educational purposes.

The project plans to reach out to visitors on two dimensions: during the real visit of the museum and on the Web.

Taking advantage of digital technology's potential, the project looks forward to return in new forms and relations the results of significant historical and documentary surveys carried out over the last 20 years and released in various publications (e.g. Civai 1990) and in the computerized inventory of the on-site collections.

The main goals of the projects are the following:

- Customized visits: Provide personalized pathways for small groups of visitors in the museum, factoring out - with the right supportive interface - the presence of specialized touring staff, and for users on the Web interested in a virtual tour. The subjective choices within the proffered itineraries will ensure in both cases a high level of involvement, interaction and quality of the insights.
- Potential audience: Disclose the specific nature of the museum to a public that generally still does not know about it, as for example Florence non-residents, young people, families with children, and people with disabilities. Access to contents will be made available also to English-speaking visitors and progressively to those of different linguistic areas. For younger visitors, audio-visual narratives on certain topics and artworks will be inserted in the digital itineraries, as well as games based

on what they have seen. For the partially sighted, a real size replica of a famous Renaissance statue that was owned by the Martelli family (Fig. 3) will be presented on site for tactile exploration. For hearing-impaired persons, audio-visuals could be adapted with subtitles or translated in sign language.
- Extension on the Web: Since the already existing Web pages dedicated to the museum (see References from Internet) are just for informational purposes, it should be possible to deepen the overview of the museum through a virtual tour and relative highlights, and more incisively transmit online the sense of continuity with the domestic private past and the hospitality approach of the "home-museum".
- Personal involvement of remote visitors: Transfer online the active relationship with the environment that develops during a site visit, giving the chance to interact with the museum staff, to post comments and photos on a web forum, to share appreciation through links to the most common social networks.
- Recovery of the connections with the "Martelli artworks": Promote contact and exchange of historical information and educational material with museum institutions and private collectors, in and outside Italy, which own artworks linked in various ways to the noble family, either because commissioned by its members or known to be in their possession. The outcome should be a clear acknowledgement of the past-present continuity of the artworks and of the changes of context.

2.2. Overview of the multimedia educational tools

At the heart of the project is an integrated system of multimedia content to surf through interactively according to different routes based on the visitor's interests and needs. Not only artworks still in *Casa Martelli* will be taken in account and put on focus, but also distinctive ones connected to the family's art-history held today by other institutions and collectors. Various key issues will be addressed while presenting pieces of the collection, opening windows on broader cultural trends and similarities in distant contexts.

The planned interfaces are of two kinds: mobile devices (tablets) inside the museum, and, online, a sub-website on the official page of the Museum. The access to contents will be following the four required conditions for an enjoyable learning experience, identified by "edutainment" specialists: a sense of discovery and fascination, appeal to multiple senses, the appearance of effortlessness, the availability of choice (Packer 2007).

The HD digital display of the artworks, also in 3D in the case of a few selected sculptures, and the set of information (text, images, audio/video) associated with them, will be accessible choosing from a range of sensitive areas (hot-spots) to be found in a representation of the museum's spaces.

As for the Web application, an appropriate frame for the focusing passageways would be a virtual tour consisting of 10-15 immersive panoramic photographs, one for every relevant room, stitched together in a circular itinerary. This would allow the Web visitor to preview the museum's environment or to bring back to mind what he has already seen in person, in both cases with high-level perception at 360°.

For those, instead, who will use on site the guide-tablet provided by the museum, the browsing experience through contents may start recognizing visual markers placed in specific locations, or, more traditionally, selecting hyperlinks from an orientation map.

As for the arrangement of the educational programs, the project can benefit from the discussion and collaboration with the education agency of the State museums in Florence, as well as make use of external specialist staff, especially for digital storytelling techniques. By another point of view, computer engineers will take care of the development of the relational database and of the software required for content management and exploitation on the Web and on mobile devices.

While art-historians are proceeding with the identification and collection of material to populate the database (digital images of artworks and of the house-museum in the current state, old pictures, texts, videos, music...), GeCo Lab has been outlining the logical system design beneath the communication project, defining data and relations between the information categories, and identifying the operations which could be performed in an interactive environment by the user. In parallel, GeCo Lab has surveyed several sculptures displayed in the house-museum and processed the data in order to integrate the digital 3D models in the multimedia system (Figs. 4, 5).

Figure 4. 3D digitization of a bronze statuette representing a *Dancing faun with cymbals*, first quarter of the 18th century (Museum of Casa Martelli): a picture taken during the survey by means of a multistripe laser triangulation scanner, and the digital 3D model shown without the photographic texture.

Figure 5. 3D digitization of the bust portrait of Ugolino Martelli, 1518-1519 (Museum of Casa Martelli): a picture taken during the survey by means of a hand-held scanner, and, on the right, the digital 3D model shown without and with the photographic texture.

As said before, another tool will fulfill the historical-critical perception of the visitor in the museum: the physical replica at a real scale of the full-length marble statue of a young Saint John, known as the "San Giovannino Martelli" (Fig. 3). For centuries it has been attributed to the famous Renaissance sculptor Donatello, and today is mainly assigned to Desiderio da Settignano, in what perhaps could have been a co-partnership with his master Donatello (Bormand et al., 2007: 124-127). The illustrious sculpture was sold by the Martelli in 1913, during a stage of socio-economic decline of the family, and displayed since then at the important National Museum of the Bargello in Florence.

The digital model of the statue, which GeCo Lab is going to obtain in the next future, will serve as the basis for the physical model in marble or synthetic resin, which will be achieved through advanced automated milling or 3D printing technologies (as in Tucci and Bonora 2011).

2.3. Expected results and impacts

The project plan includes also the final outcome tracking stages and the possibility to make improvements to the communication system and technological media, after evaluating the results with respect to the initial objectives. The monitoring activities will consist in collecting feedback in the museum and online, to survey users' satisfaction and profiles. The information could be retrieved through the observation of visitors behavior, giving direct interviews, or proposing questionnaires on-site. On the Web, pre- and post-visit comments and a quantification of the virtual visitors will give a useful orientation.

However, as authors of the project, we must admit that all of the elements which may be weighed somehow and are here described as possible indicators, are just allusive. We are indeed aligned with museum management studies which make the following preliminary recommendations for their evaluation models:

"Before suggesting some measurable performance indicators, a review of the risks of using them may be healthy. First, it cannot be over-emphasized that many, if not most, of the critical qualities of good museums cannot be measured numerically. Ratios cannot measure the importance of a museum's purpose or the quality of its educational programs. A collection of ratios for a given museum should never be intended, nor be read, as more than a partial portrait" (Ames 1990).

Given this premise, the criteria we have identified to evaluate the outputs of the project are the following:

- with respect to the development of the contents: the number and significance of meetings and contacts between the museum curators and scholars and/or owners of "Martelli artworks";
- as for the visitors: the degree of participation, satisfaction, enjoyment; an increased number of participants with special needs; the repeated occurrence of non-residents coming back after a while; the choice of visiting the house-museum to appreciate the historical context of "Martelli artworks" seen elsewhere;
- general resonance: number and importance of press mentions;
- as for the website: number of visits, number of interactions with the Web forum, number of citations and comments posted on social networks;
- follow-up activities: requests for documentation and didactic media (pictures, DVDs, apps, books...) related to the palace, the history of the family and of the collections.

Expected impacts could be also: the fact that the museum will be included in tourist and educational programs as a symbolic reality of a certain historical period and culture; and, on the research ground, the acknowledgment that puts the museum, along with the Martelli's collecting history, in relation to similar cases pertaining to other geographical and cultural contexts.

In the end, quantifying helps the museum curators to determine if the memory of the visitors' experience remains as knowledge and therefore turns into culture. And if the "image" of the museum, to be interpreted as the expression of the peculiarity of this institution, grows roots in the community over time and space.

3. CONCLUSION

Several information and communication technologies and competences are involved in carrying out the *Casa Martelli* project, aimed to exploit previous studies and episodic educational experiences in a single integrated system. The authors have presented different issues related to the planning stage of this project, highlighting objectives, means and expectations.

An intuitive interrelation of various kind of contents, supported by an immersive explorative guide system, will help to clear the evolution of an art collection that reflected not just one personality, in a defined age, but several cultural wills and inclinations along generations, and also the changes in the refined dwelling that provided or still provides its scenery.

In this way, without betraying the "non-museum" approach fundamentally chosen by the curators, the place and the collections will clearly transmit their conveyed messages and be a cultural reference point for a wide public which appreciates the feeling of being hosted as a guest in a private and, at the same time, historic house.

The tools illustrated in this paper will benefit not only the museum's visitors, but also the administrators of the artworks: the curators of the house-museum and the ones who have in charge "Martelli pieces" kept elsewhere. The photographic and 3D surveys have in fact a documentary importance, since the spherical panoramas of the house-museum's rooms and 3D models of the artworks may serve as reliable records of their current conditions, in view of future investigations. Also, the relational database, with its cross references on artworks and contexts, is going to work as a digital reservoir that can be further enriched and supply material for other engaging itineraries.

Figure 6. More details of the Martelli's picture gallery.

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SESSION 8

16 November 2012 Friday, 16.15-17.15

Topic: New Technologies for Cultural Heritage

Chairperson: Assoc. Prof. Dr. Maurizio DE VITA

PhD. Arch. Magdalena PODWOJEWSKA
Historic Railway Stations, Documentation and Revitalization of the Railway Infrastructure Facilities - Protection of Cultural and Social Heritage

Assist. Prof. Dr. Bahtiyar EROĞLU, Instr. Ayşegül KOÇ ÜNLÜSOY
Analysis of Changing in The Historic City Center: Yozgat

Dr. Shabnam AKBARİ NAMBAR, M.Sc. Nasim Najafgholi POURKALANTARI, Bc. Atabak SADR KHERADMAND
A Survey on Construction Technology in Traditional Baths of Iran (Case study: Esfahlan bath of Osku – Tabriz)

Assist. Prof. Dr. Özlem KARAKUL
Re - Creating Local Building Technology as a Way for Documenting and Conserving Intangible Cultural Heritage

HISTORIC RAILWAY STATIONS, DOCUMENTATION AND REVITALIZATION OF THE RAILWAY INFRASTRUCTURE FACILITIES - PROTECTION OF CULTURAL AND SOCIAL HERITAGE

MAGDALENA PODWOJEWSKA[1]

ABSTRACT

The article presents problems of documentation and adaptation of buildings which constitute the cultural heritage of the railway infrastructure facilities in Pomerania in Poland. Shows the potential and possibilityto be adopted for various purposes. This problem affects many sites and buildings, railway stations, railway warehouses, residential buildings, technical buildings, water towers, trackman shelters, bridges, viaducts, culverts, and the track. Technological innovation has been a huge turn which transformed the system of management of railway facilities. While many positive changes occured, many valuable from the point of view of historical, architectural, social and sentimental objects no longer serve their original function. They fall into disrepair or are managed in a haphazard manner. Difficulties with their revitalization are associated with many factors. The main problems are connected witch the of ownership and location of the function socially justified. In small towns there is no need to locate the service facilities of such a large area, or this function already exists far from the train station. The problem underlies in the lack of detailed database on existing resources, their potential for tracking, communication, technical state of buildings, architectural and historical values. A chance for the complex of railway infrastructure is to create a database in order to plan investment, both the scale of entire historical railway lines, and within individual objects. In Pomerania rail system has changed several times. It happened immediately after World War II, and at the end of twentieth century. The closure of many lines resulted in elimination of useful connections not just withering away of the communication system, but above all, loss of function performed originally by the objects of railway buildings. The result was the most serious loss of life centers and decrease their rank. The initiative of creating a database, then the model transformation and social activities in the field gives you a complete, planned activities in the field of railway infrastructure. At the same time it can have an

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impact on facilitate initiatives and decisions to local communities based on full documentation of resources. Eons ago, life of the community, was focused on the market. However, due to the development of technology, means of transport, in the late nineteenth and early twentieth century railway station has become for almost one and a half century, an important site of social life. Adopting a program of revitalization of the railway infrastructure facilities requires the assembly and development of information resources that will be a source of inspiration for local authorities, individual investors and residents. Primary task is to restore a functioning system of railways serving the residents, but equally important is the action of the railway infrastructure in the system of hiking trails, sightseeing, historical, which stimulate the activity of the local community. All these actions should be taken quickly, otherwise there will be no objects to document and revitalize.

Key words: revitalization, heritage, infrastructure, railway stations

1. INTRODUCTION

Polish central location in Europe makes at the intersection of major routes, east - west and north - south, is a significant factor shaping the Polish position on the continent. Through Polish territory four pan-European transport corridors cross, and many other significant flow traffic do, which are integrated with the system-wide. It can be concluded that passenger rail will play a dominant role in relation to international road transport.However, on a national scale and development of the region's prospects are less encouraging.[2]

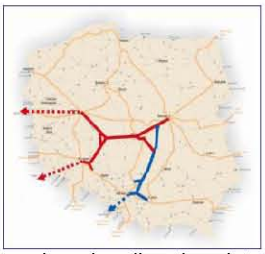

Figure 1. network expansion plan directions interregional connections

[2] The Maastricht Treaty provides for the establishment of trans-European networks in transport, energy and telecommunications to link island, regions, landlocked and peripheral regions with the central regions of the European Community. These networks are the tools to contribute to the development of the internal market while respecting environmental and sustainable development objectives.

The last of the concept involves the construction of railway lines for speeds exceeding 300 km / h connecting four major cities - Warsawa, Lodz, Wroclaw and Poznan (on the possibility of connection to Berlin and the rest of Western Europe). [3]
More than 150 year old railway operating time, both the period of rapid development in the early twentieth century, and in the interwar period, when there was a rapid increase in the number of new, important sections of the railway, and the collapse of that can be observed for last decades. The current situation of the Polish railways, and infrastructure is the result of consistent transport policy, which was particularly noticeable in the 90's. Delays in restructuring and governance failures have led to a deep crisis. Although rail transport is more cost-effective than the road, and more environmentally friendly, for many decades we observed a decline in the number of lines.

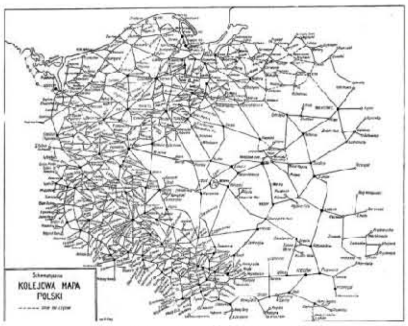

Figure 2. rail network, 1947

Figure 3. rail network, 2000

Data concerning the number of traffic does not indicate a significant decrease of them, the data cover the period to 2005, but thereafter there was no improvement in the situation (Figure 4, Figure 5). It should be noted, however, that the decrease in passenger transport is much bigger than the freight. The railway ceased to be an attractive way of transport. Its organizational structure, the stage of development was determined by the needs of the industry, but at the time of change, it did not keep up the current needs. However, we should realize that the achievements of 150 years of activity is huge and covers many areas of technology, management, planning and architecture.

[3] This would shorten the travel time between:
• Warsaw and Lodz to 45 minutes,
• Warsaw and Poznan to 1 hour and 35 minutes,
• Warsaw and Wroclaw to 1 hour and 40 minutes,
• subsequently Warsaw and Berlin to 3 hours.

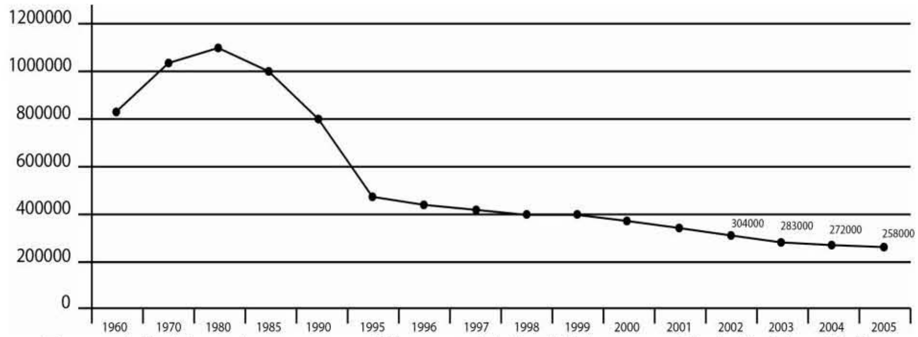

Figure 4. freight and passenger rail between 1960 - 2005, source: M. Juchnicka, "Rail transport in Poland and prospects", Central Statistical Office, the report for 2002, 2003, 2004, 2005.

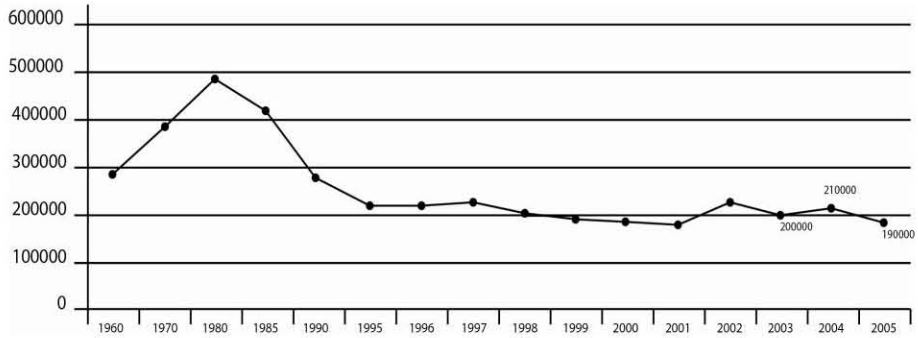

Figure 5. transport of goods by rail between 1960 - 2005, source: M. Juchnicka, "Rail transport in Poland and prospects"., Central Statistical Office, the report for 2002, 2003, 2004, 2005.

2. SMALL RAILWAY STATIONS

The situation does not only affect the rail system itself and the resources but also the functioning of the small towns that were connected local lines. For many decades, stations were an important factors organizing space and life in small towns, were a landmark and place of representation. In many cases, they have been pride of the village. Station buildings were constructed in a manner characteristic of the region, according to similar principles of design, and in many cases are examples of high-end architecture, at the appropriate scale, with well solved functional program.
One of the most interesting examples of railway stations in Pomerania is a train station in Pszczółki, a large communal village on the route between Gdansk and Tczew. The building of the railway station is a valuable example of brick architecture on Pomerania, but the object is devastated and does not have a user who could introduce refreshing new function. Pszczolki is an important passenger stop on the line Tczew-Gdańsk, a line which is a part of Gdansk-Tczew-Bydgoszcz main line.

Figure 6. Railway station in Pszczółki

Despite its convenient location on the trail and the fact that many people in the community are employed at Tri-City[4], but it does not guarantee the possibility of maintenance of the railway infrastructureThe otherl problem is the fact that in the neighborhood of the station, a new odbiect was sattled, whose origin destroyed a chance to revitalize the historic property.

Figure 7. Puck station building

Figure 8. Reda station building

Figure 9. 10. Władysławowo station building, the state before 1939 and now

3. TRAIN STATION IN KARTUZY – THE CAPITAL OF KASZUBY

Kartuzy a town with a population of nearly 16.000, is larger urban center, but the situation is typical of the railway station building for objects of this function. The station is in the immediate vicinity of the center. In 2003 passenger rail service was suspended. By 2010, the station served only warehouses and trolleys. At present, traffic is restored using the splint buses. Further plans to restore passenger rail to Kartuzy are included in the development of rail transport for 2007-2013, which envisages the establishment of a direct connection from Gdansk. However, due to the small number of connections, the station building function changed in an

[4] Tri-City is a system of three cities in Gdańsk, Sopot and Gdynia, which are connected by proximity, communication system and complementary function

uncontrolled way. At the moment is shared between many users. There are commercial service points, such as beauty salons, solarium, copy centre, and second hand clothes. The area in the immediate vicinity of the railway station, so it become car park space to service a center of the city.

Figure 11. 12. Kartuzy - Station buildings

4. GDYNİA - KOŚCİERZYNA RAILWAY LINE

The increase in exports of coal from Silesia by Gdynia, mainly to Scandinavia, has forced the need to build the so-called, "Carbon main line" (457 km), the largest railway investment of the Polish state between the first and second world war. In 1930, the French company - Polish Association of Railway SA headquartered in Paris, built a new railway line, which run still exists today, and the old track was partially removed, creating a path. Concession granted to a private company to build and operate the route would have expired if it had not World War II, until 31 December 1975 year. The construction of the main line under the direction of Ing. Joseph Nowkuński made a significant contribution to the development of the port of Gdynia. Construction of a new main line connecting Herby Nowe in Silesia of the port of Gdynia, had huge economic and political, social and military importance for newly reborn Polish state. Due to the very difficult terrain in Kaszuby between Kościerzyna, and Gdynia is a typical mountain line with sharp curves and steep profiled driveways. Many technical innovations have been applied to this historic line like this, but as a result of a number of reconstructions longer exist[5].

[5] There were (already canceled) catching tracks, or sidings at special exits, which sent wagons that have broken away from the train at the time of the driveway. Railway workers had to report without delay to the next track or train stations, which is the final signal was let through. If the signal on the last wagon was gone, it was clear that part of the composition was going back down the hill and sent it to the catching track. This track existed several years ago, leaving from the Wielki Kack station through the Sopot street. The track embankment is still there. A second locomotive was often also used to pushing trains uphill. A section Gdynia - Osowa (now Gdańsk Osowa) was a two-way for safety reasons (those being distracted wagons) and higher volume of local passenger rail traffic. Its original course has been slightly modified (hence Starodworcowa and Nowodworcowa streets in the Grand Kacku). Nearby Gdynia station, where tracks going to the side of a Danzig line (due to steepness) the catching track was used (it still exists), and between Gdynia and the main port there was a braking track built (buried under a thin layer of sand) used in the same way as catching track

Line Bydgoszcz - Kościerzyna – Wielki Kack - Gdynia since 1939, is a local line, not modernized, so apart from disappearing stations and lines is now almost open-air museum of pre-war railway order.

Figure 13. Babi Dół station building

Figure 14. 15. Osowa Gdańsk station building

The entire line of Bydgoszcz - Kościerzyna - Big Kack - Gdynia newly rebuilt stations had the same standard architecture stylized bit on the small noble mansions with distinctive entrances and alcoves. Most of them still exist. Still a functioning traffic lights shaped in this section. It is possible to preserve the historic railway control sections, which are located in the building of the Wielki Kack station, Gdańsk Osowa, Babi Dół and Wieżyca. There are also some remaining historic buildings and workshops, which, converted into apartments lost their specific climate and architecture. It is sleepy and quiet here - now it's just a line of local importance. The rest of the pre-war legend, the northern section of Carbon main line. Particularly interesting and illustrating the phenomenon of collapse and the crisis is an example of the Gdynia – Kościerzyna line. This rail link of secondary importance, the system maps the essential rail Pomerania, was important for the functioning of many tourist destinations. For many years it was the line, which transported hundreds of people living in the Kaszuby, are employed in Tri-City, especially in Gdynia, it was also a holiday and tourist line, who set off with backpacks and bicycles to the "Kashubian Switzerland". This line is extremely picturesque, beautifully winds between hills, small stations, the stations with attractive architecture. Existing groups of buildings rail stations: Big Kack, Osowa, Żukowo Wschodnie, Babie Doły, Somonino, Sławki, Wieżyca made constituted a harmonious unity, some have changed their function, some of them are not used.Many years ago, waiting rooms and ticket offices were heated with coal stoves, but they got closed. Train station buildings, have become residential objects and yards, became backyard enclosures for livestock. - but they are in a better position than those which are not used and they go to rack and ruin. Even 20 years ago due to the rapid development of housing in towns west of the Tri-City there was a discussion on the reconstruction of the line to electric one. Track reconstruction expected to get rid of turnout points in Gdańsk - Osowa, Żukowo – Wschodnie, Babi Dół, not to impede the introduction of other rail connections.[6] Modernization of which is led, however, only applies to the railway line system and does not solve the problem of existing historic infrastructure, such as water towers, railway station agent shelters, complex of the train station, rail facilities.


Figure 16. 17. Wielki Kack railway station buildings before 1939 and the present

5. ADAPTATION OF STATION BUILDINGS - PROPOSED LOCATIONS

The devastation of railway stations buildings is caused by many reasons, one of which is the ownership structure of the property. The owner of a number of objects is the railway, one of the companies founded after 2000, and the demand for usable space-related activity is limited. There is a problem establishing the user and functions of these objects can be used for. Adaptation and modernization of small stations on the Gdynia - Kościerzyna became the subject of Architectural Design on the 5th semester, at the Faculty of Architecture of the Technical University of Gdansk in the Department of Marine and Industrial Architecture. Three stations were selected to be the subject of architectural action, transformation, where the situation is different, the buildings are used differently, have different conditions and potential. In the case of adaptation the different solutions are possible.

5.1. Wieżyca railway station

Figure 18. Wieżyca railway station building

[6] The modernization of the railway line Gdynia - Kościerzyna, "Kościerski Rail Corridor" gives some chances to rail and revival movement. There is a chance that next year that form Kościerzyna to Gdynia will be reached in 50 minutes, not in 120min. as at present.

The first station, which was the subject of design was the Wieżyca railway station. The complex of buildings consists of a main building, apartment buildings, warehouses and technical facilities. The main building was built at the beginning of the last century, during the construction of the railway line Somonino - Kartuzy. Station selection is not random. In addition to the picturesque location of the station is adjacent to the lookout tower on Mount Wieżyca and ski lifts on the slopes in the neighborhood. Today Wieżyca is a popular tourist destination. Summer holidaymakers arrive here by rail, cyclists and fans of the lakes, and in winter skiers and participants of sleigh rides. However, the building and its surroundings looks like everyone forgot about him, except for vandals. You repeatedly devastated the object from the outside and the inside. The recently it was secured - walled up all the holes on the dilapidated doors and windows. Station buildings, except for the rail can play an important role as a base for tourism. They can function as shelter, hostel, "green schools", hotel, tourist information, shopping and other facilities for tourists. Number of objects allows the location of rental of sports equipment, bicycles, skis sled. It can be a place to organize sleigh rides.

5.2. Krzeszna railway station

Figure 19. Krzeszna station building

Another station is located in Krzeszna. The building with the main part of the village is located on the slope of hills Szymbarskie, with a breathtaking panoramic view of the lake and Patulskie Ostrzyckie waterway as part of "Circle Raduński". It leads the way Kaszubski tourist trail. Town is famous for its water sports, kayaking and permanent residents in addition to guests during the holidays in cottages holiday makers. The station is not an object of valuable architecture, it is not used, and it is devastated. Attempts were made to adapt the object on the common room and shop, but without extensive remodeling, and major investments have failed. With time, the decrease in the number of railway connections, the life of the community moved to the vicinity of shopping. Competition won by a large supermarket. Store and a square in front of him serves as a place of social networking. Due to the unique location of the station on the hiking trails, the place can be used as commercial functions, meeting places, clubs, tourist information. However, the condition of the object points to the need for major reconstruction, expansion or even rise a new building.

5.3. Gołubie railway station

Figure 20. Gołubie station building

The third location is the train station in a holiday village Gołubie, located on the north of the Zamkowisko lake, were the remains of ancient settlement still exist. Gołubie is visited by scouts every year during the holiday season. There are many resorts, farmhouses and Scout campsite Scout camp on Lake Dabrowski. Located in the village Gołubieński botanical garden with an area of 2.12 hectares, which collected collection of plants with approximately 3,500 species and varieties, including 140 species protected by law. Existing station building is only partially used. Location of the station in the vicinity of tourist attractions makes it possible to upgrade the existing facility, and the restoration of its functions relating to the operation of rail and road communications support .

4. CONCLUSION

The result of study and design works are many very different concepts. Some of them provide for the adaptation of the existing building, sometimes its significant expansion. Many proposals provide for the location of the new facility on the site of the old station building. However, it is characteristic, that in all the projects the maintenance or restoration of the basic functions of the station is very important, and enrichment, its expansion to more attractive locations. These actions demonstrate the belief that rail is an important part in the life and functioning of small towns. There is a belief that there is the need to improve the situation of the railways and awareness of the legacy of great value of architecture and technology heritage.

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ANALYSIS OF CHANGING IN THE HISTORIC CITY CENTER: YOZGAT

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ABSTRACT

The physical structure of the social, environmental and economic development activities leads to significant changes in urban areas. The past social, cultural, economic and architectural history that reflects the values of the tissues are affected by these changes. Today, historic monuments and protecting the tissues of an integrated planning approach to ensure integration of the urban fabric is one of the basic approaches targeted.
With this sense, work is aimed to determine the changing of the historic city center of Yozgat as from the 20 th century. Despite the rapid deterioration; between the Çapanoğlu Mosque and Clock Tower that make up the historical city center situated between the linear structures east-west axis of the tissue with areas of traditional housing pattern of trade, rent, construction impacts, the lack of protection awareness and planning decisions for reasons such as inefficiencies, the contrast of building new construction such as Bilal Şahin Külliyesi with the historicist approaches and imagined spaces in the city is wanted to draw attention. The analysis studies to available historical tissue will be the source to develop strategies intended for the revitalization of historical city pattern and the healthy decisions with the areas of new structuring.

Key Words: Urban conservation, protection, changing, Yozgat

1. INTRODUCTION

Development activities coming along with expansion problem in economic, social, environmental and physical structure causes significant alterations and transformations in cities. Historical fabrics reflecting social, cultural, economical and architectural values of the past are exceedingly affected by these alterations.
Historical/cultural accumulation constitutes the basic values of a city identity. City memory or social memory consist of *location(place)-time-remembrance-identity*

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togetherness. Overall impressions that social and spacial change in the city over time left on residents constitutes "city identity" (Bilsel 2000).

The thing that makes cities different from each other is historical environments, different stories and urban memories of them. Any negativity and any wrong intervention on these fabrics connecting the past, today and the future, causes the exstinguishment of marks coming from the past and composing the urban identity.

It is seen that modern transportation vehicles and approaches(modernisation) brought by industrialization are mostly responsible for destruction and ravages. Direct threat against classical city fabric that social structure has revealed especially before transportation with motor vehicles and against cultural property substantially wipes the city out by turning it into a construction site.

The idea that preserving the existent construction is an obstacle for development, retains its freshness in this day and age. In regard to preserving cultural heritage, Faulkner states that "Past is never death. In fact, it is not even past". Additionally, Kalfa expresses that "A past reaching to the starting point doesn't pull man back, pushes him forward and contrary to expectations, it is the future driving us into "back-past" ". These two mottos clearly shows the forced modernization event in the old city and what a gross injustice against the historical city were performed.

Historical fabrics of cities with their physical, social, economical, political etc. structures, changing within the development process of cities, have the characteristics of a living archive holding the memories of residents together(Bilsel 2000).

The most important factor affecting the processability of preservation and revitalization themes in historical urban areas is to improve the idea of urban renewal which handles physical, social and economical dynamics with an integrated approach. This approach is not only an effort for a physical recruitment performed on the basis of construction but also an effort for maintaining and recruiting social and cultural values, social identities, economical growth of these areas and life standard of the users. Economical, social and physical values, three basic components of urban transformation, must be set as main objectives for the development of the area in a sustainable and healthy way and strategies intended to these objectives must be developed. While setting strategies, primarily the historical environment must be analyzed, existent ageing in this area (functional, physical etc.) and development dynamics of the area must be defined and vitalization strategies must be determined according to performed analyses.

At the present time, performing the integration of monuments and fabrics with urban fabric by using an integrated planning concept is one of the main approches in preservation. In this sense, the aim of this study is to determine the alteration and transformation that modernization process, formed by industrialization (triggered by technology), created on historical fabric's photograph from 20th century to present with the help of Yozgat city sample. Additionally, with the study, it is intended to draw attention to oppositeness of effort for creating places built with an historicist/immitator approach within the high-density welding house fabric positioned in the extension of this axis and modern development axis, while trade areas positioned between Çapanoğlu Mosque and Clock Tower, forming the historical centre of the city, in an east-west linear axis and traditional dwelling house fabric added to this fabric are rapidly destroyed in consequence of some reasons like income, reconstruction effects, deficiency of preserving awareness and inadequacy in planning decisions. Alteration analysis which will be performed on the existing historical fabric within the scope of this study will provide a basis for the development of strategies related to vitalisation of historical urban fabric and healthy planning decisions that will be set for new settlement areas.

Because of its position in the city, diversity of its urban functions, being one of the most important trade axis in the city and having important urban identity items in its impact area, trade areas positioned in a linear way between Çapanoğlu Mosque and Clock Tower and Lise Main Street and Bilal Şahin Street has been selected as the study field of this research which is carried out concerning the effect assesment of one of the implementetion means of modernism in our country on historical urban fabric.

Figure 1. Photograph of Yozgat from Google Earth

2. STUDY AREA

2.1. Limits and General Characteristics of Study Area

Though it is narrated that Yozgat was established as a settlement in 16th century and there had been a village here before that settlement, any document related to these information couldn'd found yet. Since this date untill the Republic Period, the city was commonly known as BOZOK and it was a district bounded to Sivas state till the beginning of 19th century.

Mosque and trade areas around it, which can be seen in many Ottoman cities, and order formed by dwelling house fabric added to this fabric is seen in the Historical center of Yozgat City. This Çapanoğlu Mosque-centered area, selected as field of study, has never faded away in the historical process. It still forms the religious and çommercial center of the city.

Figure 2. An old Photograph of Çapanoğlu Mosque (Studio Alper Archive)

Westernisation or first modernisation wave and applications beginning with the royal edict of reform in 1839 is encountered in Yozgat City scale. Reflections of changes in technological, economical, social and cultural infrastructure on urban place is seen in II. Abdulhamid period with the construction of Clock Tower. It is an indicator of transition to new urban image centered planning concept like its western samples from an understanding of mosque centered planning. In the historical process, these fabrics entering into a rapid distortion process depending on the factors like insufficient and wrong planning decisions, income, unconciousness, impacts of reconstruction caused great losses in memory of the city. Field of study can be seperated into three parts also explaining the alteration process of the city. First part is Mosque centered trade fabric before the modernisation efforts.
As modernisation efforts affected the skyline of many cities, second part is the fabric constituted by the Clock Tower and city square, constructed in Early Republic Period and various public institutions describing this square. Third part expresses the fabric showing the expansion direction of the city after 1990s as a follow-up of this axis.

2.2 Historical Development of Study Area

It can be said that development of field of study in historical process made progress paralel to east-west axis fabric added to Çapanoğlu Mosque. When conventional Ottoman Cities are examined, it can be realized that a Mosque-centered planning concept was preferred. In the cities, the largest mosque and around is the fabric that trade activities are intesely performed. These fabrics also describes community's socialization areas. Traditional house fabrics formed of narrow and sometimes dead end streets are connected to this religious and trading center. This setup can also be seen in Yozgat city scale.

Figure 3. General View of Yozgat from an old photograph (Studio Alper Archive)

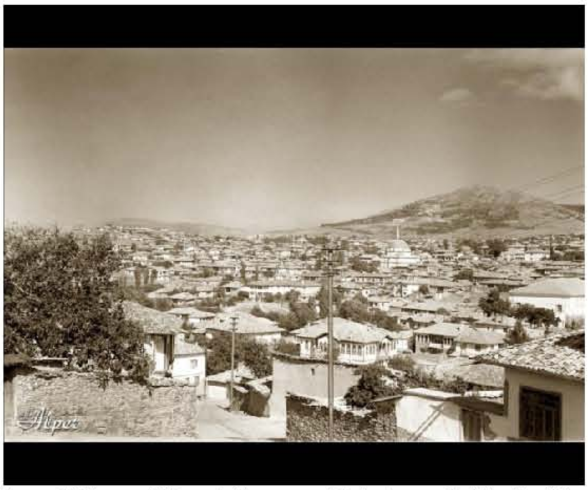

Figure 4. General View of Yozgat from an old photograph (Studio Alper Archive)

Çapanoğlu Mosque and around became one of the most important parts of urban image in the historical process. A radical change in this fabric was not observed until Early Republic Period.

Figure 5. Photograph of Çapanoğlu Mosque and araund (Studio Alper Archive)

Figure 6. Photograph of Çapanoğlu Mosque (Studio Alper Archive)

Figure 7. New photograph of Çapanoğlu Mosque Axis 2011

City squares and wider road networks that we meet as a reflection of industrilization process triggered by technological developments and improved modernization efforts depending on this process to urban places, caused irremeable losses as it couldn't adapt to structure of historical fabric. This problem were intensely experienced in Yozgat City scale. City square and around the square, constituting the second part of study area, were changed for that purpose.

Figure 8. Photograph of Cumhuriyet Square (Studio Alper Archive)

Figure 9. Photograph of Clock Tower (Studio Alper Archive)

Figure 10. New photograph of Clock Tower and around

Figure 11. Photograph of Cumhuriyet Square -1940-(Studio Alper Archive)

Figure 12. Photograph of Cumhuriyet Square -1945(Studio Alper Archive)

Figure 13. Photograph of Cumhuriyet Square 2010

Bilal Şahin Mahallesi, constituting the third part of the study area, started to be constructed after 1990 and it couldn't provide integration with historical fabric. In this fabric which has high-density and income-oriented planning, historicist approaches rather than a historical center forming the city identity and undertaking a cultural bridge duty between past, present and future are exhibited. With Bilal Şahin Social Complex(Bilal Şahin Külliyesi) ve Street Entrance Door (Mahalle Giriş Kapısı), built with historicist/immitator approaches, it was tried to create new urban images.

Figure 14. Bilal Şahin Entrance Door and around

Figure 15. Photograph of Bilal Şahin Social Complex and around

Figure 16. Photograph of Bilal Şahin Social Complex

3. RESULT

Historical-cultural environment which is the subject of artificial environment can be described as reflected images of cultural values, created by humanity throughout the history, to physical environment (Keleş 1997).

From past to present created historical-cultural heritages are values which establish a bond between past and future, able to solve identity problem, create a history deepness and awareness, able to provide communication between generations, nonrenewable, has a limited resource character. Disappearence of these values weakens the relation, communication and solidarity between societies and problems, such as the feeling of gradually crisis of identity or belonging to nowhere, "sense of unbelonging", emerge.

In our age, urban settlements experience a rapid change process and they lose their original identities gradually. Especially as an indication of globalization to cities, city management conceptions in different geographical and economic parts of the earth, consumption tendencies of urban environments and citizens resemble each other gradually. And this will cause disappeareance of original urban (or local) identity.

In this sense; Yozgat, selected as field of study, intensely experiences this disidentification process. With determination of experienced change on the city from 20th century to present, attention was drawn on this great loss in cultural heritage. With the study performed, we tried to emphasize the necessity of transmitting historical fabric to new generations with new planning decisions and applications rather than creating imitated images in new construction areas.

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A SURVEY ON CONSTRUCTION TECHNOLOGY IN TRADITIONAL BATHS OF IRAN (CASE STUDY: ESFAHLAN BATH OF OSKU - TABRIZ)

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ABSTRACT

Architectural typology of different areas shows that many factors such as natural, cultural, social, and economical factors have been introduced on behalf of the residents as effective factors in the formation of traditional architecture. Although, environmental conditions had the most effect on the form and structure of traditional buildings, but for constructing Iranian baths, trying to keep the warmth and moisture generated inside the bath is the most important and effective factor on the form and structure of Iranian traditional baths. It was experienced that putting the building floor a few meters above the ground surface, constructing thick walls, and also inside architecture of this traditional building all show efforts to maintain the warmth and moisture inside the building. Classic spaces of Iranian bath and architectural pattern of it were constant in all these conditions, but on the other hand, different limitations such as area, land position, and usage of different architectural and decorative elements has caused dissimilarity of any two baths.

Within the present paper, in order to investigate the construction of these buildings (i.e. Esfahlan baths of Osku), historical baths registered by the Cultural Heritage Organization of Tabriz were studied as statistical population by the use of knowledge of experience or use of a new technology. Also the study benefited from analytical survey method with a toolbar containing figures, tables, and maps.

The results obtained from the research shows that traditional architecture of baths, considering the sample study, has unique properties which alongside with paying attention to proper designing and using local-coordinated materials could also response to environmental issues without having a primary basic technology but on the base of the residents' experiences and observations of the area. It would be possible to carry out more research in contemporary projects considering the findings of the present study.

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Key words: Climate, Architecture, Construction Technology, Esfahlan Bath

1. INTRODUCTION

Architecture of bathroom like other old buildings follows specified spatial patterns such as access to water, maintain separate, clean and dirty areas. The original three conditions were used for the created complex and different spatial with other building in Building bath.
With regard to the limitations like area, land limit, decorative elements, architecture and various forms of spaces have caused changes in the historical bathroom but there is no bath exactly similar to the other one. Studies show that even beside the mentioned factors, special principles at the stages of design and later in construction of baths in each area has been considered as determing factors for the residents. These principles are the result of factors such as climate, natural environmental conditions as well as maintaining the principles and general pattern of architecture in baths specially in the type and arrangement of the location.

2. ARCHITECTURE OF BATHHOUSE

Bathhouses were one of the most important buildings of a city. They were usually located at the center of towns or near the bazars and main roads. From the pre-Islamic era the remainders of private bathrooms were discovered in Persepolis (Achaemenian era) and Assyrian Palace (Parthian era). But the development of the traditional bathhouses, that were used until the time before the modern urban piping emerge dates back to the Islamic era. Since bathing includes several steps, therefore Iranian traditional bathhouses had spaces with different functions. In this respect the spaces in a bathhouse can be divided into three parts:
1-semi hot and semi humid
2- hot and humid
3-very hot and very humid (Ghobadian, 2006).
The controlling system of the bathhouse was in a way that the heat and moisture enter from the Entrance vestibule and changing room (semi hot and semi humid) to the hall and bathhouse (hot and humid) and finally would reach to its maximum level in Khazineh (very hot and humid). Therefore these spaces were independent and they were only connected through indirect tunnels or vestibules.

2.1. Architecture of the inner spaces of bathhouses

Investigations of the section of old bathhouses show that the ceiling of these places were high and were caped by a dome (Kolombe, Tarkin, Karbandi, and Araghchin). Changing room dome the main dome of the bathhouse was in the main hall of the bathhouse. And the smaller domes belonged to the other spaces. Although the dome cover is one of the characteristics of Iranian architecture in terms of the structure of models for ceilings and openings, the height and dome-like ceilings were used for other reasons that originated from the functios of such buildings.
The skylight service, generally, was provided through the ceiling and with the help of an element called “Jamkhaneh” that was from glass, and a material called

"moine" (a combination of washed wool, oil, and clay) were used for sticking the glass and the clay. In addition to these items, we should mention that the circuitous tunnels prevented the outside air and dust into the bathhouse.

3. THE EFFECTIVE FACTORS IN PROVIDING GOOD CONDITIONS FOR BATHING

The main function of bathhouses can be put forward in bathing, and in order to accommodate a good condition for bathing, four factors are necessary. For a detailed study these factors have been mentioned as follows: a. Headings of Main and sub-sections should be numbered, b. The headings of main sections should be written in capital letter, c. For the headings of sub-section, only the first letter of word should be written in capital letter as illustrated in the examples (all the headings should be in bold), and d. Lines of space between sections should be as in the examples.

3.1. Temperature

One of the most important factors and perhaps the main one is temperature. Providing the temperature in the bathhouse was not possible directly. It was due to the reason that in the past the artificial heat was generally created by burning organic materials, the smoke and Carbon dioxide which prevented respiration and other human activities inside the enclosed area of the bathhouse (Kiani, 2011) . Therefore, the required temperature was obtained outside of the bathhouse and by burning the organic materials in the fireplace under the caldron of Khazine, and it would heat the water of Khazine. The smoke and the heat of fire would also be transferred under the ground of the bathhouse (Memarian, 2008). The fireplace room (Patoon) had a way to the public path that was the way by which fuel would enter the bathhouse. The heat and smoke of the fireplace go to through underground tunnels (Gorbero) that are narrow paths. These Gorberos would cross under the floor of bathhouses and bring the heat to the atmosphere of the bathhouse. The Gorberos were covered with marbles and other similar stones. These stones would both provide the heat transfer and were durable and easy to be cleaned (Ghobadian, 2006).

3.2. Water and Moisture

Water and Moisture are at the next level of our classification. The required water were obtained from the creeks, aqueducts, and wells. In the proximity of those bathhouses that were supplied by the well water, a well would be created and some men or bullocks would take out the water. The water would then enter a pool and by some ceramic pipes called "Tanbooshe" would enter the bathhouse Khazineh. In the proximity of Garmkhane in some of the bigger and better bathhouses there was a pool called "Chaharhoze". Their water were not usually warm and they were used for swimming in the summer, however some of these Chaharhozes had Tian that was used to heat the water. Except for the Chaharhozes, there were also other small pools that people washed themselves up beside them.

There was usually a big pool at the center of the changing room that in addition to beauty would help to moisturize the atmosphere. The paths to the main spaces of bathhouse were indirect and restricted, therefore the excessive moisture of the humid areas would not be entered to the semi-humid sections. The body of the clients, when entering the bathhouse, would gradually feel the water or the temperature and at the time of leaving, too, the temperature and moisture would be reduced gradually (Ghobadian, 2006).

3.3. Light

Light can be regarded as one of the influencing factors in baths construction. The residents' experiences made them benefit from such a factor as well as others, too.
The ceiling provided the Light of bathroom spaces, usually placed at the center of roofs which provided baths space with harmony, and brighter shade which in turn creates a bright beautiful environment. Pool of water under the skylights on the front adds lighting.

Figure 1. Ganjali Khan bathroom, Kerman, Iran (Memarian, 2008)

Since a major part of the lateral surfaces of most bathrooms are located under the ground therefore the sunlight would go into the bathhouse through the skylights and the windows under the vault. In order to meet the necessities, convex glasses called "Goljam" were installed at the top of the dome, and its surrounding was sealed with Sarooj or Mumine mortar. In cases of lacking adequate light, handheld lights would be used (Ghobadian, 2006).

Figure 2. Windows beneath the dome in the Ganjali Khan bathroom, Kerman, Iran (Memarian, 2008)

3.4. Ventilation

Bringing up the good conditions for bathing, in addition to controlling the temperature, moisture and light, requires a regulation of ventilation system. Bathing of many people at the same time as well as the moisture and heaviness of the bathhouse air, utilization of lights which produces smoke and carbon dioxide and the restricted area of the bathhouses requires a controlled ventilation, otherwise it may lead to Asthma or even suffocation. Therefore, the windows under the vault should be opened to avoid any respiratory problems (Ghobadian, 2006).
Then, these factors (on behalf of architects or the habitants) appeared as the permanent principles or to be more clear technologies used there after for construction of baths.

4. THE ARCHITECTURE OF THE TRADITIONAL BATHHOUSES OF TABRIZ

The traditional bathhouses of Tabriz have the same classic atmosphere of Iranian bathhouses, with the same hierarchy of the architectural patterns. If we want to be more specific about the architecture of the traditional bathhouses of Tabriz we should start from the effects of environmental conditions of this region on the main pattern of the bathhouses. As the researchers noticed, one of the features of this region is the existence of many aqueducts in this city in the direction of south to north and major proportion of the drinking water of the city provided through them. Therefore, it can be definitely stated that most of the water supply of bathhouses were provided by the aqueducts. On the other hand, Tabriz is located in a cold climate, therefore to avoid the energy exchange with the outside air and the accessibility to the aqueducts, most of the bathhouses of Tabriz (like most Iranian cities) were built in the ground.

5. ANALYSIS AND COMPARISON OF ARCHITECTURE PLANS OF THE TRADITIONAL BATHHOUSES OF TABRIZ WITH OTHER CITIES

The most important pattern used in the Changing rooms of the Iranian Bathhouses is the pattern of porch, that is octagonal plan or Eight and a Half Eight plans. Figure 3 shows the octagonal plan or Eight and a Half Eight plans of the changing room of the traditional bathhouses of Iran (Rashid Najafi, 2009).

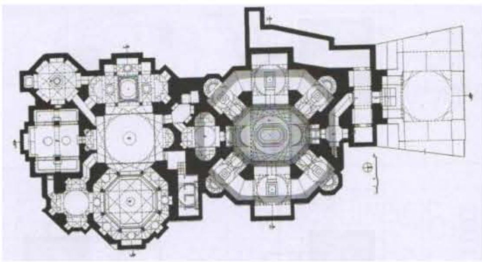


Figure 3. Nowbar Traditional Bath in Tabriz
(Rashid Najafi, 2009)

Analysis of the plans of some of the (available) historical bathhouses of Tabriz introduces two other types in addition to the typical types which are shown in figures 4 and 5 in the plan of Nowbar bath.

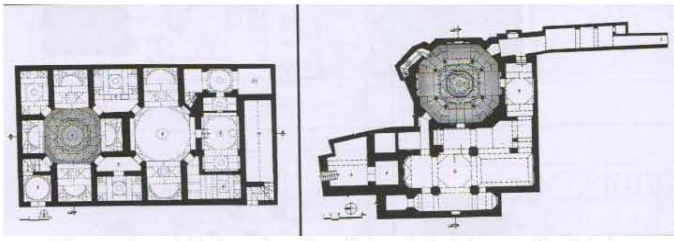
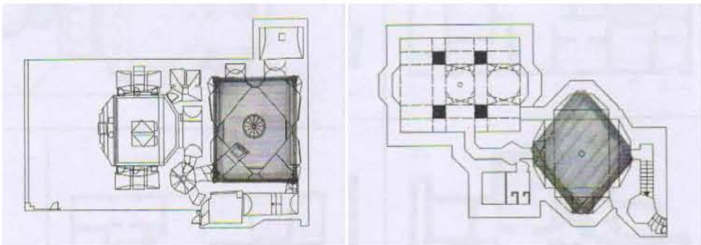


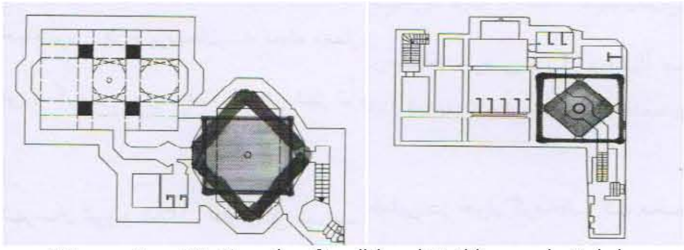
Figure 4 and 5. Sample of traditional Bathhouses in Tabriz (Rashid Najafi, 2009)

Figures 6 and 7 shows these two types of plans. Both of them are changing room plans contrary to the typical plans of changing room which are octagonal, they are in forms of squares or rectangular. This is one of the noticeable features of the architecture of Tabriz bathhouses i.e. using square-like plans to make changing room.



Figures 6 and 7. Sample of traditional Bathhouses in Tabriz (Rashid Najafi, 2009)

In the octagonal plan, four verandas were usually placed on the four main sides that one of them was bigger and decorated with feather that was called "Shahneshin" meaning the place that Shah or the king would sit. The other sides were used for the connections. But in the square-like plans of Tabriz changing rooms, two were used for connections and two were used for the verandas that one of them would naturally be used as Shahneshin. The interesting point is the application of half octagons in sides and verandas that would make it possible for the corridors to turn. This led to the point that four half octagons be combined with a square and create a new square, and therefore in some of the plans of Tabriz bathhouse, the form of changing room is in the form of two squares that are embedded in each other and made a 45 degree angle i.e. two squares that are turned inside. As depicted in figures 8 and 9.
As it is illusterated the changes are based on the newer experiences of habitants and improved according to the use knowledge of previous designs and/or construction experiences.

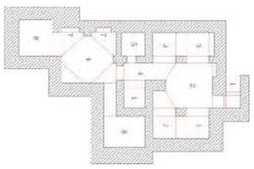
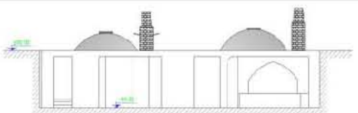
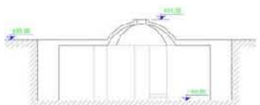
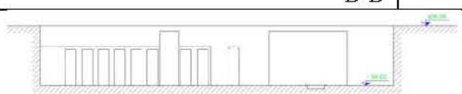
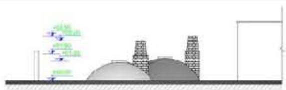


Figures 8 and 9. Sample of traditional Bathhouses in Tabriz
(Rashid Najafi, 2009)

6. INTRODUCING ESFAHLAN BATHHOUSE

The 400-year-old Esfahfan bathhouse is one of the monuments of Osku province (near Tabriz). This place was built by the people of village that were called "ill". It survived during Arabs attacks and even passed the Sasanian dynasty. Esfahlan was originally the Arabic form of "Sepahlan", a village in this region that was a military base even before Islam. According to the previous evidences, this region was geographically and strategically important as well as military perspectives. There were reasons that paved the way for the construction of bathhouses. Reasons like time and geographical requisites, policies of the kings, the traditional culture of the people, the need for building bathhouse, religious and generous people were the driving factor in the construction of bathhouses in Esfahlan.

Table 1. Information about Esfahlan Bath

 Old Plan	 New Plan	Plan
 B-B	 C-C	Section
 A-A		Section
 South	 East	Elevation

			Pictures
			

Table 2. The additions or deletions of Esfahlan building

	date
It had two water reservoirs (Khazineh) of hot and cold water that its water was provided by the aqueduct that was under the bathhouse.	1961
These two Khazinehs turned into 8 private bathrooms that their water was supplied to the showers by pumping.	1963
The bathhouse was accommodated with electricity.	1971
The bathhouse was facilitated with an equipped water piping system.	1988

This building undergone many damages during the years. Since there were not exact information about all of them we just mention the last ones:

Table 3. The damages happened on Esfahlan bathhouse

	date
Damages due to earthquake	1856
Severe damages due to the flood	1928
It was closed by sanitation office because of its insanitary khazinehs	1961
With the help of people, khazinehs turned into private bathrooms and got the authorization back from the sanitation office.	1963
It was damaged again due to the flood	1971
With the help of people, it was repaired and accommodated with electricity.	1979
Due to having private bathrooms in houses, people did not use the bathhouse anymore. It was while the bathhouse was equipped with pipe water.	1988
This bathhouse was not used from this year up to the present time.	1991

7. ARCHITECTURE SYSTEM IN THE ESFAHLAN BATHHOUSE

Architecture system of this building like other buildings of regions is based on the traditional architectures which has a special condition in terms of the location. In cold regions, the buildings would be built under the ground as much as possible to keep the temperature and heat (Kasmaei, 2006). Due to the cold climate of Tabriz and even the prolonged winters, hot bathhouses were very pleasant for people in terms of social and environmental aspects. Therefore, architects would try to make a pleasant place. Since the bathhouse required enough hot water and the water should be supplied by the aqueducts or springs, therefore, in order to direct the water into the bathhouse storage it should be built under the ground. The deeper the storage is the deeper the bathhouse would be built.

The researchers went to Esfahlan and completed their information by asking for extra detail from the oldest residents of the location.

According to the habitants, the most important issue in the architecture and construction of this building is the utilization of things that nature easily provides like different kinds of stones, sands, plasters, etc to make mortar. Rubble stones were available in the river beds. They would be carried to the construction site with the lowest possible expenses and they were used according to their size. They would use the medium-sized stone for the foundation of the building. They would also use the bigger stones for the wall of the building to be able to bear the weight of the domes of the bathhouse. Their width would sometimes surpass one meter.

Mortar or Sarooj in this region and regions around Tabriz is a mixture of lime, gypsum, ash, sand and sometimes the pure clay. This mixture, based on the need of the building, and according to the preferences of the architect would be kept in liquid mortar so as the material could be completely mixed with Sarooj and turns into sticky mixture to be used in the foundation or walls of the building. Then, they would become stiff enough to be durable for years (the ash would also be obtained from village furnaces that had an important role in the Sarooj mixture).

In general, the mortar used in bathhouses were durable and the dome of most bathhouses were dome-like vaults. However, at the beginning, since wood was more available than Sarooj or the access to bricks was limited, they might use wooden rods or thatch to cover the roof as it was easier and economic.

Figure 10. Materials used in the roof of the bathroom Esfhlan

Although the inner space of the bathhouse was independent from the outside environment, in small regions the inner space of the bathhouse had different functions, therefore adjustment of the temperature, moisture, light and ventilation in each of the spaces were highly important. Therefore, designing and running the operation of buildings required special environmental techniques to have a stable

and adequate condition for bathing in all the spaces of the bathhouse and in all the seasons of the year and in the twenty four hours of the day (Kasmaei, 2006).
According to the surveys and the supplied information by residents, direct (natural) heat accommodation was not possible and as the artificial heat would be obtained from burning the organic material, respiration and other activities would be impossible. Therefore the required heat would be supplied from outside of the bathhouse and by burning the organic materials in Toon (fireplace) that was under the caldron of Khazineh. It would heat the water, and the transfer of smoke and heat would take place under the bathhouse. This bathhouse has common features with other urban or rural constructions including the way of creating heat for the Khazineh. All the bathhouses had one fireplace (Patoon) (in Turkish Azari "tolambaz"-Toon Anbar) that had connections to the public path that through which the fuel would be transferred to the bathhouse. The fuel were usually the dung of animals (yaba and karme) and woods and leafs of trees that was used with Toon Tabi (Toolambarchi) to keep the bathhouse warm. The temperature and the smoke of fuel burning would be directed to the chimneys through underground tunnels called "Gorbehro" (Pishikpooli). They directed these Gorberos in a way that it both heat the floor of the bathhouse and also disperse the heat in the atmosphere of the bathhouse especially Garmkhaneh.
Since the Gorbehros were exposed to smoke, they would set their dimensions in a way that someone would be able to go inside and clean or take after it. They would cover the Gorbehros under the floor of the bathhouse with a delicate smooth stone (Sal Dash. These stones not only could help to exchange the heat between Gorbehros and the inner space of the bathhouse but also was very good in terms of durability and the washability of its surface.
One of the necessary measures to reduce the heat exchange between the outside and inside of the bathhouse was to place the bathhouse in the ground in a way that the bathhouse was often some meters below the surface of public path. Therefore, the soil around the walls would act like a heat insulator and would reduce the heat exchange between inside and outside of the bathhouse. Moreover, the thick walls of the bathhouse in addition to the nearby soil act as a thermal capacitance in conversion of the temperature fluctuation inside the building.
One of the other advantages of these measures is the fortification of the building against earthquake and also directing the aqueduct or spring water into streamlets and leading them to the bathhouse. The sanitary precautions were also important in Esfahlan bathhouse like in any other populated areas. There are some discoveries that show the interesting equipment and facilities that were used in bathhouses. The river or spring water was directed to the Khazineh through ceramic pipes (Tanbooshe) or Gong in Turkish Azari language, if they wanted to change the water they would first empty the Khazineh and after cleaning they would lead the water, through the ceramic pipes, first in the pool to make sure that it is clean and then to the Khazineh. Changing the water was dependent to the owner of the bathhouse as well as bathhouse quality, however, it was usually changed once in a week but sometimes it might even happen once in several weeks.

8. CONCLUSION

In the present study, the building under study is a public one and many factors were involved in its creation and disintegration. According to the information the residents and architects provided the researchers with, and later through the detailed study and analysis of the associated factors, with concentration on this building, the researchers came to the point that most of these factors were related to the weather and the climate and architects awareness was highly important in this respect. The climatic condition and the expertise of the architects were the main factors that led to building be durable in ages. A building that was providing 24/7 service to the public and yet was surrounded by humidity, cold or hot weather and various kinds of bacteria were the main reasons of the deterioration in a building. Here by observing the elements of space and the skills of architects in terms of resisting and minimizing the erosive factors we can see how they have exploited the so-called erosive factors into the advantage of the stability of the building. For instance, the thick buildings that can be the fortification factor against the earthquake. Besides, at the proximity of the building there was intact soil that not only help the building to resist against the earthquake but it keeps the heat in the winter and in summer prevents the outside heat to enter the building. We also see that the ceiling of the traditional bathhouses was made in forms of domes in different sizes for different functions. It can be assumed that the smaller domes with lower heights were used for ventilation in a way that reduce the energy loss of the building and the bigger domes with higher height were used to have the best ventilation and skylight service and create clean atmosphere in the building. All of these create a balance in the temperature fluctuation of the building. The most important stability factor can be the application of the mortars that in all the traditional bathhouses utilization of lime was common. Building materials that if remain in an adequate condition can lead to higher stability of the building. These factors hand in hand with the expertise of experience architects of this country were the stability criteria of our traditional buildings, like bathhouses.

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RE-CREATING LOCAL BUILDING TECHNOLOGY AS A WAY FOR CONSERVING INTANGIBLE CULTURAL HERITAGE

ÖZLEM KARAKUL[1]

ABSTRACT

Historic built environments have been produced by the dominant activity of local builders. Traditional building technology is the product of the builder's knowledge and creativity in using local building materials, handling environmental features and the needs of local people. The experience and the knowledge of local builders, expressed itself in the building technology, have been transmitted from generation to generation in a master-apprentice relationship, guaranteeing the transmission process of cultural expressions in the local building tradition for centuries. This tradition has also provided identity, continuity and harmony in the architectural language of environments. Today, together with the interruption in using local building ways, various conservation problems related to the sustainability of building culture have emerged in traditional fabrics. This study mainly discusses to re-create local building technologies both as a way for their documentation and conservation as intangible cultural heritage today.
Traditional craftsmanship embodied on the architecture of historic environments and the activity of local builders as the creators of local building technologies represents one aspect of the intangible heritage as identified in the UNESCO 2003 Convention. UNESCO Living Human Treasures System was designed for organizing the bearers of intangible heritage and transmitting their knowledge and skills to next generations. Critically explaining the national living human treasures systems of different countries, the study tries to conclude the appropriate principles for the conservation of the activity of local builders in the national living human treasures system of Turkey and to seek for organizing local builders and documenting their knowledge and providing their transmission for future generations.

Keywords: Traditional Craftsmanship, Local Building Technology, Master-Apprentice Relations, Transmission, Conservation

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1. INTRODUCTION

Local building technologies constitute a significant aspect of the identity of historic environments with its defining quality over architectural language. Besides being subject of conservation related to their effect over physical characteristics, they are also worth conserving as a part of "intangible cultural heritage", specifically as building practices and traditional craftsmanship, as pointed in the UNESCO 2003 Convention[2]. Local building technologies in traditional environments are completely the products of the master builder's knowledge and creativity in using local building materials and handling environmental features. In this regard, their conservation and continuation in modern building technologies is directly related to the sustainability of the activity of masters in historic environments, which has mainly based on master-apprentice relationships for centuries.
To understand and develop the ways for the conservation of local building technologies, the studies related to the safeguarding of intangible cultural heritage carried out by UNESCO can be investigated thoroughly. The UNESCO 2003 Convention defines "intangible cultural heritage" as "the practices, representations, expressions, knowledge, skills-as well as the instruments, objects, artifacts and cultural spaces associated therewith- that communities, groups and, in some cases, individuals recognize as part of their cultural heritage"[3]. One of the domains to be conserved, on which intangible heritage reflect, is traditional craftsmanship. The discussions on intangible cultural heritage, which started to define and make inventory nearly ten years ago, especially after the UNESCO 2003 Convention, have mainly focused on the measures of its conservation. While the conservation process of tangible heritage includes documentation, analysis and preservation measures, the conservation of intangible cultural heritage is intimately linked with its practice and its transmission for new generations[4], besides their documentation. With regard to the documentation and inventory of intangible cultural heritage, the UNESCO committee prepares specific lists of intangible cultural heritage in need of urgent safeguarding and the Representative List of the Intangible Cultural Heritage of Humanity[5]. The UNESCO Committee meets annually to evaluate nominations proposed by States Parties according to the 2003 Convention; and decide whether or not to inscribe those cultural practices and expressions as intangible heritage on the Convention's Lists. To provide the appropriate conditions of "transmission" pointed as one of the safeguarding measures of intangible heritage, in Article 2 in the

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[2] *Convention for the Safeguarding of the Intangible Cultural Heritage*. 32nd Session of the General Conference. September 29- October 17. Paris. Retrieved December 23, 2004, from http://unesdoc.unesco.org/images/0013/001325/132540e.pdf)
[3] See Article 2 in the UNESCO 2003 Convention.
[4] On the UNESCO website, "safeguarding" of intangible cultural heritage is explained in four titles as "involvement of communities, inventorying intangible heritage, transmission, legislation". (See http://www.unesco.org/culture/ich/index.php?pg=00012).
[5] The Representative List of the Intangible Cultural Heritage of Humanity (see criteria) is made up of those intangible heritage practices and expressions help demonstrate the diversity of this heritage and raise awareness about its importance. The Committee incorporated 90 elements in 2008 (items formerly proclaimed Masterpieces) and inscribed 76 elements in 2009 and 47 elements in 2010. In 2011, 19 new elements have been added to the list.

Convention, UNESCO established "Living Human Treasures System"[6] for conserving craftsmanship, organizing craftsmen and transmitting their knowledge to new generations and encourages state countries to establish their national system. Collaterally evaluating intangible heritage lists and the national Living Human Treasures System of different countries, the dominancy of social practices and performing arts can clearly be seen in the lists in the worldwide over the examples of traditional craftsmanship expressed on different building cultures, which are only 6 from the 259 heritage items listed[7]. Unfortunately, in the inventories prepared in Turkey for several years, there is no traditional craftsmanship yet, in spite of the diversity of the vernacular architecture. Therefore, this study critically examines the "living human treasures system" prepared by UNESCO, especially, focusing on local building techniques and local builders throughout the world and in Turkey. It also makes certain proposals and the applicable measures for the development of this system in national contexts to revitalize local building technologies as a safeguarding measure of intangible heritage.

2. LOCAL BUILDING TECHNOLOGIES AND THE ACTIVITY OF MASTERS IN HISTORIC ENVIRONMENTS

Historic environments have been produced by the handling style of builders' of the local specifics, which are created by the mutual interrelations between environmental factors and cultural practices and expressions[8]. The diversity of local building cultures has been generated by the traditional knowledge and the skills of builders transmitted by the master-apprentice relationship from generation to generation. Besides the functional aspects of the activity of builders, like bringing building materials to construction sites, and after processing, putting into their place in the building, techniques and tools particular to this process (Bingöl, 2004; 22; Blagg, 1976; 154; Marchand, 2007; 182), there are also expressive aspects, like the reflection of the cultural values, values judgments and the worldview of builder and society and the individual diversities and creativities (Aran, 2000; 122) to be considered. In historic environments, cultural expressions observed in the buildings have been transmitted to the present time especially by the information flow between master craftsman and apprentice (*usta- çırak*). Hubka (1979, p.28) investigates the methods of study of folk builders in the production process of traditional buildings, which are carried exclusively in the mind of builders and continued by tradition- the handing down of information by word of mouth, observation, replication and apprenticeship. Certainly, the transmission of the knowledge of masters to their apprentices assures the continuation of the local building tradition.

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[6] See http://www.unesco.org/culture/ich/index.php?pg=00061&lg=EN
[7] See http://www.unesco.org/culture/ich/index.php?pg=00011
[8] The production and transformation processes of historic environments are deeply analyzed by Karakul (2011a), specifically focusing on tangible and intangible values.

Anatolia has a long building tradition, which has continued for many years and embodied on the variety of the traditional buildings in historic environments. Turkey's historic environments embody the variety of local building materials and cultural expressions on their physical characteristics. Especially the excessive use of stone and timber, besides other local building materials, like, mud-brick, brick, tiles, has created the various building types with the labor of master builders specialized especially on stone and timber craftsmanship. The skilled use of local building materials by master builders has created various masterpieces of architecture, as observed both in a monumental scale, like in Divriği Great Mosque; and in a vernacular scale, like in Ürgüp, Mardin, Ahlat.

Figure 1-2. The ornate portals of Divriği Great Mosque

Unfortunately, because the conservation and inventory studies in historic environments in Turkey are tangible-led and have generally carried out by the physical concerns, the local building practices and cultural expressions hidden in the physical have been overlooked or ignored completely. But, an accurate conservation approach needs to guarantee the viability of the practice of local building technologies and traditions besides the physical entity of the buildings.

Figure 3-4-5. Stone carved ornaments on the facades of vernacular buildings in İbrahimpaşa, Ürgüp

3. "LIVING HUMAN TREASURES SYSTEM" AS A CONSERVATION APPROACH FOR TRADITIONAL CRAFTSMANSHIPS

3.1 UNESCO's Living Human Treasures System

On the UNESCO's official website, the decline in the numbers of the practitioners of traditional craftsmanship is recognized as one of the biggest threats to the viability of intangible cultural heritage[9]. In this regard, Article 2.3 of the 2003 Convention for the Safeguarding of the Intangible Cultural Heritage places "transmission" among the safeguarding measures aiming at ensuring the viability of this heritage. Because the conservation of intangible cultural heritage necessitates the continuous practice and the transmission of the knowledge to next generations, living practitioners need to be identified and the appropriate ways for practicing need to be provided. Therefore, "Living Human Treasures System" was established by UNESCO for facilitating the transmission of knowledge and skills of talented tradition bearers and practitioners to new generations in international and national contexts. Within this system, masters possessing high degree knowledge and skills have been selected as a testimony to living cultural traditions and to the creative genius of communities (Karakul, 2011b).

After drawing up the general rules of this system, UNESCO also encourages States to establish the national systems of "Living Human Treasures" and formulates the specific "guidelines for the establishment of national Living Human Treasures System"[10] to be followed by States. Within these guidelines, a preliminary measure for safeguarding the intangible cultural heritage is to ensure its identification by drawing up national inventories[11]. But, after this identification stage, it is significant to guarantee that the bearers of heritage, like master craftsmen, develop their knowledge and skills and transmit them to younger generations. In national contexts, these measures necessitate finding and organizing living builders, some of whom

[9] http://www.unesco.org/culture/ich/?pg=00061
[10] www.unesco.org/culture/doc/src/00031-EN.pdf
[11] See Article 12 in the UNESCO 2003 Convention

will be given official recognition, creating appropriate conditions and institutions for practicing master-apprentice relationships and documenting their knowledge and integrating these practices and documentation into the conservation practices.
UNESCO Living Human Treasures programme aims at encouraging Member States to grant official recognition to talented tradition bearers and practitioners, thus contributing to the transmission of their knowledge and skills to the younger generations[12]. The different systems of countries put forward the different organizing methods, which are developed through a re-synthesis of UNESCO's Living Human Treasures systems within the specifics of their local contexts. For instance, the France's Living Human Treasures system[13] brings about certain criteria for the selection of "masters of art" with regard to the period of practice, possessing a rare or exceptional know-how, demonstrating excellence; acceptance to transmit this rare know-how to an apprentice. Once selected, the "Master of Art starts to transmit his know-how to an apprentice in the Master's workshop over a period of three years. This transmission system is mainly based on two agreements: one between the Master of Art and the Ministry of Culture and Communication which provides a yearly allocation, the amount of which is fixed by the Minister; and another one between the Master of Art and the apprentice. In Republic of Korea, the term "holders of important intangible cultural properties" is defined within the cultural properties protection act to express the "Living Human Treasures"; and their selection process is explained in certain steps composed of "application for designation, investigation for designation, examination for the designation, notice for designation, deliberation for designation and announcement of the designation"[14]. Besides the steps for the designation, rights and obligations of the holders and safeguarding activities are also comprehensively explained to be evaluated as example by forming national human treasures systems. Republic of Korea explains safeguarding activities for the designated Intangible Cultural Properties in three parts: "education, support to performances and exhibitions and documentation activities". All these conservation measures recognized in the studies of France and Republic of Korea need to be critically evaluated within the local specifics of the countries during the preparation of national living human treasures systems.

3.2 Turkey's National Living Human Treasures Systems

In Turkey, the awareness for the conservation of intangible cultural heritage, which has developed with the studies of UNESCO; and directed towards the holistic

[12] On the website of UNESCO, it is stated that the establishment of a national Living Human Treasures system may also involve: adopting legal or regulatory provisions; identifying and including in one or more inventories the selected ICH elements as well as the names of their bearers; creating a commission of experts responsible for selecting candidates and for monitoring the implementation of the system, especially with regard to the transmission of knowledge and skills. See: http://www.unesco.org/culture/ich/index.php?pg=00061
[13] http://www.unesco.org/culture/ich/?cp=FR&lg=en&pg=00311&topic=lht
[14] http://www.unesco.org/culture/ich/?cp=KR&lg=en&pg=00311&topic=lht

conservatory framework of tangible and intangible values recently[15], has not been accurately reflected to the national legal instruments yet. Although Turkey ratified the 2003 Convention for the Safeguarding of Intangible Cultural Heritage in 2006[16], the national legal instruments in the area of conservation have not been still regulated according to it yet. In contrast, there are no implications of intangible cultural heritage in the definitions in the legal documents in the area of conservation. The conservation of intangible cultural heritage is carried out separately from tangible heritage with the limited inventory studies with a point of view of folklore by the Ministry of Culture.

By ratifying the UNESCO 2003 Convention Turkey has undertaken the mission for compiling and updating a national inventory of intangible cultural heritage. In this regard, the Ministry of Culture and Tourism started to do the studies on National Inventory of Living Human Treasures in 2008. The studies on the national conservation system of intangible cultural heritage in Turkey are basically carried out in two areas: the studies on the national inventory of the intangible cultural heritage of Turkey and the national living human treasures systems. The criteria used for forming national inventory of intangible cultural heritage are the value as the evidence of human creativity, being rooted in cultural and social traditions, the representation quality of the determined society or group and the risk of disappearance[17]. In Turkey, the nationalizing process of this system, the common studies of Ministry of Culture and Turkish National Commission for UNESCO are continued to document and make inventory of Turkey's intangible cultural heritage and finding living craftsmen and bearers of intangible heritage. For the Turkey's national inventory of intangible cultural heritage, the data coming from the different cities are evaluated within the regional meetings carried out the research and education directory of Ministry of Culture; and, then, specific files are prepared to be presented for the Representative List of Intangible Cultural Heritage of Humanity and List of Intangible Cultural Heritage in Need of Urgent Safeguarding of UNESCO. Until today, from Turkey, The Arts of the Meddah, Public storytellers, The Mevlevi Sema Ceremony in 2008; Aşıklık Tradition, Karagöz and Nevruz in 2009; Kırkpınar oil wrestling festival, Semah, Alevi-Bektaşi ritual, Traditional Sohbet meetings in 2010 and Ceremonial Keşkek tradition in 2011 have been listed in the Representative List of Intangible Cultural Heritage of Humanity prepared by UNESCO[18]. To be in the lists, for the elements of intangible cultural heritage,

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[15] Holistic conservatory framework which is the main aim of this study, has started to be discussed in certain publications and scientific meetings recently. (BOUCHENAKI, M., 2003, "The Interdependency of the Tangible and Intangible Cultural Heritage" (Paper at ICOMOS 14th General Assembly and Scientific Symposium, Victoria Falls, Zimbabwe, http://www.international.icomos.org/victoriafalls2003/papers.htm), (Isar, Y.R., 2004, "Tangible" and "Intangible" Heritage: Are they really Castor and Pollux?", INTACH Vision 2020, New Delhi, November 2-4, 2004)

[16] http://www.unesco.org.tr/kultur.php?gitid=1 (accessed in 17.12.2009) Law numbered 5448 about the approval of the UNESCO convention 2003 was published in 21.1.2006 in Resmi Gazete (http://www.resmi-gazete.org/sayi/7599/5448-somut-olmayan-kulturel-mirasin-korunmasi-sozlesmesinin-onaylanmasinin-uygun-bulunduguna-dair-kanun.html)

[17] See the web site of Ministry of Culture. (http://www.kultur.gov.tr)

[18] See http://www.unesco.org/culture/ich/index.php?pg=00011

provide better visibility and awareness of their significance. Since the time on which UNESCO Living Human Treasures System started to be implemented in Turkey, until today, in this system, the selected masters are generally related to crafts and musicians and the performers of shadow puppetry[19]. Within these studies, an important lack is related to the representatives and enactors of building culture. Actually, evaluating international developments and national studies, it is concluded that master craftsmen in building culture need to have a significant role in national living human treasures system because of the diversity and richness of local building techniques in Turkey. In Turkey, there are limited numbers of the building masters, who have information fully on the local building techniques and possess skills. Unfortunately, they could not find the appropriate working ground for the transmission of their information to the new generations. Thereby, cultural expressions embodied by these masters in the traditional buildings by builders are forgotten in time in the collective memory.

4. CONCLUSION: IMPLEMENTATION OF LIVING HUMAN TREASURES SYSTEM TO CONSERVE THE DIVERSITY OF LOCAL BUILDING TECHNOLOGIES

Historic environments have a particular and genuine identity identified by the integrity of the physical and cultural values. Besides local building materials and environmental characteristics as a part of physical features, local building ways and the techniques of masters, defined culturally, have significant roles to be considered for the maintenance of this identity of historic environments in conservation studies. In this respect, besides the prevailing conservation approach to buildings and tangible features, the activities of local builders, local building technologies and cultural expressions concretized on the traditional buildings need to be given essential priority as intangible cultural heritage in conservation studies and restorations.

Conservation needs to transmit the diversity of local building cultures to the next generations. Therefore, certain safeguarding measures for conserving local building ways and local builders need to be integrated in conservation studies. To explain the conservation measures regarding local building technologies, this study critically investigates the UNESCO Living Human Treasures System, the national living human treasures systems of different countries and Turkey; and recognizes their lack of master craftsmanship in building culture. The critical evaluation of these systems especially highlights their deficiencies in conserving local building technologies, mainly related to the documentation and transmission of the knowledge of master builders, the awareness rising of the subject, educative measures, the organization and participation of master builders in conservation practices. To overcome such kind of deficiencies regarding building culture in Turkey's national living human treasures system, several implementations of the internationally accepted conservation approaches to conserve local building technologies need to be

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[19] See the web site of Ministry of Culture. (http://www.kultur.gov.tr)

developed. Firstly, the holistic documentation approaches considering cultural expressions of builders and their reflections embodied on architectural features need to be integrated in conservation studies. Besides this holistic documentation approach, the awareness rising about local building technologies in society is significant for introducing the subject and forming the conservation consciousness regarding it; is developed by using the written and visual media and by arranging specific meetings and conferences. The educational and training programmes are significant for the transmission of the knowledge of builders to new generations in an applied way and revitalize the master-apprentice relationship. Finally, the establishment of a national organization model for builders makes easy to exchange of knowledge and skills between masters, apprentices and new generations; and, also develops the intercommunication between conservation architects and local builders; and guarantees the active participation of the masters to building and conservation activities in historic environments.

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POSTER SESSIONS

16 November 2012 Friday, 17.15-18.00)

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Heat Transfer Coefficient Analysis For The Old House in the Walled City of Nicosia in Cyprus

PhD. Student Ghazaleh MOKHABERI
Structural and Technological Principles in Architecture Curriculum of Eastern Mediterranean University in Northern Cyprus

Res. Assist. Filiz ÇETİNKAYA KARAFAKI, Res.Assist. Çiğdem ÇETİNKAYA
Contributions of Residential Landscape Design to Eco-Houses

M.Sc. Parisa ALİASHGARİ KHBAZZİ, Sevda HASSAN NAZHAD DAMATİ, Prof. Dr. Murat Ertuğrul YAZGAN
Artificial Light in Interior Design and Its Effects on Plants Used

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The SACS System. A Geographic Information System for the Analysis of Structural and Technological Elements in the Healthcare

Res. Assist. Muhammed Ali ÖRNEK, Assoc. Prof. Dr. Gülşen AYTAÇ
MAGA : An Interactive Tool Purpose For Urban Furniture Design Process

Res. Assist. Dr. H. Derya ARSLAN, Prof. Dr. Kerim ÇINAR, Assoc. Prof. Dr. Pınar DİNÇ
A Lens Model Approach on Estimating Perceptions of Turkish Primary School Students and Architects on Ideal Primary Classroom Settings

HEAT TRANSFER COEFFICIENT ANALYSIS FOR THE OLD HOUSE IN THE WALLED CITY OF NICOSIA IN CYPRUS

YASEMİN MESDA

ABSTRACT

This study analyses and calculates the heat transfer coefficient values of the 134 years old historical building in the walled city of Nicosia. The walled city of Nicosia is located at the center of the Cyprus Island. It had been used as a capital city in the beginning of 600 A.D. The building is the typical example of the Traditional Turkish House and built by the traditional adobe materials and stones. The ceiling, external walls, roof and the windows of the building were analysed to estimate the heat transfer coefficient values of the house and to demonstrate the influence of the climate conditions of Cyprus on the physics of the building. The estimated U values of this old building are, 0,49 W/m^{2}K for the exterior adobe walls, 0,27 W/m^{2}K for the ceiling, 0,13 W/m^{2}K for the roof and 2,0 W/m^{2}K for the windows. The comparison of these values with the modern concrete building under the same climatic conditions demonstrate that the adobe building provides better inner environment for the house life and also decreases the energy costs for the thermal insulation.

Key words: The walled city of Nicosia, Traditional Turkish House, heat transfer coefficient, stone-adobe building, cultural heritage

1. INTRODUCTION

Cyprus is the third largest island in the Mediterranean Sea after Sicily and Sardinia. Many different civilizations were lived on the Cyprus Island both before and after Christ through the history. The history of Cyprus had been started in 10000 BC. Nicosia was begun to use as a capital city since 600 A.D. (Mesda, 2012). The city is surrounded by 8-10 meters high stone walls which were built during the Venetian period on the island between 1489 and 1571 and provided a safety location for both the citizens and the king of the island to live.
Today, Nicosia is the centre of the government as well as the main business city of the island. It is the only divided capital city in the world (after the demolition of the Berlin Wall) and this division is the most important feature of the city. The cultural

heritage of the old walled city of Nicosia is very rich due to the great number of architectures that left from the ancient civilizations.

The contemporary buildings which built by many modern techniques and the materials do not provide natural inner environment for house life. In particular, heating and cooling of houses by using the electrical machines (e.g. ventilator) effect this negatively. Comparison of the contemporary buildings with the ancient buildings reveal that usage of the traditional materials in the old buildings provide natural inner environment, in which requirements for heating or cooling of houses reduce respectively.

In this study Chamber of Cyprus Turkish Architects Office building was analyzed which was built during the Ottoman rule on the island. The building was examined to calculate the heat transfer coefficient values under the Mediterranean climate conditions. The result of the calculations of the heat transfer coefficients values of the adobe that the adobe buildings have many advantages in the places where Mediterranean Climate is dominant.

2. THE LOCATION AND HISTORY OF THE CHAMBER OF CYPRUS TURKISH ARCHITECTS OFFICE BUILDING

The building is located in the Arabahmet District in the walled city of northern Nicosia. The history of this district goes back to the Lusignan period. Arabahmet District was a buffer zone during the inter-communal conflict years between 1963 and 1974. For this reason, lots of buildings got damage during these clashes. This region is taken its' name by the commander Arabahmet Pasha who controlled the Ottoman army during their rules on the island.

The building was constructed at the end of the Ottoman Period on the island. It has about 134 years historical background. The plan, facade characteristics and the construction techniques of the building represent the Traditional Turkish House characteristics. This building was used as a house in the old periods. It is a two storey building and a corner building (Fig. 1).

Figure 1. The Chamber of Cyprus Turkish Architects Office building (Mesda, 2012)

3. ARCHITECTURAL CHARACTERISTICS OF THE BUILDING

3.1. Plan and Facade Characteristics

The plan characteristic of the building is typical Turkish house plan type. This house is a two storey building. In the original plan, the service spaces are located on the ground floor; the living spaces are located on the first floor. Today, the sofa, kitchen, library room and toilets are located on the ground floor; the second sofa and the library room, meeting room and the archive are located on the first floor. In total, this building has eight rooms. Four rooms are on the ground floor and four rooms are on the first floor. This building has two facades because other buildings are located on the north and east sides of the building. The main entrance facade is on the west side. The Ottoman style, arched entrance door is located on this facade. The facades are simple and human scale. There is no ornamentation on the facades. The windows are all same. They are double winged shuttered windows. Lattice windows are not used on the facades of this building. Cumba was constructed on the west entrance facade. The eave of the building has no decoration. Only the cut yellow stone materials were used to decorate the entrance door and the windows of the ground floor.

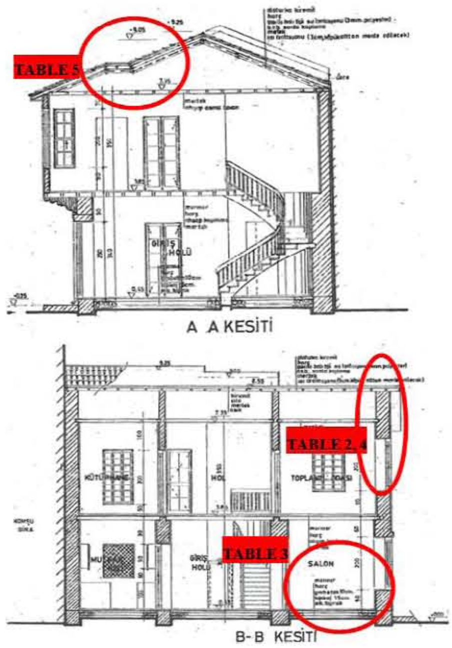

Figure 2. Sections of the building (Aktaç, 2008)

3.2. Construction Techniques and Materials

Adobe material was used for the construction of this building. This material is a traditional building material of the Cyprus Island, particularly, Mesaoria (Mesarya) region. It has environmental and ecological advantages, and also it is both sustainable and contemporary material. The adobe material has been used since the ancient times for the house constructions. Usage of the adobe building materials provide a good condition and comfortable living environment inside the houses. In addition, this material can be recycled. Beside the adobe material, the natural stones were also used in the construction of the building. The natural stones were used to build the walls of the ground floor. The first floor was constructed with the adobe material. Wall thicknesses vary between 15 to 65 cm. The walls were plastered with gypsum plaster materials. Gypsum was used to plaster both the inner and outer surfaces of the walls and it also serves as a filling material for the wooden lath. The ceiling was covered with a straw mat[8]. The detail of the roof can be seen in Figure 2. The wooden suspended ceiling roof was constructed during the restoration works. The tiles are aligned on the roof.

4. THEORETICAL FRAMEWORK AND METHODS

Table 1 indicates the estimated heat transfer coefficient values of roof, window, ceiling and walls of buildings for the four different regions of Turkey. Due to the close relationship of Northern Cyprus with the mainland Turkey and the same climatic conditions of Cyprus with the Mediterranean region of Turkey, the estimated values of TS 825 are applied in the Northern Cyprus as well.

Table 1. Recommended heat transfer coefficients (U values) for the different regions of Turkey (TS 825)

Recommended heat transfer coefficients (U values) for different regions TS 825				
	U_{wall} (W/m²K)	$U_{ceiling}$ (W/m²K)	U_{roof} (W/m²K)	U_{window} (W/m²K)
Region 1	0,80	0,50	0,80	2,8
Region 2	0,60	0,40	0,60	2,6
Region 3	0,50	0,30	0,45	2,6
Region 4	0,40	0,25	0,40	2,4
Alker structure in Cyprus(Işık&Çakır& Hacaloğlu)	0,45-0,50	0,32	0,43	2,2
$1/a_i$ m²W/K **$1/a_e$ m²W/K**	0,13 0,04	0,17 0	0,13 0,04	-

The heat transfer coefficient values of the roof, windows, external walls and the ceiling of the building were calculated in this study. Firstly, the thickness of all the materials that used in the construction of the roof, windows, ceiling and the walls were estimated. Then, the standard values of the each material were found from the TS 825's table and the thickness values of the house's materials were divided into these values and the results of this process were applied to the formula below (Yılmaz&Manioğlu).

$U_o = 1/(1/a_i+d_1/\lambda_1+d_2/\lambda_2+d_3/\lambda_3+\ldots+d_n/\lambda_n+1/_{ae})$

U_o: The overall heat transfer coefficient of the opaque component W/m²°C.

a_i, a_e: Internal and external surface heat transfer coefficients, W/m²°C.

$d_1, d_2, \ldots, d_n$: Thickness of the layers constituting the opaque component, m.

$\lambda_1, \lambda_2, \ldots, \lambda_n$: Thermal conductivities of the layers constituting the opaque component W/m²°C.

After these calculations the correlation of the house materials to the TS 825 values can be tested by using the table 1.

5. HEAT TRANSFER COEFFICIENT ANALYSIS OF THE OLD BUILDING ACCORDING TO THE ITS BUILDING PHYSICS CONDITIONS

Four different heat transfer coefficient values were calculated in this section. The estimated value for the exterior adobe walls is 0, 49 W/m^2K, for the ceiling is 0,27 W/m^2K, for the roof 0, 31 W/m^2K and for the windows is 2,0 W/m^2K. The calculation spaces can be seen in Figure 2. The result of these four calculations that are shown below demonstrate that the heat transfer coefficient values of the building comply with the Region 1 (Mediterranean Climate region) regulations of the TS 825 which is shown in table 1.

Table 2. Calculation of the heat transfer coefficient values for the south facade and the exterior wall

NO	Building Materials on the Exterior Wall	d (m)	λ (W/mK)	U_{Wall} (W/m²K)
1	Gypsum Plaster	0,04	0,35	$U_W=1/(1/a_i+ d_1/ \lambda_1+ d_2/ \lambda_2+ d_3/ \lambda_{3+1}/a_e)$ $=1/(0,13+0,04/0,35+0,65/0,40+0,04/0,35+0,04)$ $=1/2,02$ $=0,49$
2	Adobe	0,65	0,40	
3	Gypsum Plaster	0,04	0,35	

0,80 ≥0,49: It is suitable value for exterior wall.

Table 3. Calculation of the heat transfer coefficient values for the ceiling

NO	Building Materials on the Ceiling	d (m)	λ (W/mK)	$U_{Ceiling}$ (W/m²K)
1	Silt	0,15	2,1	$U_W=1/(1/a_i+ d_1/ \lambda_1+ d_2/ \lambda_2+ d_3/ \lambda_{3+} d_4/ \lambda_4+ d_5/ \lambda_5+1/a_e)$ $=1/(0,17+0,15/2,1+0,15/0,70+0,10/1,74+0,06/0,02+0,03/1,40+0,02/3,5+0)$ $=1/3,587$ $=0,27$
2	Pumice Gravel	0,15	0,70	
3	Concrete	0,10	1,74	
4	Glass Fiber Foam	0,06	0,04	
5	Mortar	0,03	1,40	
6	Marble	0,02	3,5	

0,50 ≥0,27: It is suitable value for the ceiling.

Table 4. Calculation of the heat transfer coefficient values for the roof

NO	Building Materials on the Roof	d (m)	λ (W/mK)	U_{Roof} (W/m²K)
1	Thermal Insulation Smooth Boards	0,05	0,02	$U_W=1/(1/a_i+ d_1/ \lambda_1+ d_2/ \lambda_2+ d_3/ \lambda_{3+} d_4/ \lambda_4+1/a_e)$

2	Thermal Resistance of Air Spaces 1/ λ	0,16 for 15 cm thickness of horizontal warm surface down		=/(0,13+0,05/0,02+0,16+0,05/0,13+ 0,02/1,40+0,04)=1/3,22 =0,31
3	Platen Pressed Chipboard	0,05	0,13	
4	Mortar	0,02	1,40	

0,80 ≥0,31: It is suitable value for roof.

Table 5. Calculation of the heat transfer coefficient values for the windows (TS 2164) [15]

NO	Building Materials on the Window	U_{Window} (W/m^{2}K)
1	Wooden Sash Double Glazed Windows with Low-E Coating (Air Gap=12 mm)	U_{Wi}= 2,0

2,8 ≥2,0: It is suitable value for window.

6. RESULTS

In this paper, the benefits of the adobe material usage in the constructions were emphasized, in which its advantages on many aspects were discussed. The calculations in this paper demonstrate that re-introduction of the adobe material in the construction sector will provide many benefits. Particularly, in the places where the Mediterranean Climate is dominant, the construction of the adobe buildings will reduce the energy cost (e.g electricity).

The usage of the adobe materials in this building is very significant for the heat transfer coefficient values. In particular, the thick adobe wall of the first floor has a big impact on the result. Because, it controls the heat transfer and provide the heat insulation for the house. Therefore, bio-climatic comfort are available in the building both in the summer and winter seasons without a need for the artificial heat insulation.

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STRUCTURAL AND TECHNOLOGICAL PRINCIPLES IN ARCHITECTURE CURRICULUM OF EASTERN MEDITERRANEAN UNIVERSITY IN NORTHERN CYPRUS

GHAZALEH MOKHABERI

ABSTRACT

Architecture pedagogy has various aspects and requirements. To achieve a successful architectural teaching system there is a need for giving sufficient attention to structural stability and technical issues of buildings from one hand and noticing aesthetical concerns of architecture from the other hand. Curricula of architecture schools play a critical role in this regard. The ability of integrating technical and structural aspects of building design into other design disciplines can be given to students by appropriate considerations within the architecture curricula. This survey indicates and highlights the necessary basic requirements of structural thoughts for every architecture curriculum and architecture curriculum of Eastern Mediterranean University (EMU) has been specifically focused; it sefficiency in terms of teaching of structural principles has been examined through some questionnaires and interviews. Accordingly, some comparisons with the existing literatures and also curricula of well-known universities from around the world have been done; consequently, some suggestions are made to increase the efficiency of EMU curriculum in terms of teaching of structural concepts. In fact, the research is a contribution towards updating the architecture curriculum of EMU according to the latest structural and technological requirement softhe contemporary architectural education.

Key Words: architectural education, curriculum, structure, construction

1. INTRODUCTION

Architectural design process is always in concern with two major aspects; from one hand architects are to solve aesthetical issues and on the other hand, they should deliver structural stability and technical requirements of design. To achieve a successful design project by no means these two aspects can be separated from each other, they require to be integrated and inspiring each other. From the point of view of contemporary architect Renzo Piano, separation between shape, function,

structure, technology, technical knowledge and science can be hardly distinguished; between art and science there can be no obstacle; they address the same language and require the same energy (Torpiano2009).
It is the responsibility of architectural education systems to train architects with the ability of integrating building structures with aesthetical and other design features. Thronberg (2006) emphasizes the role of architecture education on creation of the desired built environment. As he states, our built environment has not the qualities that we expect and education is a brilliant way of improving our thoughts for changes in the right direction.
Study and investigation of the existing curricula can be a helpful attitude toward sattaining the mentioned goals. Study of one curriculum and highlighting its specifications in relation to structural principles of design will lead us towards understanding the potential challenges of the current architectural education. Therefore, bachelor architecture curriculum of Eastern Mediterranean University (EMU) in northern Cyprus is considered as a case study in this research.
At first, viewpoints of students are evaluated by means of questionnaires and secondly, instructors' remarks are gained through some interviews. Finally, comparison of comments from EMU members with some curricula from some universities around the world and also some existing statements of literature about structural principles in architectural design is provided. The comparisons are done based on the quality and quantity of the taught structural principles of the discussed curricula. The final results of all of these investigations, evaluations and comparisons are the proposition of some requirements for the architecture curriculum of EMU to insure the implementation of necessary structural principles within the curriculum.

2. STRUCTURAL AND TECHNOLOGICAL PRINCIPLES WITHIN SOME CURRENT ARCHITECTURE CURRICULA ANDEXISTING LITERATURE

According to the existing documents and data, throughout history architectural design has been always dealing with structural design. Even architecture and structural engineering had been considered as the same profession until industrial revolution when the divide between the two professions initiated. From the ancient time Egyptian architect and mathematician Imhotep, who is known as the first engineer in history is supposed as the architect of the Step Pyramids of Djoser (Humbert2003). In Gothic architecture, structural form is used to create particular qualities in spaces and structural elements such as buttresses and rib vaulting express special aesthetic values (Torpiano 2009). In contemporary architecture formal arrangement of the buildings express some certain values and transfer the architects' arguments through spatial qualities. This kind of approach cannot be achieved without special attentions to structural concepts. Many landmark and remarkable buildings are created by considering building structure as dominant concepts and exposed elements; Santiago Calatrava is a contemporary architect who has designed many buildings by using this attitude (Ward2009). Hence, according to the existing

documents and data bases necessity of having the ability of integrating structural principles with building design concepts for architects seams explicit.
Moreover, the role of architecture education in this regard has been always attended. Salvadori (1967) emphasizes the necessity of structural knowledge for architectural students and considers it as an essential outline from early education stage. Because of the critical role of architecture education in teaching of structural concepts, arrangement of architecture curricula[1] and also minimum requirements for an architectural curriculum have been attended in this research.

2.1. Structural principles within architecture curricula of some universities in different parts of the world

Six universities from different parts of the world are chosen and their curricula have been attended here. Selection of the universities has been done in a way that the chosen universities have the best rankings in their countries, and even some of them have the highest rankings of the world (please refer to table 1).
The course arrangement of these curricula might not be applicable for EMU or even other universities; however, basic structural thoughts and essential technical issues of them can be inspiring and referable for updating the EMU architecture curriculum.

[1] As well as structural principles of architectural design, some other principles which are indirectly related to structural and technical issues of architecture and can help architects to convert their ideas into reality such as technological, constructional and practical issues of building design are considered in this curriculum survey.

Table 1. Structural principles within architecture curricula of 6 universities in different parts of the world.-Retrieved by referring to the official websites of the universities.

NAME	DEGREE	TECHNOLOGICAL & STRUCTURAL TOPICS IN VARIOUS YEARS
1 MIT (USA)	BACHELOR OF SCIENCE IN ARCH. DESIGN	5: 1 (colleague) : Chemistry, Physics, Calculus 4: 1&2 : building technology; 3&4 : focus on a specific branch ; such as Building Technology
2 HARVARD UNIVERSITY (USA)	MASTER OF ARCH.	5: 1 (colleague) : Calculus or higher-level mathematics + Physics 4: 1 : studio focus on building technology; 2 : studio focus on building structure; 3: elective courses in building technology; 4
3 JORDAN UNIVERSITY OF SCIENCE & TECHNOLOGY (JORDAN)	BACHELOR OF SCIENCE IN ARCH. ENGINEERING	prerequisite: math & physics in high school + 4 years : Math, Calculus, Physics, Structural & technological courses e.g. construction & material, structural analysis, professional practice, engineering mechanics, mechanical systems
4 SHAHID BEHESHTI UNIVERSITY (IRAN)	BACHELOR OF SCIENCE IN ARCH.	prerequisite: math & physics in high school + 4 years:Building material & services, site management, math, statics, strength of material, construction & regulations
5 UNIVERSITY OF CAMBRIDGE (UK)	BACHELOR OF ARCH.	4: 1 (colleague): Mathematics at A level 3: Principles of construction, structural design & professional practice
6 TECHNICAL UNIVERSITY OF BERLIN (GERMANY)	MASTER OF SCIENCE IN ARCH.	5: 3 (bachelor) : Design & construction, Structural theory, Building material, physics & equipment 2 (master) : Historical construction & material, Public construction law & project management, Structural design

2.2. Definition of minimum structural requirements in architectural curricula by different architecture education organizations

In today's architecture provision of cooperation between different architecture schools is necessary as it enables students to use exchange programs and cooperate with each other. This requires some similarities and unifications in architecture curricula of different universities. European Union has planned to do this for its members. However, proposing completely equal curricula in the universities is not a good approach since every country and university has its own specifications and cultural properties. Instead some considerations can be applied to provide minimum requirements in all curricula. Definitions of minimum requirements given by some organizations are marked below:

A)Minimum requirements defined by EAAE:
EAAE (European Association for Architecture Education) emphasizes that education and training leading to diplomas, certificates and other evidences of formal qualifications shall insure the acquisition of 11 competences mentioned in the architects Directive 85/384/EEC of EAAE(Directive 2005).
It is not possible to specify some items of the Directive as specific structural and technological requirements because they are interrelated to each other in a design project and cannot be regarded separately, but some of them highlight the important structural and technological concerns of design such as the first, second and the eighth items; the important mentioned key words are: structural design, construction, engineering, technology and association with building design
B)Minimum requirements defined by ACQA:
Minimum requirements for an architecture curriculum have been attended by the ACQA[2] system proposed by TU/e in Netherlands. The mentioned items in this proposition are: capability to analyze, synthesize, abstract (induction) and concretize (deduction). (Meijers 2005)
C)Minimum requirements defined by NAAB:
Another organization which has identified the minimum requirements of architecture curriculum is the National Architectural Accrediting Board (NAAB) in the USA. Within the minimum requirements of architecture curricula defined by NAAB, there are some requirements related to structural and technological principles of architecture, which are marked bellow (NAAB 2004):

- Comprehending of principles of structural behavior in bearing gravity loads and lateral forces and the evolution, variety, and suitable application of contemporary structural systems.
- Comprehending of the basic principles and adequate application and implementation of building materials for envelope of buildings and assemblies.

3. STRUCTURAL PRINCIPLES WITHIN THE ARCHITECTURAL CURRICULUM OF EMU FROM THE POINT OF VIEW OF EMU ARCHITECTURE STUDENTS

To explore and realize the expectations, needs and ideas of EMU architecture students in relation to structural and technological concepts covered within the EMU bachelor of architecture curriculum a questionnaire is prepared. Quantitative and statistical information which are taken from these questionnaires can be helpful in the future to fill in the gaps and compensate the probable missing points of the curriculum. Since the respondents are expected to have the experience of dealing with the majority of topics covered in the curriculum, they are chosen from the 7th semester (arch 491- Architectural design studio V), 8th semester (arch 492- Graduation design), master and PHD students who are graduated from EMU. Total number of respondents of the questionnaire is 110 persons. Information, results and interpretations of the questionnaire are presented here as following:

[2]AcademischeCompetenties en Quality Assurance

A)Preference of students on the schematic proposed diagrams for architectural design process:

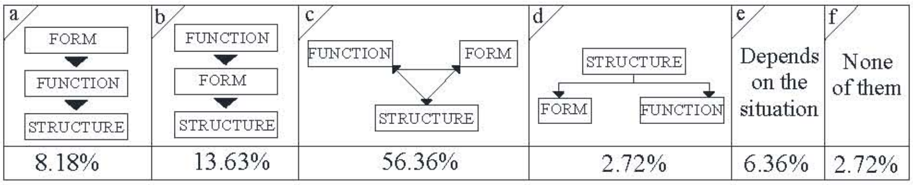

Figure 1. Comments of respondents on the preferred design process

According to figure 1 majority of students (56.36%) believe in parallel attention to form, function and structure in a design process (option c).

B)Students' votes on the quality of teaching of concepts related to function, form and structure in EMU faculty of architecture;

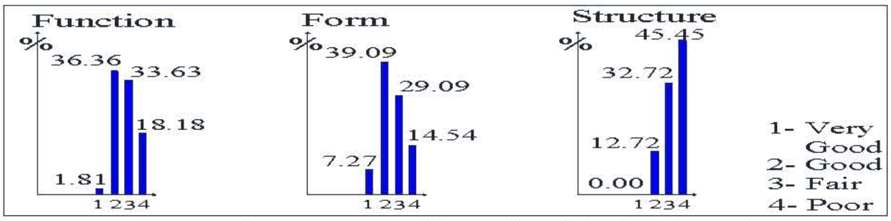

Figure 2. EMU students' votes on teaching quality of function, form and structure

Here, the function diagram reveals the fact that the highest level of satisfaction (very good) exist in a small percentage; however, majority of responds lie in the good and fair category with less than 20% believers of poor performance. This can be regarded as an acceptable situation although there is still space for enhancement. The form diagram configures the order from the lowest to the highest rank as very good, poor, fair and good. The poor percentage is less than 15% and the highest vote goes for good. The overall situation can be evaluated as acceptable although similar to the function diagram still some enhancements are potential to apply in the curriculum. The last diagram (the structure diagram) demonstrates a significant difference in compare with the first two. There is no comment indicating very good and the highest responds goes for the poor option (45.45%). The good option has fewer believers than the fair. Therefore, the situation discloses a need for review of the situation of teaching of structural concepts to promote the current situation of the curriculum.

C)Evacuation of the respondents from the existence of structural resource books for architects and architectural students to get enough knowledge of structural design which can help them in the design projects;

Table 2. Evaluation of existence of structural resource books from the point of view of EMU students.

a	There are enough resource books from this type.	10.00 %
b	There are some books from this type, but they are not respondent the whole questions of architects.	41.81 %
c	There are some structural resource books, but they are mainly useable for structural engineers and not architects.	28.18 %
d	There is not any book from this kind.	7.27 %

In this question as it is shown in the table 2, the option (b), (c) and (d) are indicating that students of architecture have some levels of difficulty in having access to structure reference information and the option (a) mentions that there is no problem to attain structural information from the resource books.
Since only 10% of the students have chosen option (a) and the rest have chosen the other options, it can be thought that architecture students have difficulty and trouble in finding enough structural resource information. This will be further discussed in compare with the instructors' comments.
D)Evaluation of the respondents on the ability of EMU architecture students to define the following items asked about the design studios;
a-Selection of suitable structural system for your selected forms
b-Selection of suitable structural materials (e.g. steel, concrete, wood, composite material) for your selected forms
c-Defining the approximate size of structural members (e.g. size of beam, column, slab thickness, space frame depth and cantilever length)

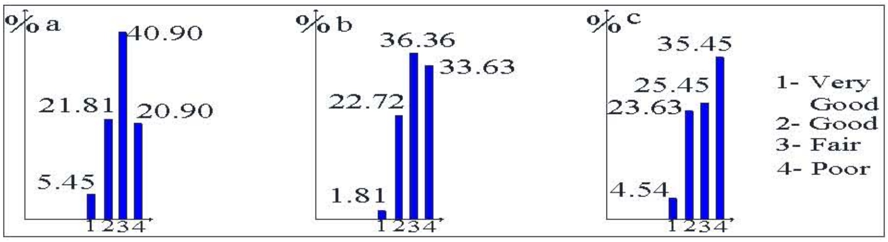

Figure 3. Evaluation of the respondents on the ability of EMU architecture students to define the mentioned a, b and c options

In all of the three diagrams number of people who have voted for fair and good options are more than the people who believe in very good and good situations. Thus, some rearrangements would be beneficial. The third diagram is related to the ability of students in calculation and estimation of structural members' size, which requires the knowledge of physics and mathematics and needs to be attended in further curriculum arrangements.

4. STRUCTURAL PRINCIPLES WITHIN THE ARCHITECTURAL CURRICULUM OF EMU FROM THE POINT OF VIEW OF EMU ARCHITECTURE INSTRUCTORS

In order to evaluate the level of teaching of structural and technical principles within the EMU courses, some interviews have been conducted with EMU architecture instructors. Their view points, expectations and suggestions are mentioned and summarized here in table 3. The interviewed instructors are chosen from persons who are experienced in various branches of architecture; such as structure, construction, urban design, landscape design and environmental control. Therefore, the interview results come from persons with various opinions and can explain the instructors' ideas in general.

Table 3. Summery of the interview results with EMU architecture instructors

COMMENTS	KEY RESULTS
1 Level of teaching of structure	• Very Good: 14.28% • Fair: 14.28% • Good: 28.57% • Poor: 42.58%
2 Comments on positive points	• Students are asked to think about form, function and structure simultaneously from the first stages of design. • There is integration between structural courses and design courses, because teachers who teach structural courses go to design studios as well.
3 Comments on problematic points	• Structural courses are not well integrated into design courses. • Although, there are some useful topics, still there are many missing points and students are not able to deal with structural problems of design studios well. • Students have problems in estimation of structural members' size. • Timing arrangement of the design classes has some problems; just after midterm juries students start to work on structural aspects. • There is not a suitable balance in teaching of form, function and structure. Form and function are more attended than structure . (imbalance)
4 Suggested solutions	• Collaboration between faculty of architecture and civil engineering, this can be done by some courses in department of architecture taught by civil engineers. Also arranging some group projects for students of the two faculties can be useful. • Implementation of some structural softwares in architectural teaching. • Students should be asked to reflect their structural knowledge into their design projects.
5 Existence of structural source books	• No idea → 14.28% • There are not enough source books → 14.28% • There are enough source books → 71.42%

5. PROPOSITION OF SOME PRINCIPLES TO INSURE THE IMPLEMENTATION OF ESSENTIAL STRUCTURAL PRINCIPLES IN ARCHITECTURE CURRICULUM OF EMU

The presented outlines here are reflecting the propositions for updating the school policies in relation to structural principles of architectural design:

5.1.Structural principles within the design studios

In all of the architecture curricula which are surveyed and studied in this research (table 1) structural principles are seen, but in some of them like Harvard University (table 1, item2) there are some special attitudes. In Harvard University, the design studio focus of the second year of architectural studies is specifically given to building structures. This gives the opportunity to students to get familiar with the concepts in the context of design and not just experience them in the theoretical courses. Another application towards integration of structural principals into design studios is seen in the Cambridge University curriculum. In this university, the main emphasize of the studies in the second year is on the integration of technical skills, studio output and ongoing lectures (table 1, item5).By this attitude students are to do two important issues in design studios in the second year. Firstly, application of their structure and construction knowledge (obtained from structure and construction specific courses of the first year of the study) into the design projects; secondly, integration of ongoing taught of the theoretical courses into their design training.

The two mentioned attitudes are parallel to structural and technological requirements that should be fulfilled by architectural schools and have been emphasized by some organizations such as EAAE, TU/e and NAAB (discussed in 2-2).

A similar attitude is proposed for EMU; having one year of design studio focus on building structures is recommended. Integration of structure and construction knowledge of students into the design projects within this year is required. Arrangement of assignments related to structural details and construction drawings for the design courses would be helpful in this period of study. Consideration of practice on building regulations while operating the design is also required.

5.2.Incorporation of theoretical structure and construction courses into the design studios

As mentioned before, EMU students have some problems and difficulties in selection of suitable structural systems and structural materials for their design projects (referring to the questionnaire survey). They also have problems in estimation of the size of structural members. Thus, it is necessary to consider some requirements to solve these kinds of problems. Moreover, the following propositions rise;

- Interviews with instructors indicate that majority of them believe that there are enough structural source books for architects and they are adequate to respond the students' questions (table 3, item5), while most of the EMU students are not able to solve their structural problems by referring to the source books (table 2); so teaching and focusing on the contents of structure hand books of architecture and inquiring relevant assignments during the theoretical courses of structure and construction is proposed.
- Some of the structural problems of students come from the fragmentation of structure and construction courses from the design studios (table 3, item3). To bridge this gap and have more integration between these two types of courses, it is suggested to give special attention to information about classifications of structural systems and materials and also methods of estimation of structure

members' size in the outline of the theoretical courses (suggestions from EMU instructors, table 3, item4).It would be beneficial if students practice these thoughts on their own design projects.

5.3. Prerequisites of structural and technical aspects of design

To avoid an architectural project from becoming just the outcome of inspiration, the logical analysis must be the first consideration. This viewpoint began with the methodology of architectural design by theoreticians Geoffrey Broadbent (1971) and Christopher Alexander (1964) oriented in a rationality composed of three stages: analysis, synthesis and appraisal. This systematic technique provides a precise evaluation of the conception and building processes and unites logical analytic judgments and emotional creative intentions. This issue has been argued by (Consiglieri V. and Consiglieri L. 2003)in a research emphasizing the importance of existence of mathematical studies in architectural curricula. As has been indicated in that research, it is necessary to enrich the theoretical knowledge in students together with the capacity of application of mathematics in architecture curricula.

Eventually, by referring to the mentioned points and also table 1, a suggestion is made to ensure the fulfillment of necessary prerequisites of structural and technological courses in the EMU architecture curriculum; testing the ability of students in handling mathematical and analytical topics through qualification exams before the first semester of architectural study (revision of entrance regulations of EMU)[3].

5.4.Information Technology (IT) and the new potentials in architecture pedagogy

In today's pedagogy, information technology can play important and effective roles in increasing the quality of teaching. Maier (1998) in the book "Using technology in teaching and learning" emphasizes the role of technology on enhancement of the university programs. As he claims, provision of better access to learning sources is one of the benefits of IT in education.

As has been previously stated, in this research two of the significant out comes obtained from the evaluation of EMU students' abilities from the questionnaire are:

- Necessity of assisting students in using the structural resource books
- Necessity of provision of structural, technical and practical skills in the students

Already there have been some implementations towards solving similar problems in students and assisting them in learning structural taught and skills. Although, they are mainly used by students of the field of structural engineering, the concepts and ideas can be beneficial and applicable for architecture as well. The usage of supplementary online environments, parallel to design studio taught would be positive towards this aim.

[3]By referring to the studied universities in this research, it might seem more useful to propose a systems similar to a curriculum which offers the same architecture degree as EMU (like Cambridge University with Bachelor of Architecture), but since there is no college level in EMU, proposing the fulfillment of mathematics based courses in the college level the same as Cambridge seems inapplicable for EMU.

6. CONCLUSION

Architecture pedagogy has been always faced with two major aspects of design; structural and technological issues of design versos aesthetical values. Integration of these two and providing a sufficient balance between them is an essential concern in provision of successful architectural education systems. Hence, evaluation of the existing architecture curricula in this regard will be helpful and efficient for architectural trainings.

Curriculum of Eastern Mediterranean University has been subjected to this research and is inspected in terms of teaching of structural principles. Current situation of EMU architecture curriculum and the abilities of students are studied and compared with some existing literature and curricula. Consequently, a set of statements and suggestions are made to increase the quality of teaching of structural principles within the architecture curriculum of EMU.

The suggestions items are intended to compensate the missing points and lacking requirements of EMU architecture curriculum and update its contents with the latest contemporary requirements. However, it is necessary to have frequent soundings from the students and also instructors in the future to evaluate their satisfaction from the teaching quality of different structural courses and eliminate the probable problems. From the other hand, this study have had some limitations in terms of the number of studied curricula from around the world which has happened due to the restriction of the research time and also the number of the interviewed instructors due to their availability during the course of this research. Conducting some similar researchers on the EMU architecture curriculum with referring to the limitations of this research and the new requirements of future would help the curriculum to stay efficient and productive for both students and instructors.

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CONTRIBUTIONS OF RESIDENTIAL LANDSCAPE DESIGN TO ECO-HOUSES

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ABSTRACT

In recent years, uncontrolled growth of world population and therewith unconscious growing has led to deterioration of plans designed in city establishments. As well as the many difficulties we face in urban, especially with 1950 s, environmental problems reveal the need of ecological approaches.

Ecology as a concept firstly is used by Ernest Haeckel in 1869. When it is considered in urban scale, in the matter of generating rational solutions with two-way; deduction, and induction methods, has been a concept rediscovered by people. Along with this concept; cities, have been striving against with different types of problem within itself, will be attempt to gain to nature. Because of the ignorance in land use; inadequate land use of necessary points and unnecessary land use in unnecessary points lead to be done in landscape planning for residential environments too. It is known that, so many methods can be produced in residential landscape design. For instance; logical and active use of wind shelters and solar shelters in landscape design, can provide %25 energy saving. Apart from that, selected and located trees can provide welcome shade whilst providing for solar access in the winter. Also, deciduous climbing plants on south facing walls, provide shade in summer whilst allowing unimpeded solar access in winter, whilst green roofs can also keep houses cool through intercepting solar energy.

The aim of the study is to defend "right ecological solutions for landscape planning will provide energy saving in eco-houses and so contribute sustainability in cities". The deductive method was adopted for this study. Firstly, the definitions of ecology and sustainability will be expressed with their role in cities to understand the need of eco-houses for sustainability in cities. After that, will be focalized on the landscape design for eco-houses. For this purpose; at the end of the study, landscape design decisions and methods for eco- houses will be defined, the hypothesis which put forward at the beginning of the study will be supported.

Key words: Ecology, sustainability, Eco- houses, residential landscape design for eco-houses.

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1. INTRODUCTION

In recent years, the population of cities and urbanization increase in a significant at a furious pace. Industry, commerce and education opportunities at some places in cities make them more attractive for people (Gül and Polat 2009). The existence of social and cultural spaces in urban, differentiation and development in economical sense are making these places more preferable to rural.
Though this accelerated and uncontrolled changes are getting more threats for nature and human health. Natural resources are consuming; air, water and soil pollution are increasing etc. Therefore, these problems and more should be solved by government and the local administrations by the help of citizens.
Existent cities are resuming their negative affairs and becoming "nature enemy cities" day by day, but this process reminds the term "ecology" that has been forgotten by human because of the defective politics.
"Ecology" first is used by Ernest Haeckel in 1869. It is derived from "oikos" which is meaning "home" in Greek. Ecology means "home for living organisms" (Begon et al. 1990). When it is considered in urban scale, it's been a rediscovered term for humanity on produce logical solutions with deductive and inductive methods.
Holistic approach should be adopted for the solution of ecological problems in cities. From the smallest scale-houses to the largest scale - cities should be thought and an urban ecology should be aimed.
Especially, the rapidly rising developments in industry and technology in cities by 1950s; bring along an uncontrollable immigration from rural to urban. Because of this intensity in cities, disequilibrium has begun in land use. In consequence, landscape use in houses has being decreased even it has finished in many places.
After all these negativeness, new concepts have been discovered. "Sustainability" is one of these concepts which become a significant term for human. Sustainability proposes a new lifestyle to human for preserving natural resources in this planet. by the help of ecologic methods.
Firstly, in small scale, these protections begin from houses. From this point of view, a new term "eco- houses" has been found. In this study will be investigated the effects of residential landscaping to eco- houses. And different natural methods will be suggested for landscape planning for eco- houses.

2. THE RELATION BETWEEN "ECOLOGY" AND "SUSTAINABILITY"

2.1. Ecology and Ecological Approach in Cities

Sustainability and ecology in the existing urban areas of the city's approach to integrating all the components, that and policies in the context of integrated urban management, urban planning and design of the institutional / social and individual responsibility and the scale must be resolved (Gül and Polat 2009).
In ecological approach, multifaceted methods are required. To increase the intensity of natural and green spaces, clean energy use, the use of environmentally -friendly technology, ecological-based urban, spatial and architectural planning and design of structures, on ecology and environmental protection education (information and

awareness) activities, ecological transport solutions, supervision and monitoring, promoting savings, environmentally friendly and harmonious use of materials are some of these methods (Gül and Polat 2009).
For all and more than these methods of ecology are based on some principles. These are:
•Nature integrity principle
•Nature limitation principle
•Nature self- audit principle
•Nature variety principle
•Nothing is disappear in nature

2.2. Sustainability and Sustainable Approaches for Cities
The majority of people worldwide live in cities and towns. By so many different reasons, their numbers are continuing to increase. Cities and towns offer an attractive living environment for the majority of people, but more knowledge is needed about the dynamics of this man- made environment, i.e. about the extremely changed natural conditions and about urban areas as living space. With increased urbanization worldwide, an urban perspective is progressively needed to understand human – nature integrations to improve research, design, planning and management of cities, towns and urban regions (Breuste and Qureshi 2011).
Sustainability was found out in the World Commission on Environment and Development report (Brudlandt Report). The definition of sustainability (1987) according to this report is: "Sustainable Development is to ensure that humanity meets the needs of the present without compromising the ability of future generations to meet their own needs."
Along with decrease use in resources, the limitation in fossil energy use, the controlling of pestilent wastes of sustainable houses, increasing of use clean energy resources are bring new initiatives to design.

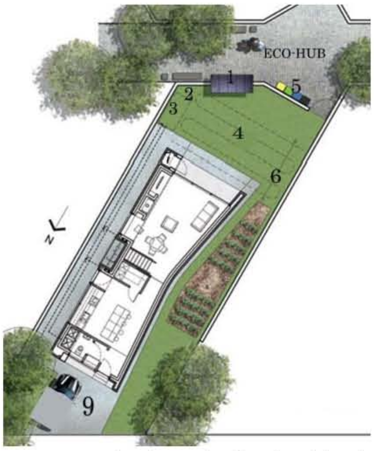
3. ECO- HOUSES

3.1. Contribution of Eco-Houses to Sustainability in Cities
Ecological houses are the houses that can be adapted to take environmental effects of domestic life into consideration, have been put forward as a crucial site and instrument of environmental citizenship (Hinchliffe 1997).
Whole of the countries in the world are making an effort for saving their own resources. For instance, UK government is attempted to cutting greenhouse gas emissions by 80% by 2050 in a bid to succeed climate change. Dwellings in the UK account for approximately 27% of the UK total of carbon dioxide emissions through the burning of fossil fuel for heating, lights and appliances. This includes combustion on the premises, mainly natural gas for heating and cooking, and combustion in power stations to produce electricity for homes. In order to address the climate change contribution from the domestic sector, the UK government has stated that every new home needs to be zero-carbon by 2016. As it is seen below, not only for keeping energy and also for producing and converting whole of

recourses; eco- houses are the essential potential for sustainable cities (Gillott and Rodrigues, L and Spataru 2010).

3.2. Contributions and Methods of Residential Landscape Design for Eco-Houses

Landscape design strategies for residential houses are additional and purposeful methods for energy efficiency in eco-houses. Logical and methodological planning process brings along minimum energy consumption in eco-houses.

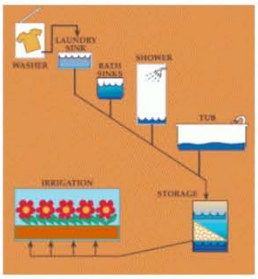


1. Photovoltaic panels
2. Wind turbine
3. Rainwater harvesting
4. Geothermal energy
5. Recycling bins
6. Clothes drying
7. Biomass stone
8. Vegetable patch
9. Hard surface run-off

Figure 1. Some ecologic methods of residential landscape

-Bio-filtering of wastes through constructed wetlands, reduction of stormwater, run-off through the use of bio-swales, rain gardens and green roofs and walls use can be provide water- saving. And using water from showers and sinks, known as gray water can be used for landscape irrigation in eco-houses.
-Xeriscaping: It is a new term that is used for reduction of water use in landscapes through design of water-wise garden techniques.
-Permeable paving materials to reduce stormwater run-off and allow rain water to infiltrate into the ground and replenish groundwater rather than run into surface water. Also, landscape products such as paving stones, mulch and other materials in landscape projects can be created from recycling products; such as glass, rubber from tires and other materials. Use of sustainably harvested wood, composite wood products for decking and other landscape projects, should be preferred instead of plastic.
-Soil management techniques, including composting kitchen and yard wastes, to maintain and enhance healthy soil that supports a diversity of soil life
-Instead of spend electricity in landscape lighting, integrated and adopted of renewable energy, including solar-powered should be used.
-A local plant, which has adapted to local climate conditions, will require less work on the part of some other agent to flourish. And by choosing the right kind of local

plants, a great deal of money can be saved on amendment costs, pest control and watering.
-Plants used as windbreaks can save up to 30% on heating costs in winter. They also help with shading a residence in summer. A dense vegetative fence composed of evergreens (e.g. conifers) near that side from which cold continental winds blow (usually north in the N. hemisphere) and also that side from which the prevailing winds blow (west in temperate regions of both hemispheres). Calculations show that placing the windbrake at a distance twice the height of the trees can reduce the wind velocity by 75%.
-Plants release water vapor in the air through transpiration and water has the ability to reduce temperature extremes in the areas near it. The larger and more leafy the plant, the most water vapor it produces. Additionally, as a principle for permaculture, the presence of trees is crucial in the creation of stable, healthy and productive ecosystems.
-For providing direct energy conservation should be pleced broadleaf deciduous trees near the east, west and optionally north-facing walls of the house. It provides shading in the summer while permitting large amounts of heat-carrying solar radiation to strike the house in the winter.
(http://en.wikipedia.org/wiki/Sustainable_landscaping).



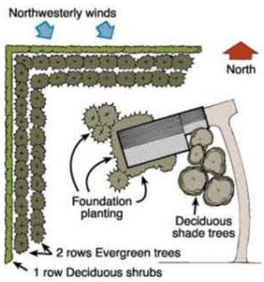


Figure 2. Gray water use in landscape irrigation
Figure 3. Plant location for energy saving in eco-houses
Figure 4. Sample of xeriscape use for residential landscape

4. CONCLUSION

Improved socio-cultural life and variety in means of existence, make cities attractive for living. Gradually; cities have been exposed to increasing in population and losing their previous silhouette. Thereby cities are becoming to transform "building masses" which are stylistically bereft of character. Whereas in 1911 Le Corbuiser could not hide his admire and said "if we compare New York and Istanbul now, we can say that the first one is a hell and the second is a heaven in planet". These words reveal changes to bad in cities clearly.
Besides of aesthetic losses, cities are beginning to be a threat for human and nature. Natural resources are being polluted, with the aim of serving to this crowd population, a lot of natural production is relinquishing to artificial one.

Human has been living this negativeness in his health and searching for solutions. Thus, it is gradually rising to seek for natural in modern world that might be defined as "return to past". Is being developed methods to provide sustainability for the world with ecological approaches.

"Eco- houses" are residential houses which are designed to preserve natural resources and provide energy saving. With the aim of increasing efficiency in systems to conserve energy, residential landscape design should be planned consciously. In the context of this research, residential landscape applications are examined in detail, necessitate a precise design and application progress. By this means, can be built energy efficient and nature- friendly residential houses that have very few operational costs.

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ARTIFICAL LIGHT IN INTERIOR DESIGN AND ITS EFFECTS ON PLANTS USED

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ABSTRACT

Light, especially sunlight, plays an important role spiritually and materially in our lives today. In the interior design, artificial light is used since the sunlight is not enough for all dimensions of the space and the activities are limited to the morning hours. All plants need for light as an energy source of Photosynthesis. In the lack of light, nutrient material decreases gradually and plant dies. Plants have an inclination to face to the source of light and only in such a case they become lively and tall. Especially, they leave their old leaves. Mottled plants may turn into green. On the other hand, if the plants are subject to extreme light, they incline to get burnt, discolored and contorted. As a resulting order to grow up the interior space plants successfully, the light requirements and light levels of specific plants must be very well determined. While assessing the light, three reasons, duration, quality and intensity of light must be focused. Main purpose of the interior space landscape design primarily is to create appropriate spaces for the human comfort. For the plants, creating human-centered space is more dominant than space design. Plants produce nutrients and make photosynthesis for further living and for light assistance and chlorophyll. Light is important for the chlorophyll that is necessary for photosynthesis. Stomas on the leaf affect photosynthesis. Stomas let gas exchange on the leaf and they need light to achieve this. While stomas are open on the light they are closed in the darkness. It consists of wavelengths between 430-700 nm. The light comes from the sun is preferred since the light that the plant requires is given from a wide spectrum. In this research primarily interior space landscape design, the importance of light, its aesthetic and functional characteristics will be emphasized. Interior space landscape design criterions will be explained and the characteristics of

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the sources of lights that are appropriate for the plants' natural light requirements will be expressed. Also, while exhibiting plants in the interior space the duration and levels of sources of lights will be determined technically.

Key Words: Artificial light, Plant, Interior Space, Illumination

1. INTRODUCTION

To give place to plants in the interior space leans on prehistorical origin. Following the changes in living conditions and technical developments, the place is given to the plants in different places such as office, mall, hotel, hospital along with houses by diversifying the plants. Along with the positive effects of the plants using aesthetical characteristics, the ecological contributions of the plants are inevitable in giving place to plant as an architectural element in the places.

2. MATERIAL AND METHODS

Material of the study has been the publications on technical characteristics of light and its effect on the plants. It is benefitted from the studies on measuring the reflex against light strength, light duration and wave length depending on the physiological characteristics of the plants.
As the method of the study, generally the characteristics of the artificial light and its effect on the plants are examined paying attention to the concept of light, its vital effect on the plants, design with plants in the interior design and utilization of light.

3. LIGHT IN INTERIOR DESIGN

Light is also a construction material as concrete. This material represents its physical existence only when it is seen by any. It is the time when the light defines the place, represents surface patterns, displays the forms, specifies the scales and functions. (Kazanasmaz, 2003)
In the 20th century, scientists had many findings about the effect of light on the visual performance and color distinction. As specified in the studies, shining light prevents the secretion of melatonin hormone (sleep hormone) and makes the worker more active and careful. In case of dynamic light, suitable light strength and color during the day provides the brain not losing its activity.

3.1. Definition and goal of light and illumination

The irradiation of electromagnetic waves with wave length of between 380-780 nanometers the man's eye is sensitive to is called "light". The reason of not so accurate wave length is the eye differentiations in people as an essential item in light definition and also the effect of light strength on optic borders. Providing the visibility of an object or a certain neighborhood by sending light from a light source is illumination. It also provides seeing the places and their objects in their natural size and color by natural and artificial illumination tools. Physiological, decorative and attractive illuminations are sorts of illumination in respect to its goal (Sirel 1997).

Luminous is grown out of a light with apparent and dominant direction, or a multi direction light or a combination of two sorts. It is the quality of luminous and is not related to fewness and plentifulness. Luminous may spread orderly in a place. It means that it is in the same level on each point. Or it is decreased and increased from place to place. It is also not related to fewness and plentifulness and order and variability is the quality. Luminous is gained using hot or cold or a combination of both and it is definitely the quality of luminous. The determination of luminous quality in a place is one of the basic illumination techniques.

The aim of illumination is to make visible the illuminated object and environment, not the source of illumination. The item being seen, in specific place, time, conditions and creating visual perception for specific aim may have so many different kinds. The man may be inside or outside the place of these objects. In order to see them in the best way, the quality and quantity of the luminous is so affective. The technique specifying how to illuminate, paying attention to these parameters is illumination technique.

Technically appropriate illumination; (Sirel 2001)

- Increasing the performance and operating speed in workplace
- Preventing the eye and neural tiredness
- Decreasing work accidents and energy consumption
- Increasing the succession in education institutions and similar places
- Providing the requested character in different indoor and outdoor spaces

3.2. What Is Light

Light is a form of electromagnetic radiation that is visible to the human eye. The radiation that we perceive as sunlight, or the visible spectrum, is a small fraction of the total electromagnetic spectrum that includes gamma rays, x-rays, and radio waves. Violet colored light rays at about 380 nm (nanometers) are the shortest wavelengths that humans can perceive in appreciable amounts, and red light wavelengths at about 720 nm are the longest. Solar radiation consists of a vast spectrum of electromagnetic wavelengths at various intensities. Visible light from the sun appears white due to the mixing of wavelengths that our eyes perceive. However, when passed through a prism or a mist of water droplets in the air, light waves become organized or refracted into visible bands of color producing a rainbow effect (Argus 2010).

3.3. The effect of the light on plant growing

The plant photosynthesizes by help of light and chlorophyll in order to sustain its life. Light is important for the chlorophyll which is required in photosynthesis. The stomas on leaves affect the photosynthesis. The stomas make possible the gas variation in leaf and light is needed for this purpose. Stomas are closed in darkness while they are open in light. Photosynthesis is increased, resolvable in water and it composes more sugar with penetrating carbon dioxide while stomas are open. The plants transform energies from natural ways (sun light) and also artificial light (electronic lamps) to nutrition. They use energies with wave lengths between 400 and 800 nanometer (nm) in chlorophyll synthesis. White light is the visible part in energy spectrum and it includes wave lengths between 430 and 700 nm (Yazgan et. al. 2010).

Table1. Colors and wave length of light (Yazgan et. al. 2010)

Light	**Band(nm:nanometre=1x10-9m or milimicron=mμ) 1 milimicron is one per million of a milimeter.**
Ultra-Violet	< 380
Purple	380-430
Blue	430-490
Green	490-560
Yellow	560-590
Orange	590-630
Red	630-700
Infra-red	700-780

Human's eye can perceive the colors between purple and red. Blue, white and purple are required for the commencement of synthesis process. Crimson and infrared lights make extension and growth in different parts of the plants. They are also affective in blooming and forming fruits. Sun light is preferred because of giving the required light for the plant from a wider spectrum. Instead of light reflected from a unique resource, diffusely coming light is more beneficial for the plant in order to gain equal energy from whole sides. In this manner, the light can reach leaves below easily. However, in differentiations in seasons and in a day, the artificial light is used in case of light insufficiency (Atalay 2004).

Three approaches in illumination set aside with certain boundaries are named as;

- Providing visibility
- To gain a good vision
- Providing visibility as it must be (Sirel 2001)

3.4. Design and kinds of illumination

Illumination design is a science as well as being an art. It is a science since the need for factors specifying illumination amount and light quality which are quantitative. It is art since it is felt by help of sensations. Illumination design is the function of integration of two completely independent factors, perception and technology in a manner that does not have a similar.

3.5. Design techniques of illumination

Light is invisible till the time of beating a surface and shaping the environment. The factors for lightening of any space are as follows:

- Condition
- Function
- Quality and quantity of light

- Architecture and decoration
- Space atmosphere
- Relation with neighborhood

3.6. Kinds of illumination

- Task illumination
  It is very close to the task area and it provides high luminous levels. It is just concerning task area. In general, it is preferred in business areas and used accompanying with general illumination apparatus.
- Accent illumination
  It is created by a linear light in order to emphasize on an object or attract attention to a part in an area. It is an important kind of illumination which architect uses in order to strengthening a design element or any theme.
- General illumination
  It is a light as a ground or back ground one created to decrease the certain contrast between the light for doing visual affairs or for emphasizing on some objects. It provides an ordered and monotonous illumination by balanced level illumination (Atalay 2004).

3.7. Light-plant relationship in interior space

Sun light is reflected from window or roof. A 1/3 ratio of the sun light from the atmosphere and the part reflected from the earth is reflected from the window (Yazgan et. al. 2010)
The light coming from the atmosphere is required for lengthwise growth. The maximum affected area is in relation with window height so that the botanic material can benefit from the reflected natural light from the window. The area the plant benefits from the natural light is constituted with a 45 degree angle in artificial direction. Because of that, this area should be estimated in lightening and an artificial light must be planned where there is not any natural light. The density and effective area of the reflected light in the building are changed according to window dimensions, its material features and the climatic conditions (Yazgan et. al. 2010)

4. CONCLUSION

In the growing of plant, the density, duration and quality of the light are important. Light density; it must be measured of quantitative expression of light lux or in terms of lumen on square meter. Lumen is the amount of spreading light from light source. Lux presented the amount of light gained on surface. It is quantitative measurement. The demand of light density is different for every plant. The bright light is 53500-128400 lux in average. This amount is different according to height from the sea, season and time of the day. Most of the plants do not bloom in case of lack of light. The light below 1600 lx in interior space prevents blooming. However some kind, Spathiphyllum, is blooming in 1070 lx.

Light duration; it must be a balance between the light density and light duration so that the plant represents the most appropriate progress. Permanent artificial lightening does not have any benefit while the required light density is not provided. The resting periods of the plants and self-concerning needed photoperiods (lightening duration) of every plant and lightness and darkness duration affect the organism progress. The average lighting duration for the plants is as follows; the lightening duration is 8-12 hours darkness/day and 12-16 hours/day. If only the minimum light density is provided, the optimum light duration must be provided.

Light quality; light quality expresses the type of the gained reflected energy of the plant. The plants use the energy between the blue and red wave lengths. The visible light spectrum is the light between the wave lengths yellow and green. The lights with wave lengths between ultraviolet and infrared are also natural light resource. While excessive red light causes in a slim long stem, inadequate blue light causes in phototropism which means one way progress through light. Chlorophyll synthesis is in the highest level between blue light energy (400-475nm) and red light (625-675nm). The type of light resource changes according to the ceiling which means the distance between the plant and light. The ideal for the plant progress is natural light. Most of the electrical light sources are basically mono-chromatic. It can be benefitted from artificial light source when natural light is insufficient. White-hot, fluorescent and mercuric lamps can be used for this purpose.

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A COMPARATIVE EVALUATION OF BASEMENT WALL INSULATION TYPES

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ABSTRACT

In this study, types of insulation materials, insulation techniques for the basement and effect on environment have been studied. This paper explains the usefulness of basement wall insulation and lists the advantages and disadvantages of various insulation materials. There are many different types of insulation materials. In terms of energy efficiency, investing in high levels of insulation materials is more cost-effective than investing in expensive heating technologies. It is worth taking the time to choose the right materials in the context of whole building design. An energy efficient building envelope contains both a thermal barrier and an air barrier. The key to an effective thermal barrier is proper installation of quality insulation products. Insulation is a key component of sustainable building design. A well insulated buildings reduce costs for energy by keeping warm in the winter and cool in the summer, and this in turn cuts down carbon emissions linked to global climate change.

Key words: isolation, basement isolation, insulation techniques, environmental effects

1. INTRODUCTION

Basement insulation is a great way to conserve energy and increase the livable area in the houses. The basement presents unique challenges therefore selecting the method of basement insulation is very important. Insulation should be done on foundations to pretect the main bearing construction from water and moisture effects. The main basic difference of basement foundation insulation from other insulations is the lack of opportunity to repair or correct the improperly done insulation applications. Therefore, it should be planned very precisely and applied carefully. There are three main reasons for the basement insulations which are due to soil water, pressurized water and non-pressurized water. The area that the structure rests on and side surfaces under the ground should be completely insulated. One coat

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of 3-4 mm thick polymeric insulation can be applied on the main shear walls against ground humidity. Also, this can be supplemented by drainage systems around the building.

Basement walls are subject to moisture from a number of fronts. Moisture can condense against the interior wall, it can be drawn into the concrete from footers or it can leak through cracks and pores in the concrete. Moisture can reduce the effectiveness of insulation and can promote the formation of mold and mildew. Choosing a basement insulation material should involve keeping the realities of moisture in mind.

2. INSULATING BASEMENT CEILING OR BASEMENT WALL

In most cases, a basement with insulation installed in the exterior basement walls should be considered a conditioned space. Even in a house with an unconditioned basement, the basement is more connected to other living spaces than to the outside. This connection makes basement wall insulation preferable to insulating the basement ceiling. Compared to insulating the basement ceiling, insulating basement walls has the following advantages:

- Requires less insulation
- More easily achieves continuous thermal and air leakage boundaries because basement ceilings typically include electrical wiring, plumbing, and ductwork
- Requires little, if any, increase in the size of the heating and cooling equipment.

The heat loss and air leakage through the basement ceiling is similar to that through the exterior walls of the basement.

These are some other advantages of insulation on exterior basement walls:

- Minimizes thermal bridging and reducing heat loss through the foundation
- Protects the damp-proof coating from damage during backfilling
- Serves as a capillary break to moisture intrusion
- Protects the foundation from the effects of the freeze-thaw cycle in extreme climates
- Reduces the potential for condensation on surfaces in the basement
- Conserves room area, relative to installing insulation on the interior.

The disadvantages of basement wall insulation include the following:

- Costs may exceed those for insulating the basement ceiling, depending on materials and approach selected
- Installation is expensive for an existing building unless a perimeter drainage system is also being installed
- Many exterior insulation materials are susceptible to insect infestation
- Some contractors are unfamiliar with proper detailing procedures that are critical to performance

- If surrounding soil contains radon gas, the house will require a mitigation system underneath the basement floor.

Adding insulation to the interior of the foundation is often more cost effective for an existing building. Interior insulation has the following advantages and disadvantages.

Advantages:

- Interior insulation is much less expensive to install than exterior insulation for existing buildings
- Almost any insulation type can be used, giving a wider selection of materials
- The threat of insect infestation is eliminated
- The space is isolated from the colder earth more effectively than when using exterior methods

Disadvantages:

- Many insulation types require a fire-rated covering since they release toxic gases when ignited
- Interior insulation reduces usable interior space by a few inches
- It doesn't protect the damp-proof coating like the exterior insulation
- If the perimeter drainage is poor, the insulation may become saturated by moisture weeping through the foundation walls
- Superior air-sealing details and vapor diffusion retarders are important for adequate performance (U.S. 2012)

3. BASEMENT INSULATION MATERIALS

While choosing a basement insulation material, effect of moisture to the basement should be considered carefully.

3.1. Blanket insulation

Blanket is a long a popular insulation material, fiberglass batts and rolls are still routinely used for basement insulation. Fiberglass blanket insulation is a poor choice given that moisture degrades its insulating ability quickly and that this type of insulation succumbs easily to mold. Standard fiberglass blankets and batts have a thermal resistance or R-values between R-2.9 and R-3.8 per inch of thickness. High-performance (medium-density and high-density) fiberglass blankets and batts have R-values between R-3.7 and R-4.3 per inch of thickness, (Aktaş 1997 and U.S. 2012). The maximum thermal performance or R-value of blanket and batt insulation depends heavily on proper installation. To evaluate batt installation, batt thickness can be measured and gaps between batts can be checked. Blanket (batt or roll) insulation and installation usually costs less than other types of insulation.

3.2. Concrete block

There are several techniques for insulating concrete block used in foundation construction. These involve pouring expanding foam or foam beads into the cavities of the blocks during construction. This is a very effective insulating strategy for new home construction. Insulated concrete blocks can accommodate many walls in the house. Their cores are filled with insulation (except for those cells requiring structural steel reinforcing and concrete infill), which raises the average wall R-value. The better concrete masonry units reduce the area of connecting webs as much as possible. There are several ways to incorporate foam insulation-such as polystyrene, polyisocyanurate or polyiso, and polyurethane- into concrete blocks. The hollow cores of concrete blocks can be filled by pouring and/or injecting loose foam beads or liquid foam, (U.S. 2012).

3.3. Foam board

Rigid foam insulating boards don't have the same moisture issues as blanket insulation. Foam boards can be expensive, however, and need to have a fire-resistant barrier installed under most building codes. They provide good thermal resistance and often add structural strength to the houses. Foam board insulation sheathing reduces heat conduction through structural elements, like wood and steel studs. The most common types of materials used in making foam board include polystyrene, polyisocyanurate or polyiso, and polyurethane, (U.S. 2012). To make beadboard, loose, unexpanded polystyrene beads containing liquid pentane are mixed with a blowing agent and poured into an enclosed container. The mixture is heated to expand the beads many times their original size. The beads are then injected into a mold. Under more heat and pressure, they expand to become foam blocks, which are shaped as needed. Their R-values range from 3.8 to 4.4 per inch (2.54 cm) of thickness.

Foam insulations should be protected against sunlight, insect and fire. Over time, the sun's ultraviolet rays can damage the insulation. Foam may be covered with a rubber or plastic membrane. Although insects don't eat foam board, they can easily tunnel through it. Insect burrows reduce the R-value and structural integrity of the insulation. A better solution for below-grade walls in need of insulation is to install the foam board over the interior of the basement walls rather than on the exterior, which is more common. Interior applications prevent ground-dwelling insects from finding the foam board at all, and they eliminate the need for the bare inspection area. Insulating interior walls, however, requires careful attention to moisture control. Foam insulation is relatively hard to ignite, but when it is ignited, it burns readily and emits a dense smoke containing many toxic gases. The combustion characteristics of foam insulation products vary with the combustion temperatures, chemical formulation, and available air. Because of these characteristics, foams used for construction require a covering as a fire barrier, (U.S. 2012).

3.4. Loose fill

Loose fill insulation like cellulose or rock wool are used when basement walls are finished. While cellulose is typically treated to be mildew and fire resistant, rock wool might be a better choice for basement insulation.

3.5. Sprayed foam

It is applied as an expanding liquid, sprayed foam insulation can be a good choice for existing basement. Most building codes require sprayed foam to be covered with an approved thermal barrier-typically drywall-which means sprayed foam is best used in situations where a finished basement is the ultimate goal.

Liquid foam insulation materials can be sprayed, foamed-in-place, injected, or poured. Their ability to fill even the smallest cavities gives them twice the R-value per inch than traditional batt insulation. Most foam materials can now be used with foaming agents that don't use chlorofluorocarbons (CFCs) or hydrochlorofluorocarbons (HCFCs), which are harmful to the earth's ozone layer. They may be cementitious, phenolic, polyisocyanurate and polyurethane. Liquid foam insulation can be applied using small spray containers or in larger quantities as a pressure-sprayed (foamed-in-place) product. Both types expand and harden as the mixture cures. They also conform to the shape of the cavity, filling and sealing it thoroughly. Slow-curing liquid foams are also available. These foams are designed to flow over obstructions before expanding and curing, and they are often used for empty wall cavities in existing buildings. There are also liquid foam materials that can be poured from a container. Liquid foam insulation products and installation usually cost more than traditional batt insulation. However, liquid foam insulation also forms an air barrier. This can help eliminate some of the other costs and tasks associated with weatherizing a house, such as caulking, applying housewrap and vapor barrier, and taping joints, (U.S. 2012 and Akıncı 2007).

4. CONCLUSION

The right insulation system can save money, reduce the amount of energy used and make houses more comfortable. The local climate has an impact on the cost-effectiveness of any insulating project. 10% of building heat loss occurs on foundations. Application of thermal insulation has positive implications on energy saving, environmental pollution and life of the building. Installation costs are usually the most expensive part of an insulation project. Costs spent for the thermal insulation covers itself for 1-2 heating seasons. Thermal insulation decreases fuel consumption used for the human comfort in winters and summers, therefore this causes significant reduction in NOx and SOx emissions to the atmosphere and provides gains in the prevention of environmental pollution. There are many different insulation materials that can be used for basement insulation. It is the most important thing to choose the best suitable insulation material and technique for your buildings. Codes should be checked before insulation application. R values and their metric equivalent, RSI values, are a way of labelling the effectiveness of insulating materials. The higher the R value or RSI value, the more resistance the material has to the movement of heat.

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THE SACS SYSTEM FOR THE ANALYSIS OF STRUCTURAL AND TECHNOLOGICAL ELEMENTS IN HEALTHCARE

LUCA MARZİ[1], ALESSİO LUSCHİ[2]

ABSTRACT

This article shows an informative tool which manages CAD digital maps in order to feed a database that provides structural, technological and organizational information of about 15,000 rooms of Careggi Polyclinic – AOUC (one of the largest Italian hospital which stands on an area of 74 hectares). The system has been developed by the Monitoring Laboratory (MonLAB) of Florence University (an autonomous office made by personnel of Department of Electronics and Telecommunications together with Department of Architectural Technologies) within an extensive restructuring process of the hospital itself. This strategic programme of transformation called "New Careggi" includes demolition, rebuilding and renovation works. The system called SACS (System for the Analysis of Hospital Equipment) is a custom Visual Basic software that drives Autocad to manage and analyse digital plans of buildings coded on specific layers. The software maps Departments and relative Operative Units, Destinations of Use, healthcare technologies and environmental comforts grouping info by single room and homogeneous areas, giving quantitative and qualitative results (such as surfaces, heights and volumes, Key Performance Indicators, etc.). The particularity of SACS is the "everything inside DWG" approach: all data is stored inside the digital maps allowing anytime to rebuild the whole information having nothing but the DWG files. This allows a great flexibility of the system that offers the possibility to elaborate pre-existing and not specifically SACS-designed plans.

Key words: hospital, management, monitoring, tools, GIS

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1. INTRODUCTION

The modern hospital organization is based upon a huge amount of data and people and the main problem is to organize and to make functional relations among them. In fact hospitals must now undergo a numerous quantity of requirements in order to fulfill their clinical and medical duties. These requirements are set by national and international institutions which force structures to respect given parameters to grant sufficient hygienic, qualitative and organizational standards (accreditation process). The university hospital campus of Careggi (Florence) is a pavilion hospital and it is hence made by 52 buildings over a 317,850 m^2 with 1,796 beds. Its inner organization has been reviewed over the years and it is now structured in Departments, Activities Area and Operative Units. Departments (or Integrated Activity Department – IAD) are functional macrostructures associated with the clinical and technical supplied offer: they are 20 and many of them works among many buildings, using different structures, technologies and rooms throughout the whole hospital area. For each IAD there are functional substructures with a lower level of aggregation: Activity Areas (AA) and Operative Units (OU). The first ones join together physical spaces in relation to the carried out activity; the second ones join together medical staffs in relation to the medical activity they are assigned to. Therefore it is possible to have one OU operating in different rooms associated with different AAs: so a single room is assigned to only one Activity Area but it can be used by many medical staffs, hence by many OUs (for example ambulatories and surgery rooms are used in many cross-specialties, but assigned to only one AA). The 20 IADs, together with the 276 Activity Areas and 181 OUs made a three-dimensional matrix and each cell identifies a single medical center.

2. METHODS

This work comes from the need to have a tool which monitors the whole hospital and give unbiased data to assess the building/technological estate and assigns priorities to necessary interventions by whomever is responsible. The developed system is special hospital GIS linked to the inner Hospital Information System (HIS) designed in Microsoft Visual Basic. The software is used to monitor the *status-quo* of the buildings (in terms of beds, square meters, destination of use, functional area and many other features for every room) by driving DWG maps in Autocad.

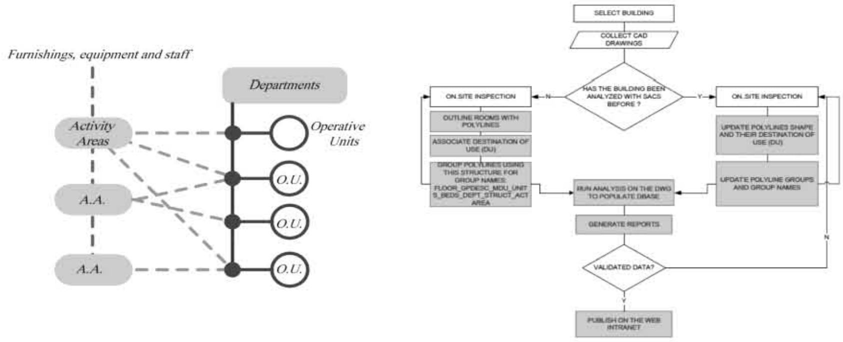

Figure 1. Organization of AOUC and SACS Process Flowchart

The system is "special" because of its singular approach to storing, analyzing and managing steps compared to a common GIS which is described as "everything inside DWG" and that will be discuss later in the article. The idea behind SACS is to bring the knowledge-sharing to its maximum allowing hospital staff to potentially comes to know of everything about the building estate (spreading of Operative Units, Activity Areas and Departments, beds, detailed destination of use and environmental comforts of each room). The informative system is composed by the core-engine software, which drives CAD maps and makes automations on them, a data-entering module and a SQL Server database that contains the tables used to decode the data stored inside the DWG files. This is the great potential of the system: all info is stored inside the maps (and also backed-up on the database for emergency recovery) so that they are self-sufficient and the information can be always rebuilt using nothing but the CAD files: this is what has been previously mentioned as the "everything inside DWG" approach. The current release of the software (SACS v4.0) electronically analyzes the plan of the hospital and outputs statistics on dimensions and aggregation of spaces, subdivided by 42 Main Destination of Use (MDU) and their 246 sub-classes (SDU – Secondary Destination of Use) in order to give a description as real as possible of the hospital organization. Data is collected using techniques which have reference to Post Occupational Evaluation (POE) through on-site surveys and personnel interviews. Spaces are classified by their "real" usage and by customer's waiting in terms of environmental comforts. Survey information is data-entered into the SACS and linked to the DWG "polyline objects", each one of them outlines the perimeter of a room. Moreover every single space is associated to an unique "talking" code that identifies it inside the hospital, letting the user immediately knows the examined position. The room code is formatted according to the following rule: *BLD_LEVELROOM, where BLD is the code of the building, LEVEL is the number of the floor mapped by the linked DWG file, and ROOM is a 3-digit formatted increasing number. Besides the above mentioned data (room-code, MDU, SDU, IAD, AA and UO), the following room-linked info is also managed by SACS: height of the room; room square and volume; square-light ratio; typology of users (medical and technical staff, students and suppliers) number of beds; code of the Air Treatment Unit (ATU) that feeds the* *room; Electrical Group (EG) for the medical rooms as described by the Italian Electrical Committee; number of medical gasses connections detailed for air, oxygen, dinitrogen monoxide and void terminals; room-afferent assets; room-afferent occupants.* This information is a powerful data source the Hospital Information System (HIS) can be linked to and is needed to compute a set of structural Key Performance Indicators (number of beds per ward square, square per destination of use, type of services and facilities per destination of use, operating rooms per day-surgery beds, etc.).

2.1 Reporting

Autocad hyperlink property of the polyline is used to associate a hypertext to every single entity. Because of the heterogeneous available amount of data, it is useful to access them from intranet consulting too. Therefore SACS automatically publishes all the gathered attributes together with those stored in the DWG files embedded in a html page accessible via web: this allows everyone to access the inner information recorded in the maps, even without having the SACS engine installed on his computer but only with a common web-browser. Before publishing SACS is able to make some automation on the CAD maps like generating hatches coloured according to the MDU's RGB colour or texts of the attributes for the single room centered in the polyline that outlines it. From the hospital intranet SACS main page the user accesses to a list of available floors for the selected building and then to the related maps or PDF reports by clicking on the desired floor. Here the previously described hyperlink gives an instantaneous information of highlighted room attributes that can be deepened by clicking on it. The structure of the reports is arranged by buildings or by departments (useful to study the scattering of an IAD in the hospital estate and to plan possible improvements). Plus the reports shows the set of KPIs calculated for 3 levels of aggregation: floor, building and hospital. SACS is also able to automatically produce door-plates with info about the room (afferent IAD, OUs and AA, room-code, names of the staff).

Figure 2. SACS-Destinations of use, classes, colors and relative icons.

3. RESULTS

The software is flexible and allows queries on rooms and gives numerical and graphical reports. Hence it is very useful as support tool for the healthcare planning. A list of few examples grouped for users follow: *Medical staff use SACS to know the "spreading" of their units/departments and which ones they eventually have to coexist with. Firemen query SACS to know the escaping pathways along the buildings, where the fire-escapes and fire-stairs are and which places are more sensible and thus ask for more attention. Technical staff uses SACS almost every day to retrieve parameters for hospital like quality of service indicators or accreditation requirements. Everybody inside the hospital can query SACS to know building code and name, floor, any medical or non-medical activities carried out inside a given room or as a tool for people-finding.*

The software is used for many purposes and in really different scenarios like space management, transfer management, accreditation requirements assessment, electro-medical devices management (through the interface with the Clinical Engineering database) and general designing and remodeling.

3.1 Transfer Management

The first problem which SACS solved was about the transfer management. Careggi has been being remodeled for about the last 10 years: during this process a lot of transfers have been made following the demolition and the re-building of many areas of the hospital. SACS is able to answer the main question in a transfer process: does the target room meet the requirements of the new use it has to fulfill? By consulting all the data stored along the room-representing polyline it is possible to know that and then easily answer the previous question. Thus SACS gives a prevision of which transfers are more or less complex to manage or generally not allowed at all.

3.2 Accreditation Requirements Assessment

Accreditation is based upon 4 main clusters: plant, technological, architectural and organizational. By using SACS and its reporting features it is possible to determinate which requirements (especially plant and structural ones) are already satisfied and which not: KPIs give a relevant, strong and very useful information about that. Obviously not all the requirements can be assessed by using the system so that on-site surveys need to be done and other HIS databases must be consulted in order to satisfy all the necessities. However there is no denying the huge save of time that SACS brings in a so massive process of evaluation. Plus SACS is recorded in the inner organization paper as the official hospital tool used to verify the possession of the accreditation requirements. Accreditation is one of the tools for environment quality assessment and it also includes accessibility, safety and comfort factors: for this reason SACS has a distinct module used to classify this type of data.

3.3 Space Management

SACS is used in hospital space management since it is able to link every single univocal room-code to the staff and furniture/equipment registers. As mentioned above SACS automatically produces room's door-plate with logistic information useful for facility management and governance activities like staff space-allocation, destinations of use verification and cost and space analysis of OUs. SACS offers a complete database with multifunctional data which allows many typologies of aggregation and enquiries by different categories of users, with the possibility to make more complex studies like cost-benefit analysis or comparative analysis.

4. CONCLUSIONS

Modern hospital organization is based on a large amount of data and people that must interact with each other in order to ensure adequate qualitative parameters. Thus informative management tools are even more necessary. SACS is one of these and it not only offers quality control functions, but results in a true user-friendly service for people throughout the hospital (staff, patients, visitors and students). SACS is always under continuous evolution due to its own nature and its development follows 2 main streams: one is focused to enlarge the management skill of the system (even by linking it to other hospital tools), the other concerns on support people along the hospital sanitary pathways. MonLAB is developing a new software release with more data stored in. Information about typologies of the Cleaning Facility Macro-Area to evaluate the price of every room in terms of cleaning operations, sound/data systems management and an intranet search engine are just a part of the future available features.

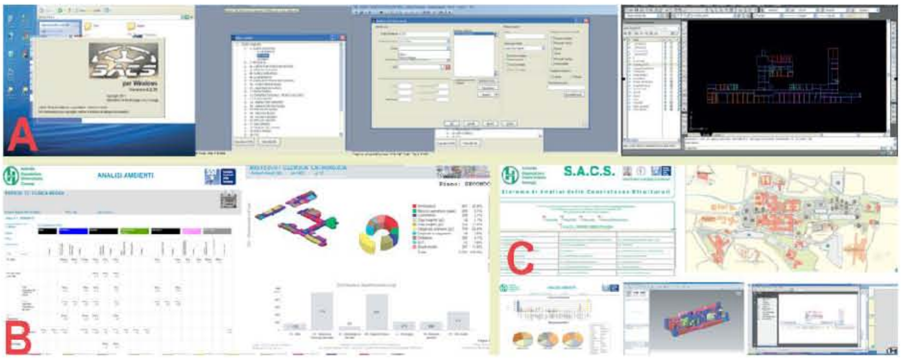

Figure 3. SACS: phases of use. A) data entry. B) PDF reporting. C) WEB reporting.

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AN EXPERIMENTAL DESIGN METHOD FOR URBAN FURNITURE DESIGN EDUCATION

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ABSTRACT

People living in commune have some necessities in public spaces. And urban furnitures became as an answer to these necessities. In history, they have been accepted as a cultural sign where they are using. As an example, Roman was building Victory Gates and sculptures of conquerors to conquests. For another example, classical red telephone boxes of Brits. In spite of being created by self-necessities and aesthetics of each society, urban furnitures replaced with less detailed, low cost mass production products during industrial revolution. Consumers who didn't discontent with these mass manufacture products, inclined to user - based designed and produced products. This orientation of customers forced producers to take care of design and designers and conduced to beginning of some design trends like Bauhaus. This time period is a breaking point for urban furnitures as other design products. Our study aims to make students using instructional design methods in urban furniture design process.

Key words: Urban Furniture, Design Education, Instructional Design

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1. INTRODUCTION

Nowadays, we are in a breaking point time again. Necessities and perceptions of costumers have changed with booming technology and rapidly adaptation drive of people. We are living in a world when calling someone is “too mainstream” now. Social media pages, blog sites and other domains are more important than ever. Advertisement sector is not available at billboards. Our mobile phones and these virtual domains of us have aimed for ads because of their use ratings. In other words, people are changed and other components of our lives need to change too. Websites can be display according to your interest or seats of automobiles can be adjustable for different drivers automatically. Computers know about us more than we gave via personal information. Nowadays, people inclining to personalized products as how inclined to user-based design products before. Urban furnitures need to change accordingly. Designers too… Some designers have a purpose something like that. Previously, trash bins were just an empty box to put garbage in it. But now, it is possible to coincide with a bottle collector blinking and beeping to you for attracting you to put bottle in it.

2. RELATED WORKS

2.1 Fun Theory

Fun Theory is an organization make this and similar ideas real. They are creating projects with ideas coming with their international competitions. Bottle Bank Arcade (BBA) project is just one of these. BBA is a glass recycle bin that interacts with you and invites you to a game. Game requires putting glass bottles to holes that indicated with a light blink on it. Fun Theory founded with supports of Volkswagen automotive company. Organization makes inconvenient daily works enjoyable games to engage people to do these works. Bottle Bank Arcade have installed to Södra, Sweden for exploring interaction between people for one evening. During this time, BBA was used nearly one hundred times, despite nearby conventional bottle bank used just for twice. This success can be understandable as a huge labor, cost, time saving.

Preferring escalators instead of stairs is another obstinate problem of city life. People prefer to wait for escalator rather than climb up stairs. For this preference problem, Fun Theory has converted stairs to a system works and sounds like piano. At morning of installation, people were surprising when heard piano sound. By the time, people preferring stairs to escalators for fun. This installation shows us, 2 of 3 people who previously used escalators, prefers to use stairs.

Figure 1. A fotograph from Piano Stairs Installation at Odenplan, Stockholm

These examples show us, people prefer systems, which interacts and reacts to them. Designers also have to fulfill lots of expectations as urban furnitures. Nowadays, collaborative multi-disciplinary design teams are designing urban furnitures, which were designed by artisans previously.

2.1 Studio Roosegaarde

Architects, industrial designers, landscape architects, software developers, electronic engineers can form these teams. Studio Roosegaarde is can be shown as an example to multi-disciplinary workplace for urban furnitures, which have founded by Daan Roosegaarde at Netherlands. This studio is interesting with sensing and reacting dynamic sculptures. They are exploring relationship between human, architecture and technology. Installations and research prototypes.. An installation called Dune, have permanently installed in the public pedestrian Maastunnel, where is a public pedestrian way alongside the Maas River in Rotterdam (NL), commissioned by the Rotterdam City of Architecture for exploring social interactions.

Figure 2. Photography from Maastunnel Dune Installation

3. INSTRUCTIONAL DESIGN FOR STUDENTS

In our study, we explored an instructional design method that helps for designing with new necessities of urban furnitures. According to understandings from recent interactive and user-based urban furniture explorations and works, a design guideline have prepared for using in design process of students who attended to Urban Furniture Design course at 2010 Fall semester. Students are formed by architecture, landscape and interior architecture and industrial design disciplines. In guideline works by making a decision according to design options that represent function, user count, physical relation between user and abilities of geometry.

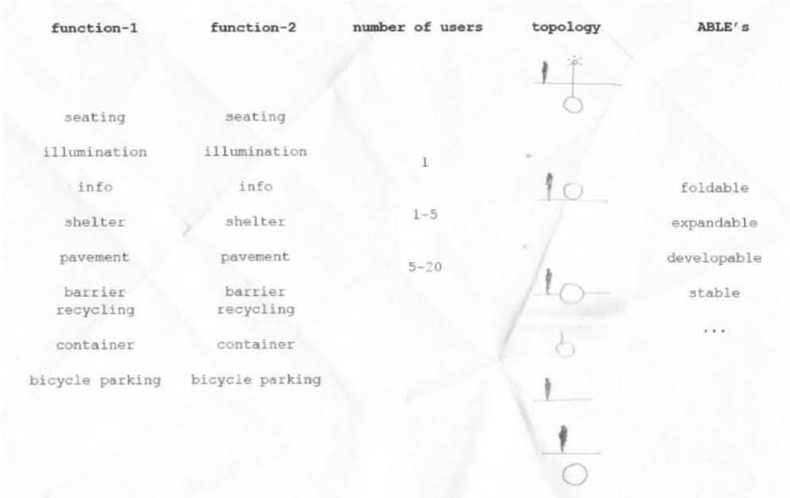

Figure 3. Guideline Chart of Instructional Urban Furniture Design Experiment

Students have experienced designing urban furniture with constrains shown by a guideline for first time. Some result works of students have shown at below.

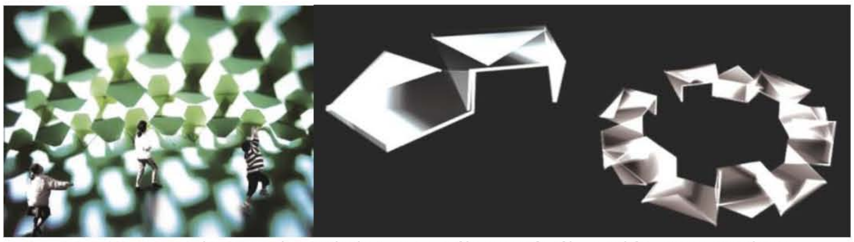

Figure 4. Student work made by Ayşe Dila Demirgil, Architecture Student.

Student designed the work which shown at above by selecting options at below.

- Function 1 ....Shelter
- Function 2 ....Lighting
- User Count ....10 – 15
- Topology ....Hanging On Top
- Ability of Geometry ....Stable

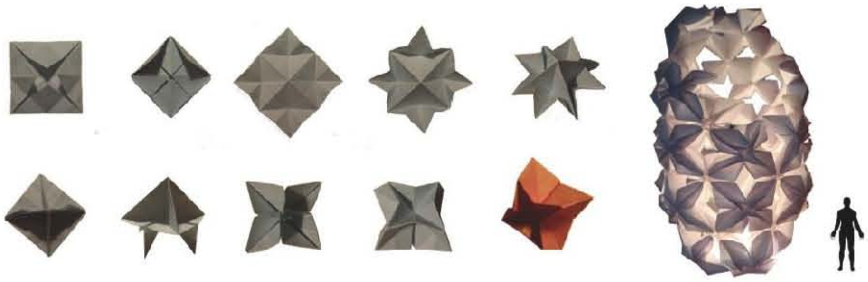

Figure 5. Student work made by Ayşe Ümit, Industrial Design Student.

Student designed the work which shown at above by selecting options at below.

- Function 1 ....Lighting
- Function 2 ....Barrier
- User Count ....5 - 20
- Topology ....On Ground
- Ability of Geometry ....Stable

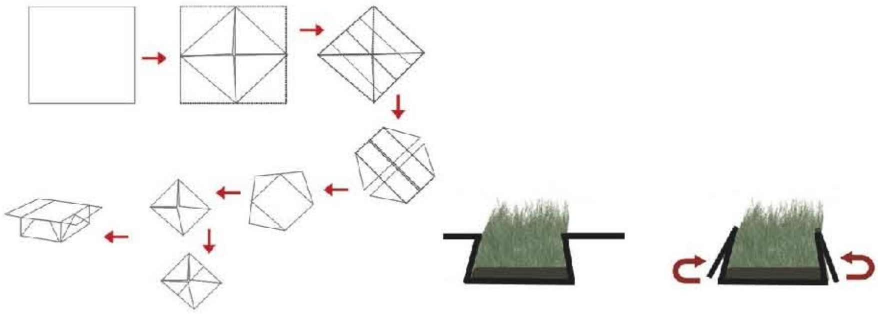

Figure 6. Student work made by E. Selen Aksoy, Landscape Architecture Student.

Student designed the work which shown at above by selecting options at below.

- Function 1 ....Sitting
- Function 2 ....Planting
- User Count ....1 - 5
- Topology ....On Ground
- Ability of Geometry ....Stable

In conclusion, urban furniture design criteria should be revised according to necessities of nowadays. Also this change needs to affect designers. Design education should include these necessities and educate new designers with these design parameters.

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A LENS MODEL APPROACH ON ESTIMATING PERCEPTIONS OF TURKISH PRIMARY SCHOOL STUDENTS AND ARCHITECS ON IDEAL PRIMARY CLASSROOM SETTINGS

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ABSTRACT

The study has been performed on primary school students and designers (architects) in order to define the components and design factors of the ideal classroom setting in which primary school students will willingly study and to decide which setting and design factors are most suitable for effective learning. To this end, the following hypothesis was developed: "*Classroom setting perceptions of students and designers differentiate in terms of setting and design factors*". Visuals of 20 different classroom settings from Turkey - the physical properties of which were pre-defined in detail by the control group - were used in the scope of the study. A questionnaire form was used to collect students' and designers' (architects') evaluations on the visuals; collected data were analyzed by using statistical methods. After that, a Lens-Model was adopted to enable comments on the primary classroom setting. The Lens-Model enables comparison of evaluations of different groups such as students and designers in relation to the same space. Also the present study defined setting and design factors suitable for positive learning by using the preferences of the students and designers. Findings and obtained perceptions of classroom setting were determined to differ from each other in terms of environmental and design factors. These variances also indicated age and education factors as two parameters of significant importance for perception studies. In addition, the study revealed that the Lens-Model method enables successful comparisons between the preferences of different groups such as students and architects related to the same setting.

Keywords: Spatial perception, comparison of preferences, positive learning, classroom design, Lens-Model

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1. INTRODUCTION

Architects create spaces that provide environmental and social conditions that are designed to enable individuals to conduct their lives without feeling great physiological, social and psychological discomfort; these spaces are also designed to enable optimal efficiency in work. Spaces are designed to serve this objective certain physical and psychological needs of human beings. There is a relationship how spaces affect their users, and the efficiency of the work undertaken in that space. Spatial design should consider potential effects on inhabitants and provide the physical arrangements that will make positive contributions in the use purpose of the space. At this point, it is necessary to determine user demands as well as user needs. Today, the human-space relationship is considered an important issue and studies are conducted on qualified space arrangements in line with these user demands. While architectural studies mainly focused on the structural properties of spaces up to the 1980s, the psychological effects of space on individuals has come into consideration in the last three decades. In this scope, studies have been conducted on how the physical properties of a space affect individuals. Spatial perception and spatial psychology are considered important factors in increasing the efficiency of the work undertaken in that space and studies are conducted on qualified space arrangements. Detection of qualified space properties for specific use is only possible via environmental-behavioral studies that facilitate consideration of user opinions. Environmental-behavioral study is a type of study which contributes to the design process by considering user opinions on designed environments and analyzes and studies the interaction and behavior of humans, as well as the consistency-inconsistency between human and environment. Literature studies on environment-behavior are primarily conducted on adults; however, there are some studies - although quite limited in number - with children. Children represent a significant part of the world population and, yet, cannot always make themselves heard. According to Thorbjorn (1992), the physical environment of children evolves on the basis of basic needs; environment - as a whole - tends to be a unit of houses and neighbourhood. Studies on children as a user group generally focus on homes and school buildings. These studies reveal the socio-demographic characteristics of children and interpret findings by relating them to these socio-demographic characteristics. There are studies on the detection of socio-economic structure, facilities provided for children and differences in the spatial perceptions of children. In a study on the effects of socio-economic level on environmental awareness and environmental academic achievement (Uzun and Sağlam 2005), findings indicated that environmental awareness differed on the basis of socio-economic structure and that there was a direct correlation between environmental awareness and academic achievement. Socio-economic structure is an important factor in such studies. In addition to these studies, there are others that investigate the effects of color, illumination and seating arrangements on student achievement and behavior. Conclusions from these studies indicate that such similar physical characteristics as color, illumination and seating arrangement do affect student achievement and behavior. There are a number of studies on the ergonomics and suitability of furniture used by children. In addition to these, there are limited number of studies that analyze both the effects of spatial components on a child's perceptions and emotional reactions, under the topic of environmental psychology-architectural psychology. In particular, studies on educational sciences have shown that different spatial arrangements affect student achievement. In this context, it is expected that the design and arrangement of classroom settings, in line with students' demands will have positive effects on learning motivation. Arrangement of physical variables appropriate for positive learning in the classroom setting can be successful through the production by a space designer of solutions related to disciplines such as classroom management, educational sciences, etc. In designing the classroom setting - a multidimensional issue - the space preferences of different user groups (particularly students and classroom teachers) appropriate for optimal learning conditions should be clearly defined; user preferences that are different should be compared; and the common denominator of user evaluations should be defined.

2. CONCEPTUAL FRAMEWORK and HYPOTHESIS

In this study, classroom setting parameters based on user perceptions were analyzed to determine the setting arrangements (setting and design factors) optimal for constructive learning. The hypothesis developed for this objective is "*Classroom setting perceptions of students and designers differentiate in terms of setting and design factors*". Using the method known as Lens-Model in the literature, and which enables comparison of evaluations made by different user groups in relation to the same space; the present study defined setting and design factors appropriate for positive learning, by comparing the preferences of the experimental group composed of designers and students.

3. LENS-MODEL APPROACH

Environment-behavior studies are conducted using one or several methods and techniques like questionnaires, visual questionnaires, simulation techniques, interviews, physical tracks documents and behavioral observations (Başkaya et al. 2003). In such studies, it is possible to collect information about/to evaluate only the opinions of one user group. However, in practice, many spaces may be used by many different user groups. Lens-Model is a method that enables comparison of different user group evaluations of one space, providing input data for architects in the design process. First developed by Brunswik (1955) for environmental perception studies and then modified by other researchers, Lens-Model is used in areas from medical treatment to weather forecast. In recent years, it has been used in architecture as well (Dinç and Yüksel, 2010, Douglas and Gifford 2001, Gifford et al. 2002). Gifford recently improved this model and adapted it into architecture as a model used only by designers. On one hand, the conventional Lens-Model includes ecological reality, which constitutes a connection set composed of real measurements and observable characteristics of the related environment. On the other hand, Lens-Model is a method of using evidence, which is the connection between observable characteristics and individual evaluations. By adapting it, Gifford re-arranged Lens-Model according to evidence use for two different groups, the evaluations of whom are taken as a basis. Results are derived from the idea that there is no absolute truth but the evaluations of two groups. Lens-Model can also be explained as a model that enables association of subjective spatial judgments with objective data of this space.

4. METHOD

Directed at primary school classroom settings, this study was conducted on primary school 2nd grade students (n=189) and university 4th grade (8th semester) architecture students (n=76), randomly selected from the regions representing low and high socio-economic groups of Turkey. Fourteen academicians lecturing in the architecture faculties of various universities were selected into the “control group”. A questionnaire was given to students to enable them to evaluate the classroom setting using pre-defined concepts and to the control group to enable them to define objective characteristics of the study classroom settings. In the scope of the questionnaires, 20 classrooms (with different properties) from ten public and private primary schools were selected. In choosing these 20 classrooms, special attention was paid to select samples (small and large classrooms with different forms and dimensions, equipped with a variety of furniture and with varying design) that would represent primary school classroom settings in Turkey. To obtain generalizable results for primary classroom settings, the questionnaire was given to students (taught in similar physical environments) attending official primary schools located in different socio-economic regions and planned according to the typical primary school projects that represent the majority of Turkish Schools. Students attending the schools of 20 classrooms were excluded from the experimental group. Since experimental groups included young students, short video shoots (nearly one minute) were used in addition to photos so as to clarify spatial perception. This is the first study to use this method with Lens-Model (Arslan 2010).
Questionnaires were given in two parts. In the 1st part, the questionnaire was given to 2nd grade students and architects and in the 2nd part, to the academicians lecturing in the architecture department (control group). The physical properties of 20 classrooms included in the questionnaire process were defined in detail in line with the data provided by the control group. Presenting a pilot study previously carried out with the researcher, the first part of the questionnaire form was given to 2nd grade students before they entered classrooms for evaluating. The second part of the questionnaire included questions on classroom evaluations. Two photos of a classroom setting and four questions related to this classroom were presented in each page of the questionnaire. Taking into consideration that the study’s target group was composed of young people, scripts were used (in the light of pilot applications) to ensure clear explanation of the concepts in question. In the questionnaire given to classroom teachers, they were asked to evaluate - in line with their educational background - classroom settings in terms of primary school students. Like the questionnaire given to the 2nd grade students, each page of the architects’

questionnaire presented one photo and four questions related to each classroom. In the questionnaire given to students and architects, they were asked to answer the questions by scoring on a Likert-type scale between two opposite answers. Before entering data into analysis program, scores collected from the scale were redefined in numbers with the help of a transformation scale. In the questionnaire given to the control group, they were asked to define objectively the physical properties of the internal classroom environments used in the study. To define properties of a specific space, literature studies use questionnaires based on semantic differentials to collect individual opinions. A questionnaire based on semantic differentials was also used in the present study to define the objective properties of a classroom setting. Adjective pairs used in the questionnaire were selected on the basis of the properties of classroom settings; criteria to be considered in primary classroom designs; characteristics of children. Adjective pairs related to internal classroom environments used in the study. The control group was asked to evaluate the spatial properties of each classroom using the adjective pairs defined and, their answers were collected using a 5-point Likert-Type scale (Arslan, 2010; Arslan and Ceylan 2012).

5. RESULTS and DISCUSSION

According to this study, the general findings are given below;

- This study, conducted with two different age groups, included a control group composed of experienced architect academicians so as to ensure determination of the design factors of the questioned classroom settings objectively and to increase the study's reliability. Students and architects, who were only asked their conceptual opinions about the space-, were related to the classroom's spatial properties, which were defined by the control group.
- In the present study, the preferences of the 2^{nd} grade students were related not to physical properties included in the spatial properties list, but to spatial properties with conceptual character, an indication that spatial properties with conceptual character should also be used in studies.
- In this study, different primary classroom settings were selected to define the properties of a classroom setting in terms of primary school students. To find a classroom setting to serve as a solid example of rule compliance, primary classrooms were accessed, regardless of the age group. While evaluations were made on the basis of photos in similar studies in the literature, this study based evaluations on short video shoots to ensure better visualization of spaces by small children. In addition, to shorten the questionnaire administration process (to prevent students from getting bored), the study was limited to 20 classrooms, the lower limit applied in such studies.
- The story-making method was also used to ask questions to the young children who participated in the study. This study has also brought a new

perspective to Lens-Model design; using a model not previously seen in the literature: evaluations were made on the basis of short video shoots of the spaces subjected to evaluation.

- The results of present study indicate that the number of spaces evaluated in the scope of these studies should be higher than those of architectural components/spatial properties and the efficiency level of architectural components/spatial properties on questioned concepts should be defined more precisely in statistical terms. The Lens-Model method enables a comparison between the evaluations of different groups about the same space and provides information that can serve as input data for architects in design process.

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