HEAT TRANSFER COEFFICIENT ANALYSIS FOR THE OLD HOUSE IN THE WALLED CITY OF NICOSIA IN CYPRUS

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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^2K for the exterior adobe walls, 0,27 W/m^2K for the ceiling, 0,13 W/m^2K for the roof and 2,0 W/m^2K 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.

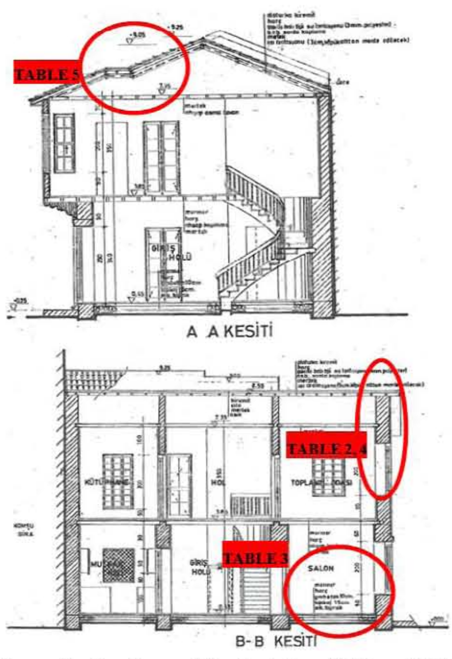

Figure 2. Sections of the building (Aktaç, 2008)

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/m^{2}K)	$U_{ceiling}$ (W/m^{2}K)	U_{roof} (W/m^{2}K)	U_{window} (W/m^{2}K)
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
$1/a_i$ m^{2}W/K **$1/a_e$ m^{2}W/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/m^{2o}C.

a_i, a_e: Internal and external surface heat transfer coefficients, W/m^{2o}C.

d_1, d_2, …, d_n: Thickness of the layers constituting the opaque component, m.

λ_1, λ_2, …, λ_n: Thermal conductivities of the layers constituting the opaque component W/m^{2o}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^{2}K, for the ceiling is 0,27 W/m^{2}K, for the roof 0, 31 W/m^{2}K and for the windows is 2,0 W/m^{2}K. 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/m^{2}K)
1	Gypsum Plaster	0,04	0,35	U_W=1/(1/a_i+ d_1/ λ_1+ d_2/ λ_2+ d_3/ λ_{3+1}/a_e)
2	Adobe	0,65	0,40	=1/(0,13+0,04/0,35+0,65/0,40 +0,04/0,35+0,04)
3	Gypsum Plaster	0,04	0,35	=1/2,02 =0,49

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/m^{2}K)
1	Silt	0,15	2,1	U_W=1/(1/a_i+ d_1/ λ_1+ d_2/ λ_2+ d_3/
2	Pumice Gravel	0,15	0,70	λ_{3+} d_4/ λ_4+ d_5/ λ_5+1/a_e)
3	Concrete	0,10	1,74	=1/(0,17+0,15/2,1+0,15/0,70+0,1
4	Glass Fiber Foam	0,06	0,04	0/1,74+0,06/0,02+0,03/1,40+0,02
5	Mortar	0,03	1,40	/3,5+0)
6	Marble	0,02	3,5	=1/3,587 =0,27

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/m^{2}K)
1	Thermal Insulation Smooth Boards	0,05	0,02	U_W=1/(1/a_i+ d_1/ λ_1+ d_2/ λ_2+ d_3/ λ_{3+} d_4/ λ_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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