DETERMINATION OF COMFORTABLE OUTDOOR SPACES IN MASS-HOUSING SETTLEMENTS IN TERMS OF WIND AND NOISE CONTROL

FATİH KİRAZ[1]
GÜLAY ZORER GEDİK[2]
NEŞE YÜĞRÜK AKDAĞ[3]
BEKİR ŞENER[4]
RAŞİDE ÇAÇAN[5]

ABSTRACT

In recent times, pre-analysis and necessary precautions and measures on wind and noises are ignored and cannot be reflected in design process of indoor and outdoor spaces. In mass housing apartments, the comfort and quality of living conditions decrease due to the wind and noise level especially in balconies, terraces, gardens and swimming pools etc. The quantitatively and empirically testing of building models according to the physical conditions in regard to the wind and noise parameters directly affect the formation of building blocks in design process. In Yıldız Technical University, a research project supported by TUBITAK has been completed in order to determine the most suitable settlement formations and to develop a methodology for a design guide to deal with the controlling of the wind and noise conditions. This paper aims to present spatial formation solutions to provide usage areas in maximum comfort level due to the conditions of different climate zones and different building orientations in terms of wind and noise in Istanbul case.

Key words : Mass-housing, noise, wind, optimum area

[1] Fatih Kiraz, Nuh Naci Yazgan University, Department of Architecture, KAYSERİ
[2] Prof. Dr. Gülay Zorer Gedik, Yıldız Technical University, Department of Architecture, İSTANBUL
[3] Prof. Dr. Neşe Yüğrük Akdağ, Yıldız Technical University, Department of Architecture, İSTANBUL
[4] Assist. Prof. Dr. Bekir Şener, Yıldız Technical University, Department of Naval Architecture and Marine Engineering, İSTANBUL
[5] Raşide Çaçan. Yıldız Technical University, Department of Architecture, İSTANBUL

1. INTRODUCTION

Wind and noise are both physical environment factors that cause serious problems in urban areas and should be considered in design and planning process. They also have many negative effects on human health and comfort. Nowadays, unhealthy structures and cities are ensued as a result of ignoring the importance of wind and noise and they directly influence the public and environmental health.
The number of mass-housing projects still increases day by day to meet the demand for housing quickly and economically that increase subject to rapid population growth and urbanisation. In recent mass-housing areas, some application samples ensue with different problems because an effective study is not realized for physical environmental factors apart from conformity of zoning laws.
As a result of not considering important sufficiently the wind characteristics of regions and interaction with noise sources results mass-housing areas are formed with uncomfortable conditions in terms of wind and noise.
Unavailable open, semi-open areas, balconies and terraces due to wind; not opened windows for natural ventilation; physical ailments and psychological disorders due to indoor and outdoor noise pollution are major problems originating from wind and noise in mass-housing areas. Depending on the placement of structures with increasing of wind speed or mass-housing areas exposed to the wind, uncomfortable wind conditions, occur in open-semi open public areas used especially in warm seasons. These areas cannot be used by reason of wrong design and applications. Allowing the wind into the structure is one of the effective and economical methods for natural ventilation. It cannot be possible to use this positive effect of the wind due to the windows and openings that cannot be opened because of the excessive speed and blowing number of wind.
One of the major sources of noise pollution is road noise. In mass-housing areas that designed without considering the position of the road according to settlement area and traffic density serious noise problems are occurred. Structures with negative influence on human health are built by reason of ignoring necessary precautions on design process of mass-housing, around roads, on layout plan works and directly in structure.
In Yıldız Technical University, a TUBITAK supported research project has been completed with the aim of developing a method that will guide the designer in determining stage of most suitable settlement formations in terms of wind and noise control (Zorer Gedik et al. 2014). Within the project, it is targeted to determine common uncomfortable open spaces that both wind and noise problems overlap and to design optimized barriers and to generate suitable settlement formations for mass-housing. Simulations are realized in five different climatic zones (cold, hot humid and hot dry, temperate humid and temperate dry). In this paper, it is aimed to determine maximum comfortable usage areas in different noise levels and settlement formations with using the wind data of Istanbul.

2. METHODOLOGY, DATA AND ACCEPTANCES

Methodology of this study consist of five stages as creating settlement scenarios for mass-housing, determining data and acceptances related with wind and noise, simulations in two different software, determining comfortable areas in terms of wind and noise and determining the common comfortable areas with overlapping for wind and noise.

2.1. Creating The Settlement Scenarios For Mass-Housing

Within this paper, the size of unit house that will be used in analyzes is taken as 150 sqm according to size of residential zone determined by TOKİ Housing Development Fund as an upper limit for credit support at housing and infrastructure (Anon 1997). Based on this, the width, length and height of house is specified as 10x15x3m, respectively.

The joining types of unit house are defined as point-type block and linear block, fig. 1. For point-type blocks, the quad-joining is selected due to being the most applied type by TOKİ mainly for economic reasons. In linear blocks, different joining types are created at least quad-joining according to specified land data. Analyzes are realized for four different number of floors (3, 5, 7 and 10) that effects the results directly.

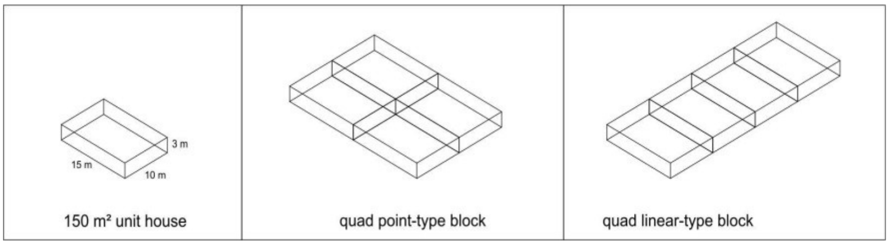

Figure 1 : The joining types of buildings

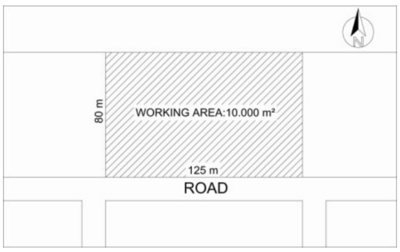

Figure 2 : The position and dimension of land

1 hectare (10.000sqm) land is assumed as working area, fig. 2. The width and length of the land is determined as 80x125m, respectively. The possible road alternatives are defined from one-way to four-way (parallel to short edge, parallel to long edge, at short and long edge). However, because it directly affects the wind and noise analysis and in order to limit the duration and number of analyzes, the road was selected on the south parallel edge of the land. "Planned Area Type Zoning Regulations" is used to determine the front, side and back yards of the houses (Anon. 1985). The 25 different mass-housing settlement scenarios are shown in fig. 3.

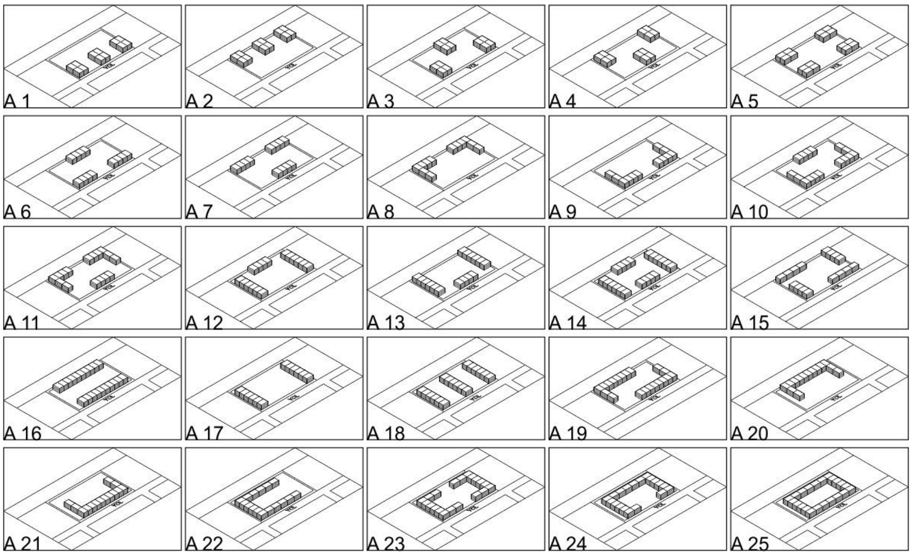

Figure 3: Mass-housing settlement scenarios (A1-A5: Point type blocks, A6-A25: Linear type blocks)

2.2. Data and acceptances related wind and noise

Within the project, used data and acceptances are explained below.

- The road noise level is taken as 55-65-75-85 dBA (1m distance), respectively.
- The road is assumed at the south side of the houses.
- Road width is 14m for 55-65 dBA sound levels and 21m for 75-85 dBA sound levels. Lane width is 3.5m, refuge and pavement widths are 2m.
- Sound absorption of ground is accepted as 0.6 (medium absorption).
- In simulations, NMPB-Routes-96 method is used for noise propagation (Braustain+Berndt GMBH. 2012).

- The wind data of İstanbul is transferred into the simulation software.
- In simulations, grid spacing is taken as 5m and the height from ground 1.5m.
- Acceptable noise level is 55 dBA for daytime (Anon. 2010, Anon. 1996).
- In this work, the wind data for Istanbul is used that obtained from daily and hourly measuring during 30 years by Turkish State Meteorological Service (Anon. 2013).
- Acceptable maximum wind speed is taken as 5m/sec for sitting and walking (Caniot et al. 2011).
- Percentage of annual hours of exceedance frequency of acceptable wind speed is accepted as F(V>5) < %5 for sitting and F(V>5) < %10 for walking. F states the percentage of annual hours of exceedance frequency (Caniot et al. 2011).
- Calculation height is 1.5m from ground.
- Because of the wind data used in the software ought to be in .tab file format, all data obtained from Turkish State Meteorological Service for 30 years was compiled and converted to related file format. Wind measurements are realized at 10m height in Turkey. Therefore, a reference point at 10m height was defined in software and calculations are realized according to this reference point (Urbawind 2013).

3. DETERMINATION OF COMFORTABLE OUTDOOR SPACES OF SETTLEMENT ALTERNATIVES IN REGARD TO WIND AND NOISE

3.1. Determination of comfortable spaces in terms of wind and noise

To determine the comfortable spaces in terms of wind and noise, the process steps were followed for each settlement alternatives, as shown below:

- “Urbawind” software for wind simulations and “Soundplan” software for noise simulations were used.
- Wind data for 30 years were transformed to proper format and entered to Urbawind and maps were obtained that shows comfortable areas in terms of wind.
- Noise maps were prepared based on road noise as 55-65,75-85 dBA, respectively.
- Tables were created for all results which show the percentage of comfortable areas in total open areas.
- The maps obtained for wind and noise were superposed to determine common suitable usage areas for both factors. Some examples of the comfort maps prepared for 25 settlement alternatives according to different number of floors, noise levels and activity type are shown in fig. 4.

Percentages of comfort calculated from common comfort maps in terms of wind and noise for 25 settlement type are presented in table 1. To create the table, ratio by percentage of common comfortable area to open area (calculated as difference of total land area and house area) was calculated.

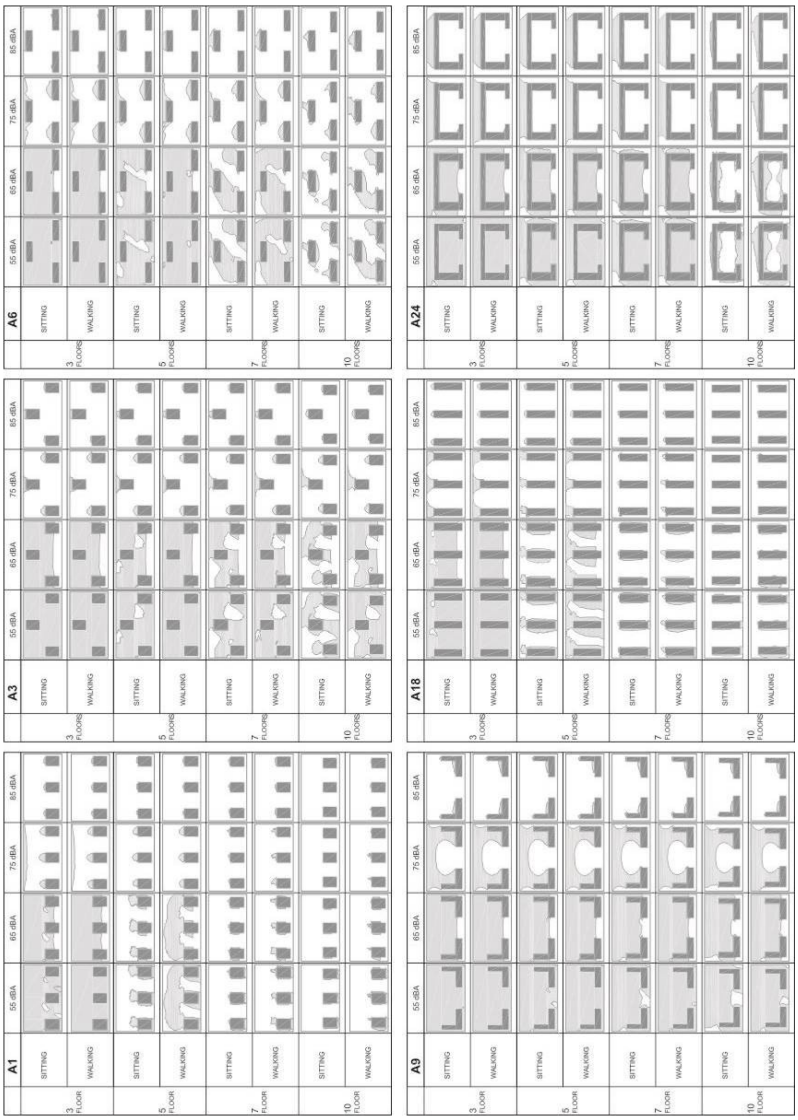

Figure 4: Common comfort maps for wind and noise

SETTLEMENT TYPE	NOISE LEVEL	WALKING 3 FLOORS	WALKING 5 FLOORS	WALKING 7 FLOORS	WALKING 10 FLOORS	SITTING 3 FLOORS	SITTING 5 FLOORS	SITTING 7 FLOORS	SITTING 10 FLOORS
A1	55 dBA	96	20	6	3	100	63	10	7
	65 dBA	81	14	2	1	83	55	6	3
	75 dBA	13	4	1	0	13	5	3	1
	85 dBA	1	1	1	0	1	1	1	0
A2	55 dBA	100	90	76	55	100	100	99	77
	65 dBA	71	62	49	33	71	71	71	49
	75 dBA	4	6	8	11	4	7	9	14
	85 dBA	3	3	2	2	3	3	2	3
A3	55 dBA	100	92	76	52	100	100	91	78
	65 dBA	79	70	57	37	79	79	72	59
	75 dBA	5	5	5	7	5	5	6	7
	85 dBA	1	2	2	1	1	2	2	1
A4	55 dBA	89	30	17	6	100	74	30	15
	65 dBA	65	25	14	4	76	53	23	11
	75 dBA	4	5	3	0	4	5	5	2
	85 dBA	2	2	1	0	2	2	2	1
A5	55 dBA	99	93	74	44	100	100	98	87
	65 dBA	81	77	59	36	82	81	80	71
	75 dBA	8	10	12	11	9	10	13	18
	85 dBA	3	4	5	4	3	4	5	5
A6	55 dBA	100	85	51	18	100	99	82	38
	65 dBA	86	73	42	12	86	85	69	29
	75 dBA	16	13	11	6	16	15	14	11
	85 dBA	2	3	3	2	2	3	4	3
A7	55 dBA	76	42	14	18	100	65	33	27
	65 dBA	64	38	11	14	79	54	29	22
	75 dBA	8	7	4	6	9	9	8	8
	85 dBA	4	5	3	4	4	6	6	5
A8	55 dBA	99	87	80	63	100	99	87	79
	65 dBA	70	58	80	41	72	70	58	52
	75 dBA	4	8	10	11	5	8	11	14
	85 dBA	4	6	7	6	4	6	7	7
A9	55 dBA	100	98	93	88	100	100	99	96
	65 dBA	86	85	84	80	86	85	85	85
	75 dBA	51	49	50	51	51	49	50	54
	85 dBA	3	2	2	2	3	2	2	2
A10	55 dBA	100	71	65	33	100	98	89	60
	65 dBA	84	58	55	26	84	83	72	50
	75 dBA	44	7	29	13	44	8	41	28
	85 dBA	3	3	5	1	3	3	6	6
A11	55 dBA	82	41	13	8	100	68	26	18
	65 dBA	62	28	9	0	77	48	27	11
	75 dBA	9	8	3	0	12	10	8	2
	85 dBA	4	5	2	0	4	6	6	1
A12	55 dBA	94	89	81	45	100	100	93	68
	65 dBA	70	64	67	29	76	75	75	45
	75 dBA	10	11	13	4	11	12	14	11
	85 dBA	3	4	5	3	3	4	5	5
A13	55 dBA	92	22	6	1	100	39	14	3
	65 dBA	64	14	3	0	79	29	8	2
	75 dBA	18	6	2	0	24	7	3	1
	85 dBA	2	2	0	0	2	2	1	0
A14	55 dBA	91	40	7	0	100	55	23	0
	65 dBA	75	34	4	0	82	47	16	0
	75 dBA	22	9	1	0	24	13	4	0
	85 dBA	4	4	0	0	4	5	3	0
A15	55 dBA	67	50	18	1	100	61	28	3
	65 dBA	58	43	13	0	84	53	21	2
	75 dBA	16	14	6	0	27	16	9	1
	85 dBA	3	5	2	0	4	6	4	0
A16	55 dBA	91	41	11	15	100	79	28	28
	65 dBA	80	34	7	9	87	69	20	21
	75 dBA	35	17	5	6	35	28	16	15
	85 dBA	6	9	5	6	6	10	11	12
A17	55 dBA	100	75	97	65	100	78	99	98
	65 dBA	78	78	74	51	78	78	77	75
	75 dBA	7	7	6	3	7	7	7	6
	85 dBA	1	1	1	1	1	1	1	1
A18	55 dBA	97	31	11	5	100	62	18	11
	65 dBA	73	24	8	2	78	48	13	7
	75 dBA	13	7	1	0	14	11	3	0
	85 dBA	2	2	0	0	2	2	1	0
A19	55 dBA	92	43	19	7	100	56	28	14
	65 dBA	75	30	12	4	100	41	19	9
	75 dBA	41	16	6	1	48	23	11	5
	85 dBA	6	8	3	0	6	8	5	2
A20	55 dBA	99	91	84	55	100	99	92	78
	65 dBA	69	63	58	36	70	69	64	53
	75 dBA	6	10	13	10	6	10	13	16
	85 dBA	6	9	12	10	6	9	12	14
A21	55 dBA	94	34	15	29	100	48	26	41
	65 dBA	84	28	12	24	89	41	21	34
	75 dBA	71	27	12	24	71	37	20	32
	85 dBA	53	26	12	24	53	34	20	32
A22	55 dBA	77	52	16	12	100	65	36	24
	65 dBA	71	45	12	8	86	59	30	19
	75 dBA	45	32	9	6	45	42	22	13
	85 dBA	14	13	6	1	14	14	11	4
A23	55 dBA	98	88	72	50	100	98	90	67
	65 dBA	84	76	63	43	85	84	76	58
	75 dBA	38	31	25	16	39	36	32	27
	85 dBA	14	15	13	3	14	15	15	11
A24	55 dBA	98	92	87	26	100	97	92	48
	65 dBA	80	74	69	13	81	78	74	32
	75 dBA	25	22	21	4	25	23	22	10
	85 dBA	19	19	17	3	19	19	19	9
A25	55 dBA	100	78	18	13	99	84	45	18
	65 dBA	84	70	13	9	87	75	38	12
	75 dBA	69	65	12	9	70	67	34	11
	85 dBA	65	63	12	9	65	65	34	11

Table 1: Percentage tables of common comfortable areas for wind and noise

3.2. Review of common comfortable outdoor spaces in terms of wind and noise
To review the results shown in table 1, for each settlement alternative, the results obtained according to number of floors were averaged for different noise levels. Results are presented as graphics and reviewed as follows.

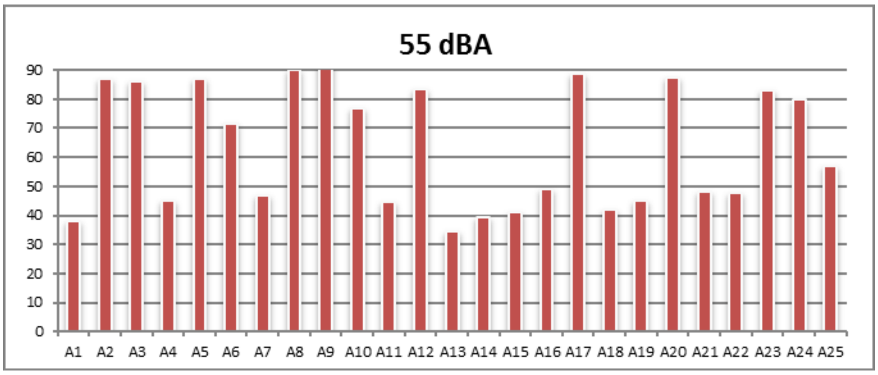

Figure 5: Average comfort percentages of wind and 55 dBA noise level results

- 55 dBA noise level is also the comfort limit value, so 100% comfortable results were obtained for all settlement alternatives. Therefore, the percentages shown in fig. 6 are values obtained depend on wind. As it can be seen from the figure, best results are provided by A9 and A8 settlements with L-shaped buildings (SW-SE and NE-NW corners of buildings are closed) and A17 settlement that the blocks vertical to road are arranged as wall along the short edge of the land (alternative which N and S directions are completely empty and not used block part that can create canal and strait effect). Additionally, alternative A20, that arranged to close N, NE and NW directions, the dominant wind directions of Istanbul, shaped like a continuous wall and S direction keeps opened, provides very high performance in terms of wind. The alternatives with lowest suitable area percentage are A13, that arranged as linear blocks vertical to road and block part at south that creates canal effect; and A1 that the point-type blocks are aligned at the south of land.

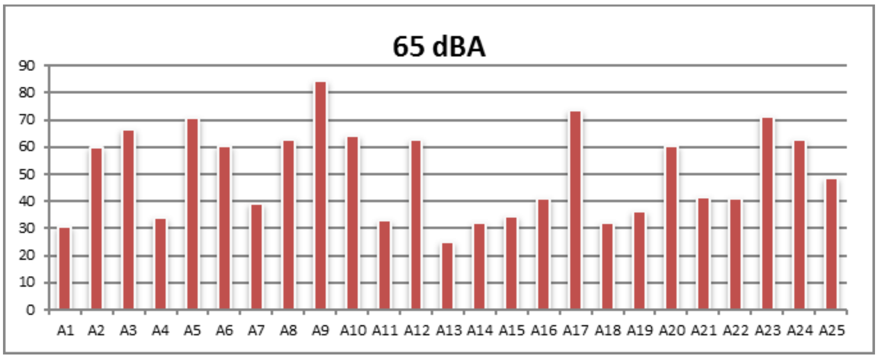

Figure 6: Average comfort percentages of wind and 65 dBA noise level results

- At 65 dBA noise level, the percentage of comfortable area changes between 70-88%. The most suitable settlement type is again A9 like 55 dBA level. A17 with blocks vertical to road provides high percentage of comfortable area. Conformably to 55 dBA level, at 65 dBA, percentage of comfortable area is mainly subjected to wind. But it can be seen that the percentages of comfort obtained from noise starts to effect the common comfortable areas percentages. For instance, while A20 type settlement with very high percentage of comfort at 55 dBA decrease to the lower level in comfort ranking, settlements shaped like linear walls and closed from the road side, like A23, come to the higher ranks. A1 and A13 types are again the settlements that have lowest suitable areas percentages.

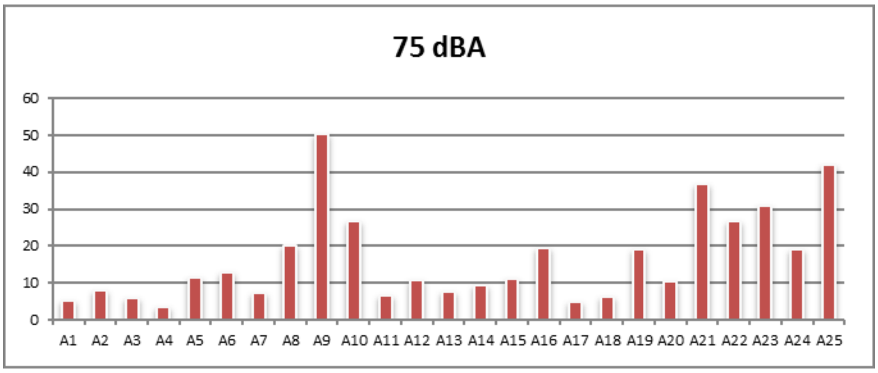

Figure 7: Average comfort percentages of wind and 75 dBA noise level results

- As can be seen from fig. 8, A9 type settlement provides again maximum comfort percentage with 50% at 75 dBA as that 55-65 dBA. A25 and A21 types with atriums are the settlements that provide higher percentages as 42% and 37% as against the other alternatives. With increasing the noise level, it can be seen that common suitable comfort percentages are considerably decrease especially in the settlements with point-type blocks. With the effect of comfort percentages obtained from noise, while the performance of the settlements that north side is closed like A20, decrease to the lower level; settlements with atriums that close the road side completely like A21 and A25 come to the higher ranks.

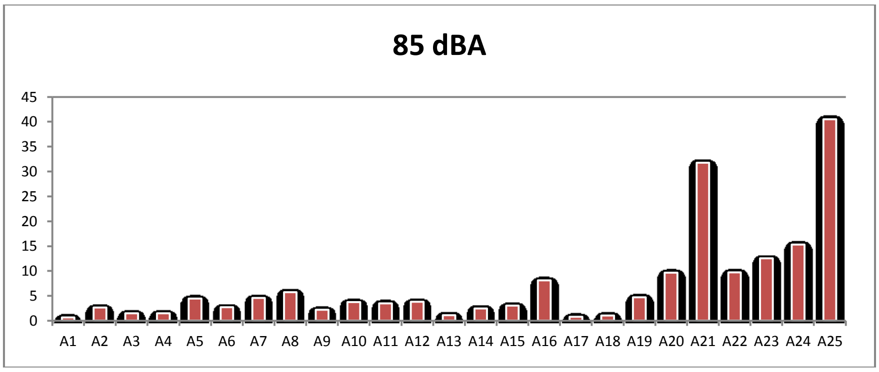

Figure 8: Average comfort percentages of wind and 85 dBA noise level results

- At 85 dBA noise level, high decrease occurs in all settlement alternatives. Comfort percentages show decrease till 1%. Except A21 and A25 types settlements with atrium that close the road side completely, comfort percentages decrease under the level of 20%. Comfort percentages obtained from noise effects the results significantly.

General review of the results is given below:

1. In the settlement options that the blocks arranged vertically to the road (north-south direction), the comfort ratio decrease. As a result of acting the blocks that are parallel to the road as noise barrier, comfortable areas increase behind the buildings. Therefore, improvements occur in comfort values for alternatives with blocks parallel to road.
2. Better comfort results appear in alternatives with L-C-U shaped buildings than point-type and linear block layouts. This situation is related with sheltered areas created by layout alternatives. For all noise levels under 85

dBA, A9 type settlement with L-shaped buildings shows the best performance in terms of wind and noise. But, at 85dBA noise level, C and U type settlements provide better results because of closed road side.

3. Increasing of number of floors causes decreasing of comfort level. The decrease on comfort level occurs as a result of reflections on building surfaces, dispersions and directions created by building forms. From the perspective of noise control, the main reasons of this situation are the distance of buildings to road, distance of one another and reflections from buildings surfaces. As for the perspective of wind, both increase of number of floors and structuring on the north or south side that creates canal or strait effect decrease the comfort level considerably.

4. CONCLUSION

Wind and noise, physical and environmental factors that directly affect user comfort. Due to both factors, outdoor and semi-outdoor spaces are not used efficiently. This situation is also valid modern-day mass-housing. Both wind and noise are important components of building physics in the field of specifying the area for structuring, orienting structures in terms of climatic factors, designing of structure shape and positioning according to other structures. In compliance with the analyze results of 25 settlement alternatives realized using climatic data of Istanbul, linear type layouts provides better results compared to point-type blocks. In block type settlements, layouts parallel to road continue along the south side have more comfortable areas than vertical settlement alternatives. Increase in the number of floors of buildings effect negatively both wind and noise comfort. Therefore, buildings with lower number of floors should be preferred. Position and configuration of buildings should be determined considering dominant wind direction and annual blowing distribution. As a result of the study, it was found that the performance of comfortable open spaces is not sufficient provided by components such as structure configuration, position and height. For this reason, additional precautions are needed to provide common comfortable areas in terms of wind and noise. Within the scope of an completed research project in Yıldız Technical University, several studies are carried out to determine optimum percentage of common area in terms of wind and noise comfort and the design of optimum wind and noise barrier that will be applied to settlement types that cannot provide requested percentage. In project, all simulations and calculations realized for different cities which have characteristic features of five climatic zones and it is only exemplified for Istanbul in this paper. By means of the data that will be presented as a result of the project, it will be possible to select suitable configuration in regard to wind and noise depends on wind data of current city, position of the design area according to road and the noise level of the road.

Acknowledgement

This paper is written within the TUBITAK 1001 project and authors would like to acknowledge TUBITAK because of their support.

REFERENCES

- Anon.1985, The Zoning Regulation of Planned Areas, The Official Gazette, No: 18916, Turkey,02 November 1985 (in Turkish).
- Anon. 1996, Future Noise Policy, European Commission Green Paper, Com (96), Commission of E.C., Brussels, Belgium.
- Anon., 1997, Prime Ministry Housing Development Administration Regulations For The Implementation Of The Public Housing Loans, The Official Gazette, No: 23019, (14.06.1997), Turkey, (in Turkish).
-Anon, 2010, The Regulation of Environmental Noise Assessment and Management. The Official Gazette, No:25862, (04.06.2010), Turkey, (in Turkish).
- Anon. 2013. Turkish State Meteorological Service Archive.
- Caniot, G. , Li, W. , Dupond, G. 2011. Validations and applications of a CFD tool dedicated to wind assessment in urban areas, 13th International Conference on Wind Energy, Amsterdam, The Netherlands.
- Braustain+Berndt GMBH, SoundPLAN Manual V 7.3, 2012.
- UrbaWind User manual, 2013.
-Zorer Gedik G, Yüğrük Akdağ, N, Kiraz, F, Çaçan R., Şener, B.. Optimization of mass-housing settlements in terms of wind and noise control, Tübitak 1001 Project, Pr. No: 111M560, 2012-2014 (in