

EVALUATION OF USER COMFORT IN TUNNEL FORMWORK HOUSING AREAS: Izmir as a Case Study

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Abstract

Houses are spaces where we spend most of our lives, meeting our accommodation needs and reflecting us and our personality. The tunnel formwork systems are effective in house production. They appeal to the people in different social status varying from high-incomers to low-incomers from the city center to the peripheries of city. Based on such determination, the satisfaction of house user set forth the main line of work. For this purpose, six parameters have been ascertained to determine the user's comfort, by interrogating the comfort of interior space in the houses: The thermal comfort, visual comfort, acoustic comfort, humidity and moisture control and design quality. With the purpose of interrogating the user's satisfaction, four mass housing areas constructed with tunnel formwork system in Izmir have been investigated. These are: Gaziemir Emlak Bankası Houses, TOKI Uzundere Houses, Mavişehir Stage I and Mavişehir Soyak Houses. After providing general information about all these mass houses, the surveys applied to the users have been evaluated.

Keywords: tunnel formwork; housing; user comfort; user satisfaction.

INTRODUCTION

The comfort conditions of living spaces influence our physiological, as well as psychological health to a great extent. The comfort status can be defined as the whole conditions in the living environment to which the people can adapt to by spending minimum energy, and is psychologically satisfied (Oral & Efe, 2010). Today, people spend almost 90% of their time indoors and more than half of this time takes place in homes. It is therefore make important to identify the parameters that influence the comfort of inhabitants in their homes (Frontczak , Andersen, & Wargocki, 2012). To create personalized, healthy, secure, comfortable, and productive environments with low energy and environmental impacts is main object of architectural design to meet the expectations of growing housing areas. To be able to obtain a healthy environment for the user, and optimal performance in his activities, the conditions in the indoor environment must be adjusted as to ensure the desired thermal, visual and acoustic conditions, in other words, the conditions of thermal, visual and acoustic comfort (Koclar Oral, Koknel Yener, & Tamer Bayazit, 2004)

That the resources are limited in the developing countries, while the demand for energy grows fast, further increase the importance of energy efficiency strategies. Basically, designs with minimal negative impacts on the environment and minimal energy and resource consumption over the building's life cycle come into prominence (Vezzoli & Manzini, 2008). With proper decisions, the heating, cooling and ventilation of the building should be addressed within a

holistic design approach within the framework of location, design, building technique and life cycle of the structure.

In Turkey, a considerable portion of total energy consumption is used in buildings especially for heating (Manioglu & Yilmaz , 2006). In this context, with the TS 825 (Standard for Heat Insulation Rules for Buildings in Turkey), which published in 1998 and make Heat Insulation mandatory in new buildings as of 2008, the energy saving buildings were started to be constructed, by way of using materials in compliance with the standards, proper detail solutions and heat insulation materials.

In addition to design of building, used materials and construction techniques and their quality has significant role to obtain comfortable indoor environment. Most of the time building envelope, which is the totality of (building) elements made up of components which separate the indoor environment of the building from the outdoor environment, becomes most important part of the building to resist the environmental effects especially in big cities as a result of unplanned and/or high density building stock and increase of population.

When housing stock is evaluated in İzmir; it is seen that multi-storey and most of the time adjacent apartment blocks made of reinforced concrete continues through the streets in city center. Another common housing typology is again multi-storey but separated or semi-separated apartment blocks with similar design, built on a defined site and surrounded by a fence. This housing areas are placed relatively distant to the city center. The tunnel formwork is one of the most preferred construction systems in such housing areas in Turkey and similarly in Izmir today. They appeal to the people in different social status varying from high-incomers to low-incomers from the city center to the peripheries of city.

In this context, four different mass housing areas built with tunnel formwork system in Izmir have been selected as cases of the paper to evaluate user comfort. These are: Gaziemir Emlak Bankasi Houses, TOKI Uzundere Houses, Mavisehir Stage I and Mavisehir Soyak Houses. Cases are selected on purpose to be able to make some comparisons and evaluate the effect of heat insulation regulation. Two of the housing areas had been built before thermal insulation regulation 2008 (Gaziemir Emlak Bankasi Houses Stage II and Mavisehir Stage I) and one of them built for higher incomers (Mavisehir Stage I) (Figures 1&2).



Figure 1: Gaziemir Emlak Bankasi Houses (Stage II) – (Source: Ozgul Y. Karaman).



Figure 2: Mavisehir (Stage I) houses (Source: Ozgul Y. Karaman).

TOKI Uzundere Houses, which are built by considering low-incomers and Mavisehir Soyak Houses, where higher incomers live are built after the regulation (Figures 3&4).



Figure 3: TOKI Uzundere Houses (Source: Dilek Tezgelen).



Figure 4: Soyak Mavisehir Houses (Source: Ozgul Yilmaz Karaman).

Six parameters have been ascertained to determine the User's comfort, by interrogating the comfort of interior space in the houses: The thermal comfort, visual comfort, audio comfort, humidity and moisture control and design quality and the satisfaction of house user. Evaluation of the questionnaire results that held in four areas set forth the main line of work. In other words, user comfort has been studied preferentially and then tunnel formwork system has been questioned in terms of it provides and not provides.

DEFINITION OF COMFORTABLE HOUSE

With its simplest definition, house is the accommodation protecting the individuals from outside effects and climate conditions. The qualified houses should be the structures which ensure interior comfort by controlling the outside environment conditions, which take maximum advantage of daylight, enabling natural ventilation, and do not give harm to the individuals and the environment with its insulation materials.

Designing energy efficient and comfortable buildings requires harmonizing the complex interactions of architecture, construction and building service engineering. In other words, besides being comfortable, a house is expected to meet some social (security, socialization and expressing oneself... etc.) and aesthetic requirements of its user. Focusing on satisfaction of the user means that the indoor climate is a key for a holistic design approach. Only a satisfied user will not intervene with the designed energy concept or the indoor climate control; dissatisfaction results in multiple system interventions which may cause waste of energy and sometimes even damage to building envelope components. Satisfaction with the indoor environment also increases working productivity or enables effective recreation of residents. (Christoph, Kunzel, Herkel, & Holm, 2012)

"In the reality of everyday life conditions, overall comfort certainly depends upon thermal comfort but not only this; discomfort originates from other stimuli too, like odors, light, or noise. In houses and buildings, light can be changed, modulated, and fairly well adapted to the inhabitants or occupants. Noise is more difficult to adjust because it is often not under control, especially in

working conditions. In addition, noise and temperature often interact because air conditioning and ventilation increase noise for a thermal requirement” (Pellerin & Candas, 2003).

According to the literature survey by Frontczak and Wargocki (Frontczak & Wargocki, 2011) there are 4 main indoor environmental parameters; thermal, visual, acoustic environment and air quality to obtain a satisfying indoor environment. Thermal comfort was perceived by building occupants to be of greater importance for comfort compared with visual and acoustic comfort and good air quality. The literature survey also suggested that apart from indoor environmental parameters there are other factors that can influence satisfaction with the indoor air quality, among others, type building, occupants’ control over the indoor environment and outdoor climate, including season (Frontczak , Andersen, & Wargocki, 2012).

On the other hand, even though the requirements of user are met according to the regulations or standards, result may not satisfy all the building occupants. People and their responses may differ and therefore not all are satisfied by the same conditions. Also, other requirements like architectural design, social facilities, and neighborhoods can influence satisfaction from physical conditions within indoor environments (Frontczak & Wargocki, 2011).

Within the scope of research, the parameters which have been questioned by the survey in order to ensure interior space comfort are as follows:

- Thermal comfort
- Visual Comfort
- Acoustic comfort
- Humidity control
- Design Quality

EVALUATION OF RESULTS

As mentioned before, today, the tunnel formwork systems gain increasingly more recognition and are preferred to meet the expectations of wide range of projects. The projects are quite similar in terms of architectural design (spatial organization, room geometry and dimensions etc.) and material use as a result of used construction system. But they are different in terms of site organization, location in the city, security facilities, spaces for the social activities within the area and user profile. For example, Uzundere houses are constructed as part of urban transformation project for people who were living inappropriate conditions, and supported by Government. While Soyak houses are constructed for high-incomers and projects are advertised as “luxury” by the construction company (Real Estate Investment Trust). All in all, this system, appealing to a very large community from high-incomers and to low-incomers has been investigated, and the house satisfaction levels were tried to be measured on the examples in four different house regions in the province of Izmir.

The evaluation studies in the four selected regions have been conducted in line with the following parameters:

- i. User profile
- ii. Measurement of user’s level of awareness for the building system
- iii. Determination of satisfaction from space and of design quality
- iv. Evaluation in terms of physical features of structure
 - a. Thermal comfort
 - b. Humidity, moisture control
 - c. Acoustic comfort
- v. Survey evaluation on research areas, environmental expectations, sense of belonging and security.

User Profile and Awareness of the Building System

Since Mavişehir Stage I and Gaziemir Emlak Bankası houses were built before 2008, the age average of users is 50 and above. On the other hand, since Toki Uzundere and Soyak Mavişehir houses are new areas, the age averages are as low as between 30 and 40. Other qualifications of the users that joined the survey are summarized in table 1. The users of all the four building groups are aware that their building was constructed with tunnel formwork technique. They state that they preferred tunnel formwork building for its earthquake safety (Table 2).

Table 1: Summary of user profile of the studied housing areas (Source: Authors).

STUDIED MASS HOUSING AREAS	USER PROFILE											
	Sex		Occupation				Age of User		Duration of Usage	House Status	Using Hours	
	Male	Female	Public Worker	Freelancer	Housewife	Laborer and Other	Age - Above 50	Other	Mean Living Duration	Own House	18.00 and later	Other
	%	%	%	%	%	%	%	%	Years	%	%	%
GAZİEMİR II.STAGE	76	24	46	13	14	27	42	58	8,5	73	78	22
MAVIŞEHİR I. STAGE	55	45	19	34	13	34	48	52	11,3	89	51	49
TOKİ UZUNDERE	66	34	9	18	32	41	17	83	1,5	85	50	50
SOYAK MAVIŞEHİR	61	39	15	41	8	36	18	82	3,5	68	68	32

Table 2: Information about building system (Based on most preferred choices of the questionnaire) (Source: Authors).

STUDIED MASS HOUSING AREAS	INFORMATION ABOUT BUILDING SYSTEM		
	WHAT IS BUILDING SYSTEM	BUILDING SYSTEM PREFERENCE	REASON FOR PREFERING TUNNEL FORMWORK BUILDING
GAZİEMİR EMLAK BANKASI HOUSES	TUNNEL FORMWORK 67%	STEEL 37%	EARTHQUAKE SAFETY 59%
MAVIŞEHİR STAGE I. HOUSES	TUNNEL FORMWORK 86%	TUNNEL FORMWORK 43%	EARTHQUAKE SAFETY 40%
TOKİ UZUNDERE HOUSES	TUNNEL FORMWORK 67%	TUNNEL FORMWORK 54%	EARTHQUAKE SAFETY 50%
SOYAK MAVIŞEHİR HOUSES	TUNNEL FORMWORK 64%	TUNNEL FORMWORK 75%	EARTHQUAKE SAFETY 40%

Determination of Satisfaction from Space and of Design Quality

The living spaces in Gaziemir and Mavişehir Stage I houses are rectangular, and the balcony can be functionally used from the living room and kitchen. In Gaziemir, because the long sides of Living Rooms are in parallel with the road, they receive adequate daylight. On the other hand, since the narrow sides of Mavişehir Stage I. houses are in parallel with the road, this increases the depth of room and prevents it receiving adequate daylight.

The measurement restriction of tunnel formwork hinders flexibility in designing the sizes of space to meet the changing needs. For instance, in Mavişehir Stage I. houses, the kitchen of 2+1 (2 bedrooms and 1 living room) flat and the kitchen of 4+1 flat and their bathrooms are in the same size. However, given the number of persons living and the rate of using the space, the bathroom of 2+1 flat will not be sufficient for the users of 4+1 flat. Therefore, not the quality of life, but only the number of rooms increase in such houses manufactured under the name of “lux.”

Table 3: Satisfaction from interior space in house examples (Source: Authors).

STUDIED MASS HOUSING AREAS	SATISFACTION FROM SPACE										
	Satisfaction From house & Surrounding Area		Functionality		Material, detail & workmanship Quality			Size of Space		Repair Status	
	Satisfied	Not Satisfied	Yes	No	Good	Mediocre	Bad	Satisfied	Not Satisfied	Repaired	Other
	%	%	%	%	%	%	%	%	%	%	%
GAZIEMİR STAGE II	94	6	89	11	37	59	4	83	17	62	38
MAVIŞEHİR STAGE I	98	2	91	9	37	52	11	87	13	76	24
TOKİ UZUNDERE	62	38	94	6	9	55	36	79	21	72	28
SOYAK MAVIŞEHİR	82	18	87	13	49	36	15	67	33	37	63

As for Toki Uzundere houses, the curve of satisfaction is lower than Gaziemir and Mavisehir I, since they are houses of low-incomers. Because the population living in the house is more, satisfaction from the size of space is lesser. The residents of Toki Uzundere are not satisfied from the House and the surrounding in comparison to other areas. It is because they cannot adapt to the life in apartment, since they are brought to here by force due to urban transformation.

In Soyak Mavişehir blocks, the space sizes and material qualities are not sufficient when compared with the prices of houses. While the expectations of users here are higher, such expectation was only visually met by good environment, landscaping, safe site, etc., but it could not be met in terms of the functionality, building physics, space sizes and material quality. As the expectations of the users could not be met, increase is seen in dissatisfaction.

Evaluation in Terms of Physical Features of Structure

When the survey results are evaluated in terms of building physics, problems related to thermal comfort, humidity and noise are observed in all of the four research areas.

Table 4: Thermal Comfort Evaluation (It has been evaluated over 5.) (Source: Authors).

STUDIED MASS HOUSING AREAS	THERMAL COMFORT		
	Penthouses	Mezzanine Floors	Ground Floors
	Between 1-5	Between 1-5	Between 1-5
GAZİEMİR II.ETAP	2,4	3,6	3,7
MAVİŞEHİR I. ETAP	3,5	4	4
TOKİ UZUNDERE	3	3,2	2,6
SOYAK MAVİŞEHİR	3,5	4,4	–

It is observed that the satisfaction is less in Gaziemir Emlak Bankası houses for thermal comfort. Although heat insulation was applied, the insulation is not adequate, since it was made before the heat insulation regulation (table 4).

On the other hand, in Toki Uzundere houses, although the heat insulation calculations and application is expected to be made according to the new the regulation, the thermal comfort is low especially in penthouses. Despite the related projects indicate insulation from inside, it was not implemented due to lack of control during the construction process. Also, that the houses are situated on a high hill and open to wind should be considered as one of the factors of such dissatisfaction.

As for Mavişehir Stage I. houses, though they were built before the regulation on heat insulation, they seem good in terms of heat insulation. The reason for this might be that the heat insulation was made properly, that the central heating systems are present, that such systems are operated by the site management consciously, and that the income levels of house owners are high so as to meet the heating expenses. In order to figure out this, the energy performances of such buildings must be measured and the pictures of thermal camera must be examined.

It has been detected that the connection details, implementations related to insulation prepared according to the heat insulation regulation are unsuccessful, and there are labor errors, and that the control mechanism during the construction process was not conducted to sufficient extent. The tunnel formwork, which does not have any difference from a conventional structure, is built with fine construction structure solutions through tender procedure and subcontractor companies. The auto-control mechanisms do not work correctly, due to the pressure of time and lack of qualified workers, that the control engineers are officers affiliated to TOKİ, that it is not mandatory to make the projects approved by the related professional chambers, and also that they are outside the building control system. This causes emergence of problems in fine structure solutions in implementations such as insulation which do not tolerate any error. The transmission of sound between the rooms has been determined as problematic in all of the four house areas.

As in can be seen in the table 5, during surveys, serious problems as regards with the humidity and moisture control have been detected in four housing areas. Most of the problems are derived from insufficient detail and workmanship. The cracks formed in the walls due to the

functioning of precast components as different from the tunnel system are effective on humidity and moisture. In addition, the failure to close the holes caused by the conics and stabs used in the conjoining of tunnel formworks and insulate such holes gives rise to the humidity problem in the outer fronts.

In Soyak Mavişehir Houses, the roof's being terrace increase the humidity and moisture problem. That the humidity reach to the levels of 66% in the ceilings, despite of the two layers of water insulation is a serious problem. The surveys reveal that the insulation details specified in the project were not implemented and they were not appropriately audited and the preference of terrace roof is a mistake.

Table 5: Humidity & moisture control problems (Source: Authors).

STUDIED MASS HOUSING AREAS	HUMIDITY – MOISTURE CONTROL PROBLEMS		
	PENTHOUSES	MEZZANINE FLOORS	GROUND FLOORS
GAZİEMİR EMLAK BANKASI HOUSES	IN THE CEILING 58% IN THE WALL 33%	IN THE WALL 16%	IN THE WALL 16%
MAVIŞEHİR STAGE I. HOUSES	IN THE CEILING 50% BOTH IN THE WALL & CEILING 25%	IN THE WALL 10%	NO PROBLEM
TOKİ UZUNDERE HOUSES	NO PROBLEM	IN THE WALL 25% BOTH IN THE WALL & CEILING 5%	IN THE WALL 37.5%
SOYAK MAVIŞEHİR HOUSES	IN THE WALL 34% BOTH IN THE WALL & CEILING 66%	IN THE WALL 62.5% IN THE CEILING 27.5%	-

Noise problem has been observed in all of the four mass house examples. In that Gaziemir houses are near to the airport, the disturbance due to noise seems very high. Since Toki Uzundere houses are on the Highway, the disturbance due to noise is high here, too. However, it is striking that the disturbance is more in the mezzanine floors in four research areas. In tunnel formwork applications, investigations must be made on the noise insulation, and especially on the sound transmission through building elements. Monolithic characteristic of the construction system and solid structure of the concrete material cause structure-borne sound transmitted through the floors and walls.

When the acoustic comfort of penthouses are examined in the table 7, it is seen that the disturbance is most in Gaziemir Emlak Bankası and Toki Uzundere houses and that there is noise transition problem between the lift machinery room and the flats. The least disturbance is seen in Mavişehir Stage I. houses. The users are aware that there is noise problem due to the tunnel formwork, but they do not regard it as a big problem, since they are generally families over the age of 50 and with no children. In Soyak houses, there is no noise problem that mentioned by users, because the lift wells are insulated and they do not touch the same wall with the bedrooms.

Table 6: Acoustic comfort evaluation for the exterior noise (Source: Authors).

STUDIED MASS HOUSING AREAS	DISTURBANCE FROM EXTERIOR NOISE					
	Penthouses		Mezzanine Floors		Ground Floors	
	WIND	NOISE	WIND	NOISE	WIND	NOISE
	%	%	%	%	%	%
GAZİEMİR STAGE II	67	75	8	50	23	30
MAVIŞEHİR STAGE I	100	NONE	50	25	50	NONE
TOKİ UZUNDERE	60	40	70	15	100	12,5
SOYAK MAVIŞEHİR	80	40	25	12,5	NONE	NONE

Table 7: Acoustic comfort evaluation for the interior noise (Source: Authors).

STUDIED MASS HOUSING AREAS	DISTURBANCE FROM INTERIOR NOISE								
	Penthouses			Mezzanine Floors			Ground Floors		
	LIFT	BETWEEN THE ROOMS	BETWEEN THE FLATS	LIFT	BETWEEN THE ROOMS	BETWEEN THE FLATS	LIFT	BETWEEN THE ROOMS	BETWEEN THE FLATS
	%	%	%	%	%	%	%	%	%
GAZİEMİR STAGE II.	92	92	100	41	84	84	38	76	61
MAVIŞEHİR STAGE I.	25	75	50	5	40	65	0	100	50
TOKİ UZUNDERE	80	60	60	20	68	90	38	88	100
SOYAK MAVIŞEHİR	0	40	80	3	42	44			

Survey Evaluation on Research Areas, Environmental Expectations, Sense of Belonging and Security

When the survey results are examined in terms of sense of belonging, expectations from the surrounding of buildings and security; it is seen that although Soyak Mavişehir Houses are protected by security guards, the sense of belonging and perception of satisfaction is most in Gaziemir houses and Mavişehir Stage I houses. According to this, it can be concluded that in mass housing areas, the concept of quarter which is united with the domain with its small shops (newspaper dealer, flower store, etc.) –where neighboring relationships can be obtained – should be maintained, instead of being isolated with walls. As in Mavişehir Stage I houses, the entry and exit of cars are monitored through the private security stands positioned on the entry of streets and remote controlled barriers, and the cameras inspire feeling of security.

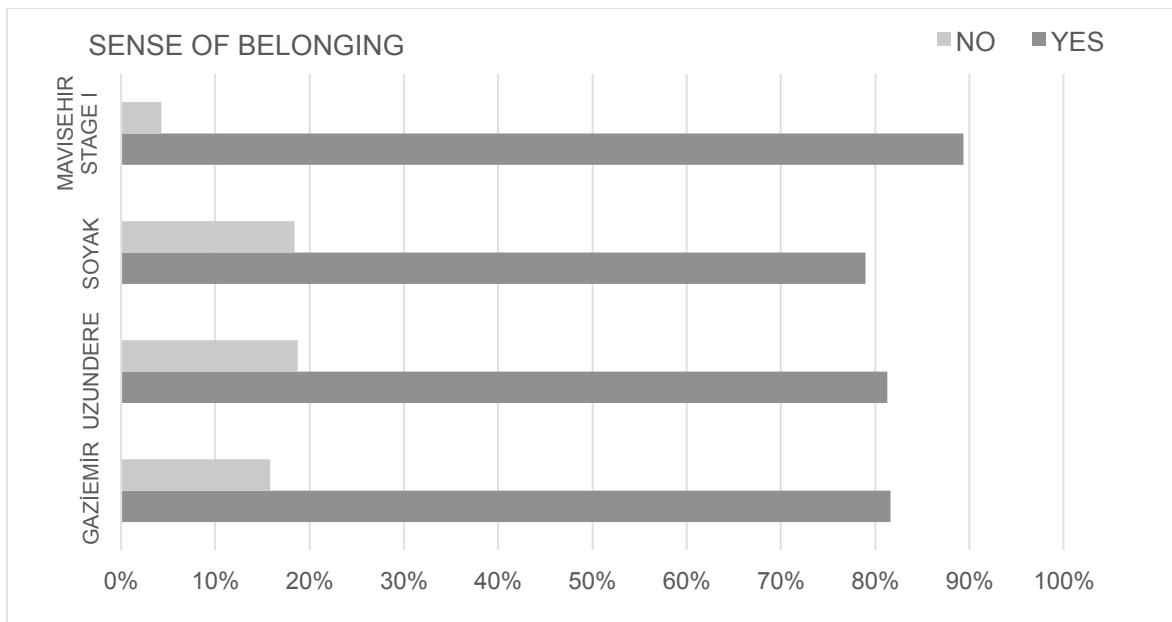


Figure 5: Comparison of sense of belonging in the studied housing areas (Source: Authors).

The comparative investigation reveals that building’s entry hall, access to the lift, caring for the disabled, being located on the corner, no parking lot problem, the user’s stating the reason for owning a house in this site as the security and special social facilities suggest that the users are satisfied from their houses. That the neighbourhood relations are weak, there is much circulation of tenants and that the working young population do not have time to use the social facilities have been observed as the problem of Soyak houses. Gaziemir Stage II. Houses are successful in that they try to ensure front aesthetics in structure to reasonable extent with being 5-storey and in that having green areas between blocks.

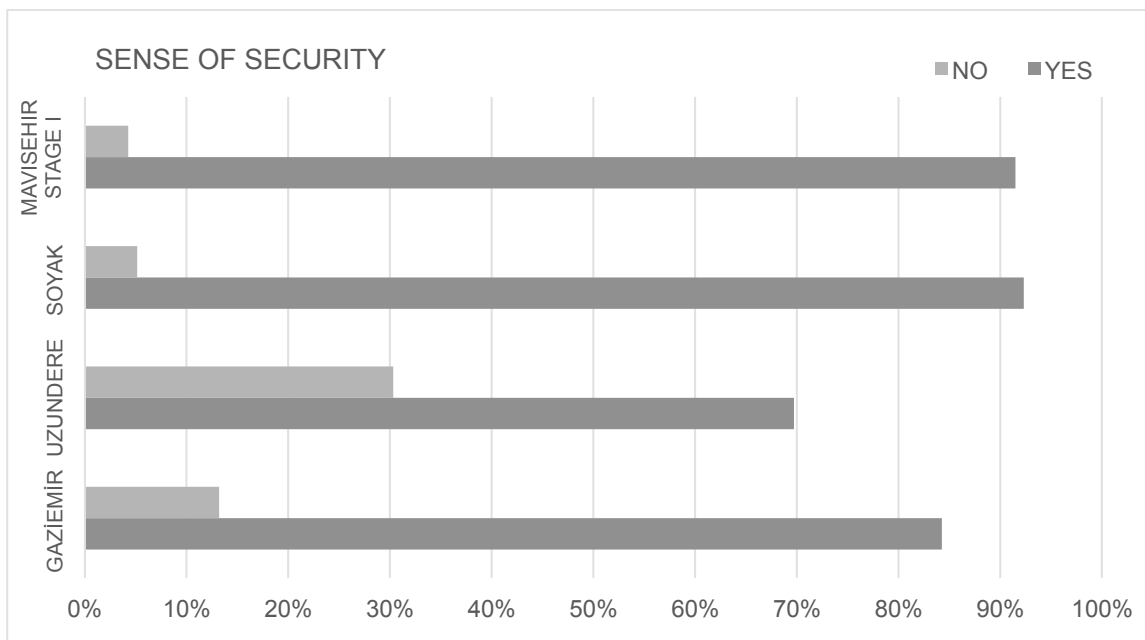


Figure 6: Comparison of sense of security in the studied housing areas (Source: Authors).

Soyak Mavişehir users feel themselves most secure, while the users of TOKİ Uzundere do not feel themselves secure. In such case, it can be seen that one of the most important differences of houses built as “lux houses” is the security parameter. The security rate is much low in TOKİ Uzundere houses as a result of being a new settlement place, situated on the side of highway and being detached from the city.

In all four housing areas, as to the aesthetical requirements do not meet the expectations, either. The building entry hall, landscaping, common areas of Soyak and Mavişehir Stage I Houses are successful, while they are insufficient in terms of outer front aesthetic. Gaziemir Emlak Bankası Houses have less floors and are designed in a more humanly scale. Protrusions were tried with an aim to ensure aesthetic on the front, but since there is no building entry hall, and the landscaping is not sufficient, they do not fully meet the aesthetical expectations. On the other hand, Uzundere Houses were built under the urban renewal project, and they meet only the ‘accommodation’ needs, and disregard the aesthetical requirements.

The decisions to be taken at the design stage affect the quality of space and user’s satisfaction to a significant extent. The user must be known in order to produce correct and functional solutions which meet the requirements. Even if the user is not known, a good prediction must be made to realize the suitable designs in line with their culture, family style, education, level of income. Maybe for this reason, many urban transformation project do not achieve success. With its social house (low-cost housing) projects realized typically in all corners of the country, TOKİ puts into the background user specific features, environmental and climate values.

Today, it is expected from TOKİ, Real Estate Investment Trusts or big private construction companies to build sustainable structures in harmony with the environment, using the renewable energy sources. We see that the certificates such as BREEM, LEED, applied across the world, have recently been taken into consideration in the building of houses in our country. Nevertheless, a very big proportion of energy is consumed by houses and the precautions to be taken here are of vital importance. The data of land must be analyzed thoroughly to advantage from it to the maximum level. For example, TOKİ Uzundere Houses are located on a quite sloped area. In such case, the rain waters might be collected and used in the irrigation of garden, with a system to be developed. In our country, with very big potential of sun and wind energy, it is expected that the renewable energy implementations are increased, the awareness of engineers and architects are raised on this issue, and that they train the investors and the public on this with the projects they will realize.

Although many technical requirements are stipulated in the regulations, there are defect in the implementation. For instance, in the regulations, there is a requirement to build chimney to each independent section other than the kitchen, but in tunnel formwork systems, it is very difficult to ensure this, and therefore it is drawn in the projects, but neglected during the implementation (example of TOKİ Uzundere Houses). Likewise, even though the regulations necessitate solutions caring for the disables, many points are omitted in the implementation. In Gaziemir and Mavişehir Stage I Houses, the lift on the ground floor is accessed by a stairs of 7-8 steps.

CONCLUSIONS AND EVALUATIONS

The errors in the design criteria directly affecting the user comfort, wrong manufacturing and detail solutions, incompliance with the regulations and the deficiencies in auditing reduce the life quality. In this part of the study, assessments are made under 4 titles (design, tunnel formwork construction system, energy consumption and building physics), with some general suggestions to increase the comfort conditions of the houses.

House Design

- The mass houses must meet the environmental expectations during the design stage and the socio-economic status of the users must be determined accurately. The space needs must be determined accurately and a sense of belonging must be created.
- During the design, the opinions of community engineers who respond to the socio-cultural needs of users must be taken to render the house a 'warm home'.
- The mass houses, and especially those which are manufactured by the state are generally built based on the stereotype projects. In our country, divided into four different climate regions, the projects must be designed by caring about the differences in cultural and social structures. The local climate conditions must be taken into consideration during the designs. For example, yard-type plans can be designed for hot regions, while more compact structures facing the south must be recommended for the cold regions.
- In mass houses, the next step after catching up with the standards in terms of the building physics is to evaluate the environmental expectations depending on the income level and educational background of the users. For instance, in a structure of 'lux' segment, while a parking lot of three cars must, pool and spa center are an option for users having a certain income level, the public areas such as children's park, gangways must absolutely be included.

Structural System

- While evaluating the user comfort in tunnel formwork systems used in the production of mass houses, decisions must be taken on structure design, as well as on different issues from environment to energy, and on different scales from status plan to point details.
- In tunnel formwork systems, maximum span between load bearing vertical panels is limited to 5.50m – 6.50m by depending on the size of the formwork. The span size can be formed with supplemental components and molds. However, since the system is constructed without beams, the floor thicknesses increase very much and the system ceases to be economic.
- Possibility of using partition walls within the system should be considered to obtain some flexibility of spatial organization.
- If it is possible, house should not be placed on ground floors in tunnel formwork buildings, and the entry hall must be allocated to the machinery room, housekeeper's flat and the parking lot. In designing the lifts, easy access by the disabled must be ensured, and the lift wells must not be designed to share the same wall with the bed room walls, but to share the walls of spaces such as the bathroom, store, fire ladder, etc.
- In mass houses produced with tunnel formwork, it is accepted that the private social facilities of the site carry the houses into the 'lux' segment. However, the users complain about the small size of apartments, failure to meet the needs, and the insufficiency of interior fixture. It will challenge the system to endeavour to produce with tunnel formwork system to designs which will meet the demands for bigger length in meter, 80 m² living room, higher ceiling, bigger windows and door gaps, bath for each room, changing room, smart house automation, etc. It is because, the concept rendering a structure 'lux' can also be achieved with fine structure solutions. The tunnel formwork system which was started to be applied for the purpose of economic and serial production, must serve for the original purpose. It should be preferred in the production of social house (low-cost house), without sacrificing from the comfort conditions in terms of the structure physics.

Energy Consumption

- Comfort in the interior environment must meet the appropriate other physical conditions, depending on the user expectations. At this point, by using renewable energy sources,

consuming energy in an efficient way, and taking the insulation measures against the current environment conditions, the quality and life of building must be increased.

- In the new structures to be built after 2008, the implementations such as giving Energy Identity Certificate to the buildings, applying the legal legislation such as the Energy Performance Regulation for all buildings in Turkey, and performing heat insulation in the structures must be encouraged.
- The Energy Identity Certificate obligates that the energy class must be C Class at the lowest in the new buildings, while the target must be to design houses in A Class using the renewable energy sources. Furthermore, interest-free loan is given to the users who will insulate their current building and the system amortize its own cost within 3-5 years. In structures initiating the implementation, the 'calorimeter' implementation which calculates the fuel consumed by the houses with central heating system and figures out the payment to be made shall be one of the most important steps in energy saving.
- The awareness of the public must be raised on issues such as energy efficiency, renewable energy and insulation, and training programs must be developed with the joint efforts of the related ministries, schools, media and nongovernmental organizations.
- The methods such as BREAM and LEED, measuring the environmental impacts of buildings through an evaluation of life cycle are applied across the world. BREAM and LEED do not only mean 'green building', but they also mean economic, cultural sustainability. With the goal of creating a method in line with the conditions of Turkey, the universities, and institutions such as TUBITAK, TSE must conduct studies to determine national standards.
- The architectural designs may be developed to take into consideration the environmental factors, and support the using of sustainable energy sources, and student contests on this may be opened with the support of professional chambers and universities. For instance, the project on 'New Istanbul' with one million population designed on the shore of Black sea might be considered as an advantage to be used as pilot region where the energy efficient policies can be implemented. On the other hand, in İzmir, the TOKİ houses to be built in Alsancak Ege district and Bayraklı district, determined as the urban transformation area, is a good opportunity for implementing the energy efficiency policies.
- The technologic infrastructure, the walls' becoming thinner, etc. increased the energy consumption, and as a result of this, it became necessary to construct and operate buildings which generate their own energy. The houses increasing become structures which target a more comfortable life, protect the environment and the ecologic balance, and use renewable materials. In mass housing projects, regional heating systems should be installed instead of a separate heating system for each building, by taking into consideration the renewable sources such as geothermal, wind energy, and sun.
- Today, the 'two-way meter', deployed in only industrial structures and aiming to allow to buildings to generate its own energy, and purchase it from the mains when it is not adequate, and sell the surplus to the mains, might be actively used in the buildings to ensure significant saving on energy. The surplus of energy generated by the buildings might be sold over the Internet for energy need of 'hybrid vehicles', so that each structure will have its own 'energy station.'

Building Physics

- In quality houses, every individual deserves to sustain a healthy life. The factors such as heat, noise and humidity control details directly influencing the user comfort, it must be necessary to use it in all structures. The producer and implementing companies must be held liable for wrong detail solutions and errors in labor. Selection of quality material and labor must not be sacrificed in the sake of being economic. The errors in labour eventually bring about structural errors. For example, water insulation not made according the

project and failure to build drainage channels lead to water related and humidity problems in the basements and roof parapets. The paint of outer front torn apart, the walls or ceilings become mouldy, the foundation irons are subjected to corrosion to the extent endangering the carrying capacity of structure. In heat insulation, the selection of material in wrong thickness increases the heating expenses and affects the comfort level of interior space. Since the TOKİ and Real Estate Investment Trust projects are outside the control of structure auditing system, the heat insulation visit, and foundation insulation visit cannot be made for such structures. It is open to debate how sound results such insulation projects might yield, since they are totally under the initiative of project team. Thermal pictures of these structures must be taken, and they must be controlled in terms of structure physics, and energy identity certificate must be arranged for them.

- The details solving the problem of noise transition between the floors must be developed. An insulation material like heraklith must be placed between the floor and the cement finish, parquet must be mandatory in the rooms, the interior space must be covered with partition curtain and the walls must be covered with plaster boards, and the transition of noise between the floors must be prevented with the application of suspended ceiling. This system section solution influencing the floor height, influence also the formwork height and building regulations.
- The surveys revealed out that one of the reasons of devastations in Gölcük and Van earthquakes in our country is the corrosion of foundation irons. As an infrastructural service, the ground water must be controlled with drainage channels at the conjunction points of parcel and road and in the foundation elevation of the buildings. In the scale of building, accumulation and concentration of excessive moisture must be prevented, by designing permeable mantle systems with ventilation function without any obstacle. Furthermore, transpiration of building must be hindered, and the contact of foundation with the ground water must be cut by way of bundling.
- Considering that the implementation errors are inevitable, terrace roofs must be avoided from, if possible.
- With the rising life standards and the developing house building technology, the structure materials also change. In the contemporary world, many structure components such as furnishing, plaster, bricks, paint and leveling concrete can be made as self-insulated by way of adding chemical ingredients and using along with the materials containing fibres.

The tunnel formwork systems are preferred commonly in house production and paper is focusing on creating more peaceful environments that built by tunnel formwork system to increase the user satisfaction. In brief, projects must aim to produce mass houses which are considered in connection with its surrounding, have plan solutions with multiple options, have good positioned status plan, are insulated against heat, noise, humidity and moisture and whose designs are addressed as a whole and create a sense of belonging.

ACKNOWLEDGEMENTS

This paper is derived from the MSc thesis entitled "EXAMINATION OF USER COMFORT IN TUNNEL FORMWORK HOUSING AREAS: IZMIR AS A CASE STUDY" by Dilek Tezgelen under supervision of Ozgul Yilmaz Karaman, submitted to the Dokuz Eylul University, Graduate School of Natural and Applied Sciences.

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