CONTEMPORARY TIMBER WINDOW SOLUTIONS IN TRADITIONAL TURKISH HOUSES

FATİH YAZICIOĞLU

ABSTRACT

Traditional Turkish houses are known with their unique architectural character within a wide perspective, comprising different detail solutions. The character of these houses is mainly shaped by the place and context they are located. Geographical conditions, such as climate, sun, and wind, together with the cultural factors dominate the planning of these houses in different scales. Organization of the facade and especially the windows and doors, are some of the important attributes of these houses. Within this framework, this paper aims to question and analyse timber window solutions of traditional Turkish houses. Because of the different configurations of traditional Turkish Houses this paper is limited with the houses located in Istanbul, Bosporus. Firstly, traditional wooden houses, called 'köşk', of Bosporus will be introduced. The visual relation of the house with the outer world and mahalle, starts from the road they are located in with their entrance door and continues through their inner hall 'sofa'; and continues back to the road with the views from the windows. This introduction shows the importance and dominance of the windows in traditional Bosporus houses. The timber window solutions of these houses allow the visual relation with their wide openings which bring several challenges about the details of the windows. The weight of the sashes is an example for these challenges. Without a mechanical support operating the sashes are a hard and tiring activity, hence sometimes counterbalance systems were used in the original details. Today in the restoration and reconstructions by using contemporary technological solutions these kinds of side effects can be surpassed. In the paper, a traditional house reconstruction in Bosporus is introduced by focusing its timber window solutions. In this project, the form and size of the windows are the same as the original traditional house so that the visual relation of the house with its surrounding, and the overall original character of the building continues. By the implication of contemporary detail solutions for its timber window, like the usage of hydraulic pumps, double glazing, aluminium roller shutters, etc. its performance is improved significantly. The performance of the window system is evaluated and tentative proposals for the reconstructions, and restorations will be made.

Key words: windows; u-values; emissions; counter-balance systems, Traditional Turkish houses

1. INTRODUCTION

The design of one building element critically affects the function of the entire building. External walls, which are parts of the envelope systems, are mainly designed to be a barrier between the natural outdoor and the artificial indoor, and they may perform a structural role (Binan, 1975). On the other hand, external walls are far more inclined to be pierced with holes, better known as windows and doors (Harris, 2001). Windows are the most critical parts of the envelope as several different performance requirements are expected from them. They are both expected to stay as an opening but on the other hand to stop unwanted conditions of the natural environment (Pearce, 2007). The resulting output is a complex building element with several components.

Bosporus has its unique architecture with unique window details. After 1983 it has been protected by a special law through which new building constructions are forbidden (TBMM, 1984). It is only possible to make restoration or reconstruction of old buildings. The details used in the reconstructions of the Bosporus region is a challenging field to study as the typical requirements of windows are also expected from them, with the same appearance of their original design.

In this study, the details of the window system of a reconstructed original Bosporus mansion is examined. 4 main implementations have been realized in the reconstruction of the window system to better its performance. The examinations are focused on those 4 main implementations. A performance assessment has been realized to find out the usefulness of the implementations. The assessment is mainly based on a self-reflection. At the end tentative proposals have been made to guide the architects about the reconstruction of the window systems.

2. METHOD

The method adopted to this research consist of 3 parts. The first part is the detailed documentation of the detail design of the case building’s window. The second part is the analysis of the window, determination of the important implementations to the original detail and the explanation of those implementations.

In this second part 4 important implementations have been determined and explained:

1. The chemically treated and laminated wooden parts,
2. The double glazing,
3. The operation components, locking system and counter balance system,
4. The aluminium roller shutters.

In the final part a self-reflective performance assessment of the implementation have been realized. 6 different performances were assessed in this part:

1. The structural performance,
2. The thermal performance,
3. The acoustic performance,
4. The water & moisture related performance,

5. The durability performance,
6. The sustainability performance.

At the end tentative proposals for the detail design of the window system of reconstructions have been made considering the assessment of the performances.

3. THE CASE

In 1980s, the case mansion was partly damaged because of the lack of maintenance and in 1992 it was damaged entirely because of a fire. The necessary architectural drawings for restoration were then prepared, and by the year 2004, the necessary permissions were granted. In 2005, the reconstruction works was started and completed at the end of 2008. The external wall core was built of vertical perforated bricks. Gypsum plastering was applied internally and a wooden siding externally. The entire facade was constructed similar as the original façade visually, in terms of the type of the main material, which is wood. The structural system of the roof was also changed into steel in order the attic to be used. Clay roof tiles were applied as the roof covering. But, the new roof system was detailed to have a thermal insulation and waterproofing membrane.

The window system of the house is constructed mostly with the original wooden window details. Double glazed glass, new lock systems, new counter balance systems and new vertical aluminium roller shutter systems were preferred for windows, as the primary differences from the original details (Fig. 1).

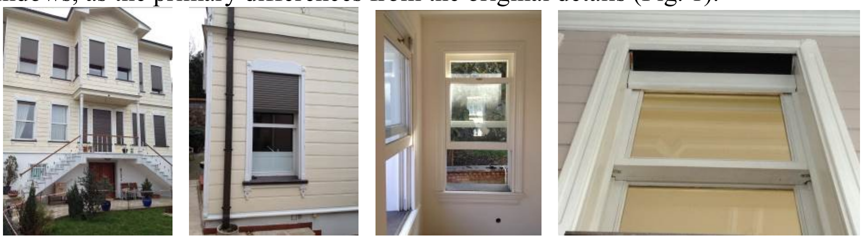

Fig. 1. (a) General view of the Case a house; (b) View of the window system with the aluminium roller shutters are half closed from outside, Case a; (c) View of the window system from inside, Case a; (d) view of the aluminium roller shutter box with the lid of it open, Case a.

In Figure 2, the reconstructed window elevation (a) and the window section detail drawings (b) are given. In the section, different parts of the window system, including the window sill, frame & sash, glazing, and roller shutters are marked with a1 – a11, in order to be separately taken into consideration in the calculations. The list of the components of the window system which comprise each part are: a1. Wooden frame; a2. PU filled aluminium shutters, air cavity, and head of the wooden sash; a3. PU filled aluminium shutters, air cavity, double glazing; a4. PU filled aluminium shutters, air cavity, and overlapping transoms; a5. PU filled aluminium shutters, air cavity, and double glazing; a6. PU filled aluminium shutters, air cavity, and head of the wooden sash; a7. Wooden siding, PU filled aluminium shutters, and head of the sash; a8. Wooden siding, PU filled aluminium shutters, air cavity, and wooden head of the sash; a9. Wooden siding, air cavity, rock wool, cements plaster, R.C. lintel, and gypsum plaster; a10. Wooden siding, air cavity, rock wool, cements plaster, aerated concrete, and gypsum plaster; a11. Wooden siding, rock wool thermal insulation, cements plaster, aerated concrete, and gypsum plaster

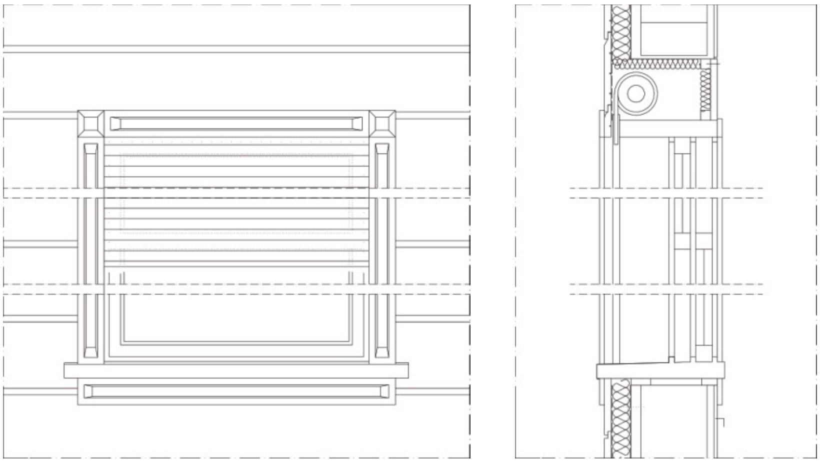

Fig. 2. (a) elevation of the window, (b) section of the window

3.1. Wooden Component

The wooden parts of the window can be analysed in 3 parts, jamb, rail & stile, and roller shutter box.
The first part is the jamb of the window. The total depth of the jamb is 30cm with a thickness of 5cm. Thus this part is formed by laminated wood to minimise the deterioration of the jamb in time. The parts of the laminated wood are placed to make the annual rings perpendicular and is glued to each other with a polyurethane timber glue. The vertical and horizontal components of the frame is attached to each other by timber glue with screws. The external wooden sills of the window is covered by copper to increase the durability of the window against wet conditions of the atmosphere.
The second part is the rail & stile of the window. These are made from wood of 5x5cm. These are single piece of wood and they are both glued and screwed to each other.
The third part is the roller shutter box. To place a roller shutter will improve the thermal performance of the window system but the volume left for it to be rolled up is a critical part decreasing the thermal performance. In order to improve the performance of this part a solid wall is placed at the back of the volume, and the external face of it is covered by an insulation. Hence the total depth of this part is 15cm with a thickness of 5cm.

3.2. Glazing

In the first sample window manufactured a standard double glazing is used, which consist of 6mm of glazing, 12mm of air space and 6mm of glazing. But the total weight of a sash has become about 19kg which is much for a standard counter balance system. So it is decided to use a specially manufactured double glazing with 4mm of glazing, 6mm of air space, and 4mm of glazing. Although this will decrease the thermal performance of the glazing of the window the performance related with the ease of usage is accepted to be more critical. The double glazing is dimensioned with the exact same size of the sash, this is rare in window designs and only in wooden windows it is possible to do so. In other materials the difference between the expansion capabilities of the materials usually deteriorates the glazing. This detail make the integrated working of sash and glazing better and removes the need of a nail to hold the glazing in its place. Once the glazing is placed, a glazing lath is nailed to the rails & stiles, and silicone is applied in between.

3.3. Operating Components

There are 2 main operating components in the window systems; the lock mechanisms, and the counter balance system.

The locking mechanism used in the window systems are specially produced to be fit in the windows. They are working by tying the upper rail of the lower sash to the lower rail of the upper sash. A pin attached to a spring is the component which ties them. The resulting tying is strong and durable as the pin enters inside the upper sash about 1cm.

The counter balance system used in the windows are also specially manufactured as they should be critically designed to carry the exact same weight of each sash. The working principle of the counter balance is simple but inspiring. A plastic tube of about 1cm of diameter is hosting a spring. The spring is the critical component which should be precisely manufactured to carry the load of the sashes. Though the spring is adjustable it is limited to 0.5 kg. At the end point of the tube 2 small plates is connected perpendicular to the spring. When these plates are screwed to the sashes they start to tension the spring when the sash is open and loose the spring when the sash is closed. The tube is placed in a space inside the jamb, next to the sash. Both the upper and lower sashes of the window is operable so 4 counter balances are used in each window.

3.4. Solar Control Component

Aluminium roller shutters are used in the window system. The casing used to store the shutters when rolled up has been explained in section 2.1. The shutter is made of aluminium and the lamellas of the shutter is filled by polyurethane thermal insulation material which results a considerably improvement in the thermal performance of the window system. A previous study has shown that the total U-value of the window system is about 0.30W/m2K which is about 10 times better than the U value of the wooden windows of 3.00W/m2K (TSE, 2008), (Yazicioglu, 2013). In order to make the air space between the shutter and the sashes contribute to the thermal performance it should be a closed space and the related standard only accepts an open space of about 0.4mm. In order to achieve this a brush is added on the intersection point of the shutter and the frame (ISO, 2012). It is for sure that the shutters won't be kept close all along but it will make significant contributions. The rails the aluminium shutters are moving in are also made of aluminium and they are placed inside the jamb near to the front. The shutters are operated with a tubular electric motor which is activated from the buttons placed next to the inner face of the jamb.

4. PERFORMANCE ASSESSMENT

The reconstruction of a historic building is always a difficult and problematic activity. The reason of this is the intention to keep the buildings appearance and character the same as the original building, but at the same time improving almost all performances of the building and its elements. This makes the detail design activity even more complicated because the original details limits the usage of most detail patterns available and the architect should find a new way for almost all simple detail parts. The windows are the most critical parts of these reconstructions as they are both giving the main character of the building and they are most critical part of the building in terms of performances. In this section of the paper the performance of the parts of the window system is going to be evaluated. In each sub-section firstly the main performances expected from that component is going to be listed according to their priority, and then each component is evaluated according to each performance. Charts has been generating showing the success of the component according to each performance. If a component is very successful it is going to get a "+", if it is moderate it is going to get a "0", and if it is not successful it is going to get a "-".

4.1. Performance Assessment of the Wooden Components of the Window

The main performance requirements expected from the wooden components of the window are; structure, thermal, water & moisture, acoustics, durability, and sustainability. Firstly the structural performance; loads coming onto the window, both static and dynamic loads are transferred to the wall by the help of the wooden components of the window. The wooden component of the window are very successful against static loads. But it is not as strong as the static loads against the dynamic loads. Depending on the amplitude of the wind the sashes may sometimes make cracking noises. The reason of this is the absence of a rubber joint sealant but in these kinds of sliding windows it is not possible to place a sealant as a space should be left between the sash and the jamb to make sliding possible. There is only a felt between them but under strong wind conditions that becomes insufficient. Secondly, the thermal performance of the window is very successful both about the low heat transfer, and the sense of surface heat. That is a natural benefit coming from the wood material. Thirdly, acoustic performance of the window is moderate. Especially because the rails and stiles of the window is considerably small in size they do not perform well about airborne sounds, and the sashes may not be closed tightly the acoustic performance is not well. The impact sound performance of the wooden components are also insufficient as under the effect of roaring engines of the trucks passing nearby the wooden components vibrates as well. Fourthly, the water & moisture related performance of the wooden component is sufficient. Especially the copper flashing used on top of the external sill has great contributions to the performance. Another important factor improving the performance is the appropriate usage of the overlaps between the sashes and the jamb of the window. Fifthly, the durability performance of the wooden components is sufficient. The unpressurized impregnation against biologicals performs well and a defect has not been observed. The paint has stayed very well and cracks/peelings of the paint haven't been observed which results the mechanical movement performance of the wooden components to be sufficient. Finally, the sustainability performance of the wooden components are moderate. Although wood material is very sustainable excessive amount of paint should be used which decrease the production CO2 footprint of the window. Wood has a low heat transfer capacity which make it a sustainable material, but as the rails and stiles are small in size this positive speciality of the wood has a limited effect on minimising the usage CO2 footprint of the window. Recycling performance the wooden component is insufficient as all of the components are connected to each other permanently.

4.2. Performance Assessment of the Glazing of the Window

The main performance requirements expected from the glazing of the window are; structure, thermal, water & moisture, acoustics, durability, and sustainability. Firstly, the structural performance of the glazing is sufficient. As there is not any space between the glazing and the sash the loads coming onto the glazing is directly and successfully transferred to the sash. Secondly, thermal performance of the glazing is moderate. In order to minimise the weight of the glazing a double glazing of 4mm of glazing, 6mm of airspace, and 4mm of glazing is used which is thinner than the appropriate dimension of 6mm of glazing, 9mm of air space and 6mm of glazing. The sense of surface heat is insufficient as glass transfer heat easily in other words heat transfer coefficient of glass is high. Thirdly, acoustical performance of the glazing is moderate. The acoustical performance of the glazing is related with the number of the sheets of glazing used and the thicknesses of them. The glazing of this window consist of 2 layers of glass with a total of 8mm which is insufficient for a sufficient acoustic performance. Fourthly, the water & moisture related performance of the glazing is sufficient. The connection of the glazing and the sash is covered by a glazing bar and the bar is adhered to the glazing with silicone which don't let any water penetrate inside. The double glazing used in the window is sufficient to stop the occurrence of moisture. Fifthly, durability performance of the glazing is sufficient, deformation hasn't been observed on the glazing. Sustainability performance of the glazing is moderate. Glass is a material which needs high energy to be manufactured or recycled. Hence production CO2 footprint performance is insufficient and recycling performance of the glazing is moderate. The in use CO2 footprint of the glazing is moderate as the thermal performance of it is moderate.

4.3. Performance Assessment of the Operation Components of the Window

There are 2 operation related components in the window system, locking mechanism and the counter balance system. The locking mechanism is placed in the internal side of the window and the counter balance system is buried inside the jamb which makes them irrelevant with thermal, acoustic, and water & moisture related performances. The main performance requirements expected from the operation components of the window are; structure, durability, and sustainability related. The performance assessment of the locking mechanism is going to be made firstly. The structural performance of the lock system is sufficient. It doesn’t let sashes to be opened when closed. The durability performance of it is moderate because there the lock is working by the help of a spring inside the lock system. That spring sometimes loosens which results a malfunction. The sustainability performance of it is also moderate as it is made of aluminium and although aluminium is a recyclable material it needs high energy to recycle. The performance assessment of the counter balance system is going to be made secondly. The structural performance of the counter balance system is sufficient. The counter balances holds the sashes in the desired height without a failure. They also make the operation of the sashes easy and smooth. The durability performance of them is also sufficient as a failure or malfunction hasn’t been observed. Finally the sustainability performance of the counter balances is moderate as it is made of plastics and steel which are both recyclable but need lots of energy to be produced and recycled.

4.4 Performance Assessment of the Roller Shutters of the Window

The main performance requirements expected from the roller shutters of the window are; structure, thermal, water & moisture, acoustics, durability, and sustainability. Firstly; the structural performance of the roller shutters are sufficient. The roller shutters may operate easily. The only moderate thing about them is under the effect of strong winds some cracking noises may come from the shutters which decrease its structural performance a little bit. Secondly; the thermal performance of the shutter are sufficient. It gives great contribution to the thermal performance for the window system with the help of the PU filling inside the lamellas. They also act as a shading device in summer conditions and minimising the heat gains from sun light. Thirdly, the acoustic performance of the shutters are moderate. As they do not have a large mass their contribution to acoustic performance of the window is limited. Fourthly, water related performance of the shutters is moderate. The shutters mainly blocks the penetration of water on the internal side of the shutter. But on the internal joints of the lamellas moisture may sometimes be observed. Fifthly the durability performance of the shutters are sufficient. Malfunctions related with the movement of the shutter were not observed. Lastly sustainability performance of the shutters are moderate. The shutters are made of aluminium with PU filling inside both of which have very large CO2 footprints because of the energy needed to produce the materials. But they have significant contributions to the thermal performance of the window system which minimise the in use CO2 footprint of the system. On the other hand recycling the lamellas are also not convenient as separating the PU and aluminium is not easy (Yazicioglu, 2013).

5. CONCLUSION

In 2005 a traditional Bosporus mansion has been reconstructed. The character, the overall appearance, and the main material of the window has been kept same as the original window but some modifications have also been made to improve the performance of the window system. The main modifications realized are the usage of treated wood, double glazing, new counter balance & lock, and the implementation of an aluminium roller shutter. The new window system has been observed for 4 years, the maintenances realized has been observed and interviews were realized with the users of the windows. The data obtained has been analysed and a critical performance assessment has been made about the new implementations. Table 1 demonstrates different performances of the implementations. 6 different performances have been taken into account for the assessment, these are; structural, thermal, acoustics, water & moisture related, durability, and sustainability. If the implementation is sufficient about the performance than a "+", if it is moderate about the performance than a "0" has been marked, and if it is insufficient about the performance than a "-" has been marked to the designated space in the table.

Table 1. Performance assessment of the implementations of the window.

		wooden component	glazing	operation components	aluminium roller shutter
Performance related with structure	static loads	+	+	+	+
	dynamic loads (wind)	0	+	+	0
Performance related with thermal issues	low heat transfer	+	0	/	+
	sense of high surface heat	+	-	/	/
	shading	/	/	/	+
Performance related with acoustics	impact sound	0	0	/	0
	air born sound	0	0	/	0
Perf. rel. w. water & moisture resistance	water resistance	+	+	/	0
	moisture resistance	+	+	/	0
Performance related with durability	resistance to biologicals	+	/	/	/
	res. to mechanical movements	0	+	+	+
Performance related with sustainability	CO2 footprint of production	0	-	0	-
	CO2 footprint of usage	0	0	/	+
	recycling	-	0	0	-

The structural performance of the implementations of the window is mainly sufficient. Only the usage of wooden component and aluminium shutter is moderately satisfying the performance. In order to slide the sashes vertically a space should be left between the sash and the jamb which results a decrease about the dynamic loads. The same kind of a situation also exists in roller shutters, as they consist of small and light lamellas they perform slightly insufficient under the effect of dynamic loads. The thermal performance of the implementations of the window is mainly sufficient. Only the glazing used has a moderate thermal performance. The reason is the need of lightening and minimising the window and in order to lighten it thin layers of glazing is used and in order to minimise a thin layer of air space is used. The acoustic performance of the implementations of the window is mainly moderate. The joints between the sashes and the lamb and the minimal design of the window are the main reasons of this. Water & moisture related performance of the window is mainly sufficient. Only when the roller shutters are closed rainwater or moisture may pass between the lamellas of the shutter, but as the passing rain water or moisture is still in the external environment this is not a critical performance failure. Durability related performance of the window is sufficient. Although there are several working pieces in the window a critical failure has not been found. And finally sustainability performance is moderate. Treating wooden component with chemicals, painting them, usage of aluminium with PU fillings are the main factors decreasing the sustainability performance.

Although further quantitative studies should be made, with this qualitative assessment the overall performance of the window system is found to be sufficient. There isn’t any major performance failures in the window system. The most important performance requirement, which is the appearance or appropriateness to the original character, has also been satisfied sufficiently. Hence the details implemented for this window may be used for other reconstructions’ windows.

REFERENCES

-Binan, M. 1975. Yapı Elemanları, İstanbul İTÜ

-Harris, S.Y., 2001. Building Pathology-Deterioration, Diagnostics, and Intervention. John Wiley&Sons, Inc.

-Pearce, J., 2007. Windows : history, repair, and conservation. Shaftesbury : Donhead Pub.

-TBMM, 1984, Boğaziçi Kanunu, T.C. Resmi Gazete, Ankara

-TS825 Standart for Turkish Regulation of Heat Insulation in Buildings, Istanbul, 2008

-ISO 10077-2 2012, Thermal performance of windows, doors and shutters — Calculation of thermal transmittance, Part 2: Numerical method for frames

- Yazicioglu, F. 2013, A comparative analysis of the energy performance of traditional wooden shutters and contemporary aluminium roller shutters in Istanbul, a case study, Energy Procedia, Volume 42, Pages 483-492