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EVALUATION OF EARTHQUAKE PERFORMANCE OF HISTORIC MULTI-STOREY MASONRY STRUCTURES: BEYOĞLU CASE

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Abstract

Turkey is located on one of the most active earthquake zones. Therefore, it is faced with the earthquake danger at any moment. Earthquakes in Turkey, has led to many tangible and intangible losses. There are many historic buildings in Istanbul, which was the capital city of many empires in the past. There are also examples of individually owned civil architecture of historical structures rather than monumental qualifications. User needs change over time because of the social, cultural and economic changes in the regions that historic structures are located. Therefore, there are architectural change requirements rather than structural damage, repair and reinforcement requirements in historic structures. Maintenance, repair and reinforcement work cause a change in dynamic properties and affect the earthquake behaviours. In this study, conservation status of these structures were analysed in terms of various criteria according to the information and documents obtained from the local management of an example of civil architecture of historic masonry structures in Beyoğlu District in Istanbul. Three of restorated and reinforced structures were chosen and dynamic analysis of their recent status was examined with the selected seismic code of masonry structures. Existing seismic performance of the structures with original architecture and carrier system and highly protected structures are better. However, the structure with too much intervention after extensive reinforcement cannot reach the predicted performance level.

Keywords: Historic Buildings, Masonry Structure, Performance Analysis, Strengthening, Retrofitting.

1. Introduction

There are 31,815 historical buildings in Istanbul [1]. Beyoğlu, which is an important historical area, is one of 39 districts of Istanbul. It is a major attraction region in terms of trade and tourism, which is why the historical structures gain great importance. At least 14 earthquakes with intensities greater than nine have occurred in Istanbul in the past [2]. These earthquakes have caused losing some of historical building stock.

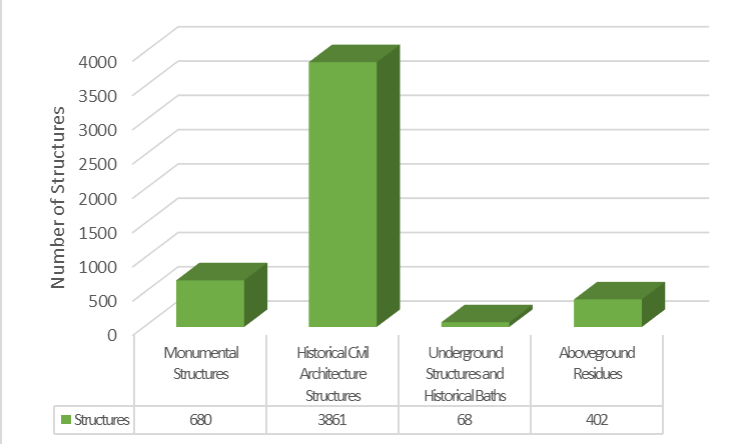
Turkey is faced with a constant threat of earthquake because it lies on an active seismic zone which lies through Java, Myanmar, Himalaya region, Iran, Turkey, and Greece [2]. Therefore, the stock of historical buildings is in danger unless it is protected. There are 10,104 historical civil architecture buildings in Istanbul. These buildings are most likely to be affected from that danger [2]. The architectural and structural features of many of these structures are not being protected as monumental structures. The structures under the possession of private persons are in worse condition comparing to the structures owned by legal persons and government agencies. Architectural and structural characteristics of private owned structures vary according to the trade and tourism potential and socio-economic status of their region.

Historical structures that have economic gains or located in high socioeconomic status are protected better. In other regions it cannot be protected enough. In other regions, construction of new buildings may be preferred instead of repairing and reinforcing. Many historical buildings lose its original function and serve another function because of the structural interventions on behalf of improving earthquake-resistance and/or more effectively use. These interventions may preserve the building's architectural features, and improve the structural characters. However, they may turn out to affect the architectural quality and structural dynamics of historical buildings, negatively. Therefore, the investigations of maintenance and reinforcing work to preserve historical building stock and pass on to future generations is important and necessary to prevent false applications.

2. General Situation of Historical Masonry Structures located in the Beyoğlu District

Beyoğlu district is considered as the 2nd degree earthquake zone, according to Turkish Earthquake Code. General conditions of historical buildings were examined in order to predict the losses that might occur in the existing building stock and determine the earthquake vulnerability status of the historical buildings in the region. There are 5011 pieces of historical structures in Beyoğlu [3]. 3452 of them have detailed information and this information is examined [5]. Most of them are examples of historical civil architecture structures, as can be seen in Table1.

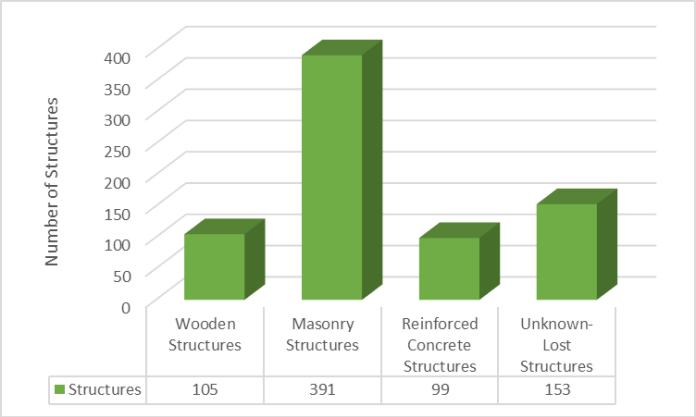
Table 1 - Distribution of historical buildings in the Beyoğlu District



Protection laws can give permission for easier ability to intervene these structures rather than registered monuments based and for constructing new building to the place of buildings that is in a bad situation. Therefore, historical civil architecture structures are the most damaged structures among historic buildings in terms of architectural and structural integrity.

When the history of historical civil architecture types of carrier systems located in Beyoğlu is examined, as shown in table 2, majority of historic buildings in this area was seen as the masonry buildings. Masonry wall is the most important element of masonry structures that enables transportation and transmission of horizontal and vertical loads. Earthquake loads creates shear forces and moments in masonry walls. Therefore, the interventions including the removal of the wall of masonry structures applied to elements of the masonry structures, especially walls, and changing the cavity ratio of walls affect the dynamic balance of the carrier system and earthquake resistance of the structures negatively.

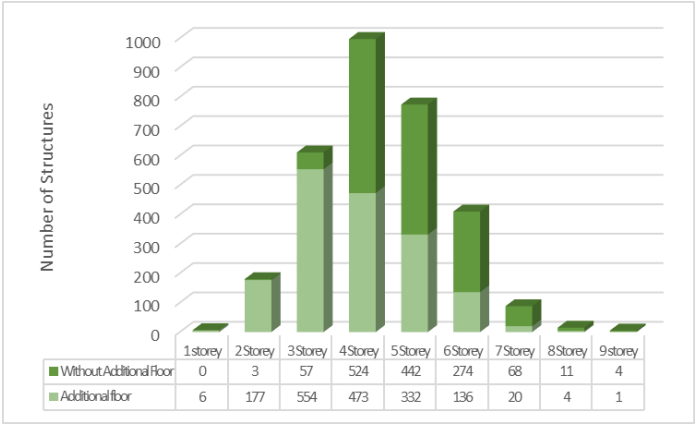
Table 2 - Distribution of carrier systems of historic buildings in Beyoğlu



Another factor adversely affecting dynamic stability and the seismic behavior of the structural system of masonry structure is adding an extra story. According to Turkish Earthquake Code, total stories of masonry structure is 2 in 1st degree earthquake zone, 3 in 2nd and 3rd degree earthquake zone and 4 in 4th degree earthquake zone. The permitted roof area is less than 25% of one basement and normal floor area. Table 3 shows the number of stories of historic buildings in Beyoğlu district.

Average number of stories is expected to be 3 because Beyoğlu district is located the 2nd degree earthquake zone[4]. However, when the number of stories in these areas is examined, it is seen that the 3, 4, 5, and 6-storey buildings are high in number as can be seen in the Table 3. Also, there are a lot of buildings that have an additional storey as can be seen in Table 3.

Table 3 - Additional storey status and number of storey of historic buildings located in Beyoğlu



2.1 Protection status of historical masonry buildings located in Beyoğlu District

When the protection status of masonry structures located in Beyoğlu is examined, it is seen that only 16% is in good condition as can be seen in Table 4. Also, 77% of them are moderately protected. The moderately protected buildings have a probability of getting damaged after the probable earthquakes. Therefore, these structures need to be protected, repaired, maintenance and reinforced in order to pass on to the future generations. 7% of the structures has been observed to be in very poor condition and is about to collapse.

There are many highlights regions in terms of historical identity in Beyoğlu District. Historic masonry structures are seen as the essence of the region and improve the quality of placements. On the other hand, in some regions, abandonment and neglect have turned cultural richness into poor suburbs and many historical buildings have been abandoned to their fate. Referring to Figure 1, when the conservation status of the areas located in Beyoğlu is examined, it can be seen that the buildings located in commercial and tourism centre were preserved in a better condition compared to other residential areas. In Figure 1, yellow coloured dashes represent the moderately preserved buildings; green dashes represent well-preserved buildings [3]. Well preserved structures located and focused at the locations starting from Taksim Square that is the most important commercial and cultural axis of Beyoğlu District, continues to the area of Galatasaray High School, and lays to the Galata Tower, and on the locations called Istiklal Street and Tunnel, and it's around.

Figure 1 - Distribution by region of masonry structures located in Beyoğlu District

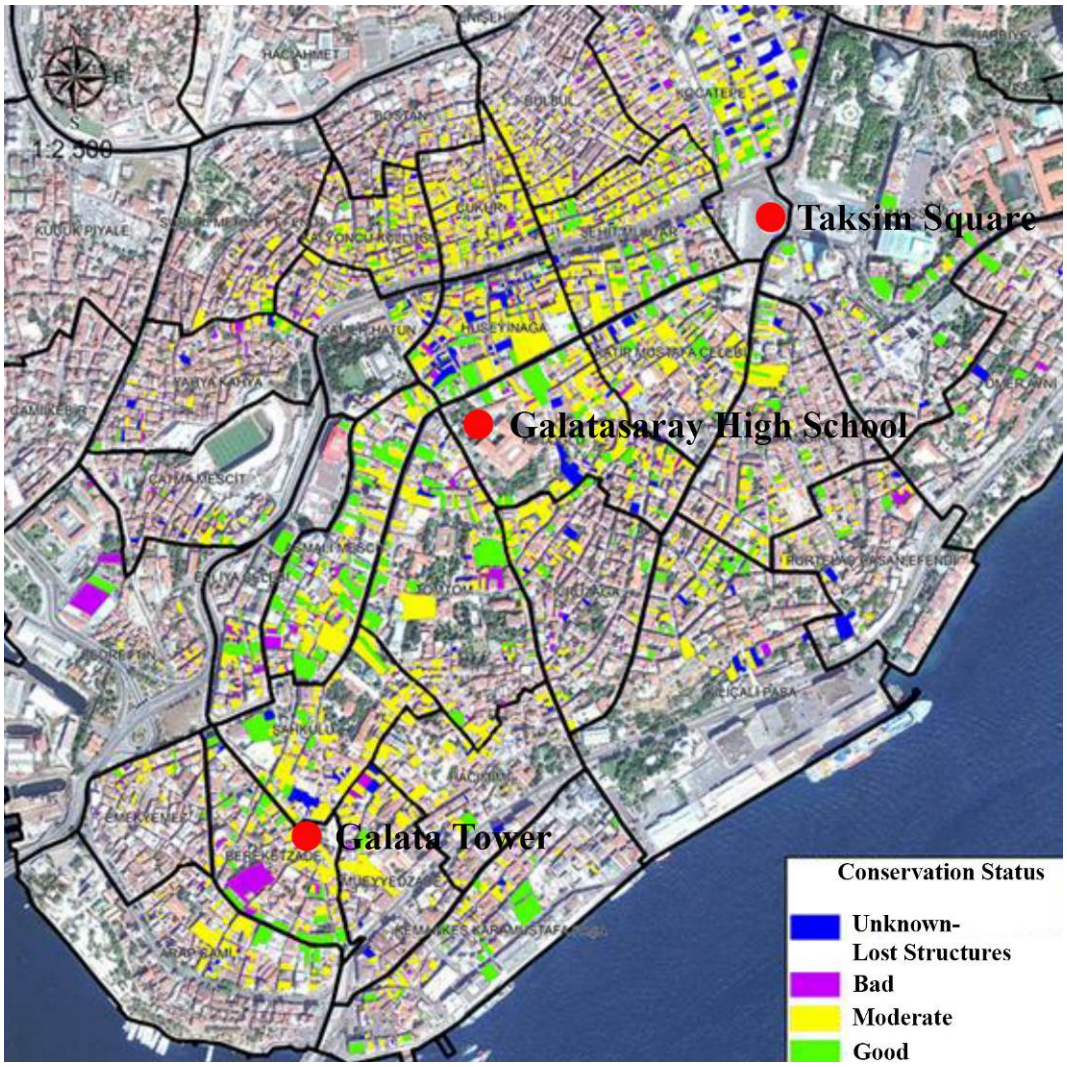
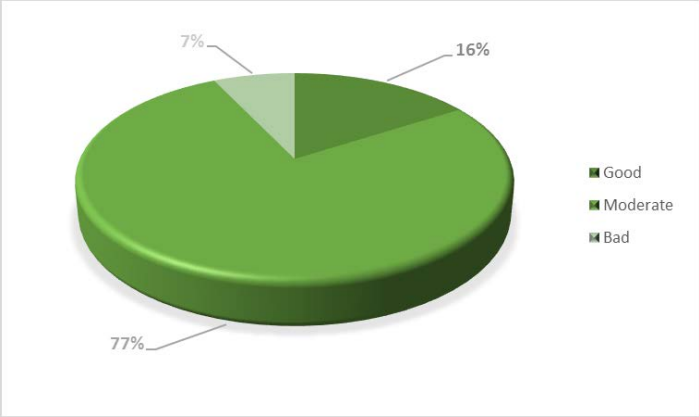


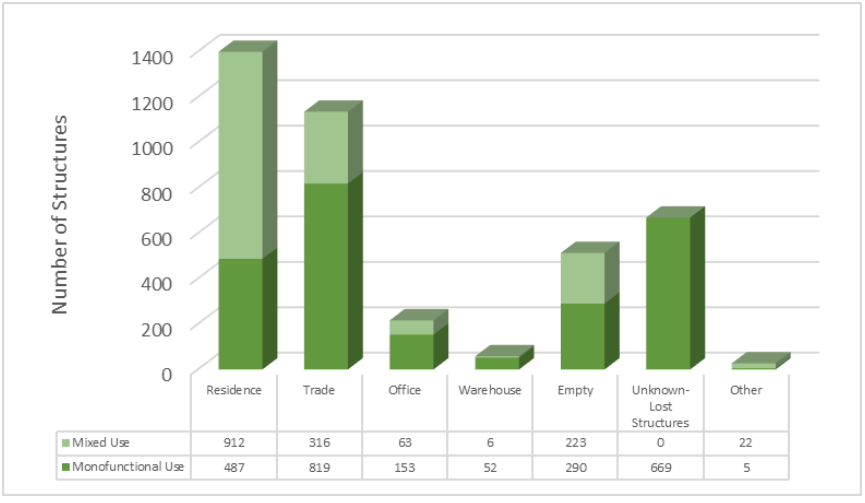
Table 4 - The protection status of the masonry structure in the Beyoğlu District



2.1 Using types of masonry buildings located in Beyoğlu District

A wide variety of user types shows up when the use of historic masonry buildings which are examples of historical civil architecture in Beyoğlu district are investigated. Table 5 indicates that the user types are grouped under the general headings. Residences and lodgements are grouped under the “Residence” title; workshops, factories, banks, shops, inns, offices, hotels, arcades, restaurants, cafeterias are grouped under the “Trade” title; public and private institutions, healthcare facilities, educational facilities, socio-cultural and religious facilities are grouped under the “Other” title. In addition to these, 'Warehouse' and 'Office' titles are included. Also, the structures that there is no information about or lost are grouped under the “Unknown-Lost Structures” title and the unused structures are grouped under the “Empty” title. Furthermore, these structures can be used as multifunctional or they may have a single function. Monofunctional and mixed-use buildings are shown in Table 5.

Table 5 – Using types of masonry structures located in Beyoğlu District



According to Table 5, the most common types of uses of masonry structures are residential and commercial uses in Beyoğlu District. A portion of trade, office and residential structures are used as a mixed-use function. Due to the changing functions, residential needs can vary. Intervention applied to the structure in accordance with these requirements, changing the architectural design of the structure due to the function

changes and reflections from its carrier system can adversely affect the dynamic characteristics of the structure. Especially, the structures where the partial utilization rate is high in the ground floors are used for commercial functions. It is known that frequent structural changes are done because of the spatial requirements brought by the commercial function of these structures. These structural changes adversely affect the dynamic behaviour of buildings.

3. Evaluation of Masonry Structure Examples of Registered Civil Architecture in Beyoğlu District According to Turkish Earthquake Code and Examination of the Static and Dynamic Behaviours

There is no section for evaluation and reinforcement of historic and cultural registered structures and monuments in existing Turkish Earthquake Code. However, there are overall minimum rules and restrictions in the code for the number of stories for masonry structures to be built, load bearing wall, the size and location of the window and door openings, the walls unsupported length, and lintel and bond beams size. Because of the fact that there is no other code for these kinds of structures, the existing earthquake code has an important role for determining boundaries of engineering initiative for specifying earthquake safety.

When the parcels where historic masonry structures in Beyoğlu District are examined, it can be seen that majority of them are located on the corners or in adjacent order. The geometry of the structure of the plan is generally rectangular form. In the buildings on adjacent parcels, main load-bearing walls are perpendicular to the direction of the street. Also, wall lengths in the short direction are limited. Together with that, these narrow facades provide the relationship between these structures and the outside space. The front gap is adequate more than the Code regulations on the adequate enlightenment. In particular, interventions are done in the buildings where the ground floor is used for commercial function, in terms of opening the necessary wall space for business functions and the interventions on the walls due to the change in the function of use, stairs, elevators and opening gaps in the floor for installations, and extra storey additions. Furthermore, these structures were constructed before the code regulations. Thus, it is not expected that the historic masonry structures comply with all design requirements of the code. However, they must meet performance targets specified in the earthquake regulations and masonry calculation conditions.

Table 6 – General characteristics of three masonry structures of registered civil architecture in Beyoğlu District

Name	Geometry of Plan	Number of Floors	Floor Height	Location	Slab	Vertical Carrier System	Vertical Wall Continuity
Küçük Parmakkapı Hotel	Rectangular	1 Basement F. Ground F. 5 Floor 1 Roof Floor.	BF (2.8m) GF (3.5m) 1.F (3.7m) 2.F (4m) 3.F (4.5m) 4-5.F (4m) RF (2.8m)	Adjacent single axle	Secondary steel beams Reinforced Concrete Slab	Brick Wall	Moderate
Büyük Parmakkapı Hotel	Rectangular	1 Basement F. Ground F. 4 Floor 1 Roof F.	BF (2.5m) GF (3.6m) 1-2.F. (3.4m) 3.F (4.5m) 4.F (3.5m) RF (4.6m)	Adjacent two axles	Voltaic	Brick Wall	Bad
Tarlabaşı Residence	Rectangular	1Basement F. Ground F. 5 Floor 1 Roof F. 2 Additional Floor	BF (3.4m) ZF (3.5m) 1-5.F (3.3m) RF (4.6m) 1-2. AF (3.3m)	Adjacent two axles	Voltaic	Brick Wall	Good

Three repaired and strengthened masonry structures, which are examples of registered civil architecture located in Beyoğlu District, are examined according to Turkish earthquake regulations. Then, they are modelled as masonry structure according to their ground and material features. Lastly, with the help of a computer program, static and dynamic analyses are done. Two of the examined structures are used as hotels and the other one is residential as can be seen in the Table 6. Hotel functioned structures were used as residential function in the past. Then, they were converted into hotels. However, the residential one's previous function was maintained.

Vertical structural system should be continuous and the main structural system of the building should be approximately symmetric with respect to the orthogonal axis on plan according to the Turkish Earthquake Code. When the intervention plans of these structures are examined, it can be seen that the layout of load-bearing walls of the residential structure is largely preserved and most of the walls are continuous in vertical direction. Two additional stories were added in the scope of the repair and strengthening project of this building. High number of interventions on the structural system was done for creating necessary spaces due to the change in function of the from-hotel-to-residential converted structures. Some of the walls were removed, some new walls were constructed, and some space for elevator, stairs, ventilation, and installation were opened on the floor. Therefore, in these structures, vertical-wall continuity is not sufficient.

These three structures are located in a second-degree earthquake zone. Maximum number of storey except basement is 3 stories according to the regulation for the masonry structures located in 2nd degree earthquake zone. Storey height can be at most 2.40m in basement, and 3.00m in other stories [4]. The related structures cannot satisfy the requirements as can be seen in the figure 2. Also, partial basement construction is not suggested. As can be seen in the figure 2, there is a partial basement in Büyük Parmakkapı Hotel, but the two others.

Figure 2 – The floor plans of three strengthened masonry structures of registered civil architecture in Beyoğlu District

The minimum thickness of load-bearing walls for natural stone wall in basement is 50 cm; for brick walls in basement and ground story 1.5 brick, 1.0 brick for the other stories according to regulations [4]. Existing wall thickness is adequate in terms of minimum thickness level; however, it is inadequate because of the exceedance

of the minimum number of story limits in the regulations. In the code, the minimum length of the structural walls defined as the ratio of total length of the structural walls extending along each of the orthogonal directions on plan, except the gaps, to the gross floor area ($\ell d/A \geq 0.2I$ m/m2) [4]. In the x direction of measured drawings of Tarlabaşı Residents, the minimum length of the carrier walls is 26.5/112 = 0.24 m/m2, and in Y direction it is 38/112 = 0.34 m/m2. These are larger than the value of 0,2x1,0 = 0,20 m/m2 . In the x direction of measured drawings of Büyük Parmakkapı Hotel, it is 25/114 = 0,21 m/m2 and this value is close to 0,20m/m2. In Y direction, 39/113 = 0.30 m/m2 and these are larger than the value of 0,20m/m2. In the x direction of measured drawings of Büyük Parmakkapı Hotel, it is 25/110 = 0,22 m/m2 and this value is close to 0,20 m/m2. In Y direction, it is 22/110 = 0.2 m/m2 and does not satisfy the required level.

The required condition of being 7.5m of the largest unsupported length for load-bearing walls in 2nd degree earthquake zone is satisfied in the walls (L_{max}=4.30m) in each direction in Tarlabaşı Residents and Küçük Parmakkapı Hotel structures. However, there are some walls in Büyük Parmakkapı Hotel that do not satisfy the conditions in Y direction. On the other hand, along with any of the unsupported length of a wall in the regulation, total length of door and window installation space on the plan should not exceed 40 % of the unsupported length. This condition is not satisfied in all three buildings on facade and some internal walls. The largest door or window space length on plan should not be exceeding 3.0 m according to the regulation for masonry structures. There is no wall and window space exceeding this condition in all three buildings.

In the 1st and 2nd degree earthquake zone, full part of the wall between the closest window or door to the corner of the building and the corner of the building should be larger than 1.5m on plan. Also, apart from the corner of the building, the full part of the wall between window and door space should be larger than 1.0m on plan[4]. These two conditions cannot be satisfied in all 3 buildings more than once. On the other hand, the full part of the wall between the closest window or door space to the intersection of two perpendicular walls except than the corner of the buildings and the intersection of the walls cannot be smaller than 0.50 on plan for all earthquake zones[4]. This condition is satisfied with none of the buildings.

For determination of the seismic performance level of masonry building mentioned in Turkish Earthquake code, the classification in terms of knowledge level are used as follows. The shear strength of the entire wall of the building in both directions if there is enough to meet shear forces that occur under the applied seismic effects, the building satisfies "**Ready for Use Performance Level"**, In any of the stories, if the contribution of the walls with unsatisfied condition, contributes to the shear forces in the direction of applied seismic effect is smaller than 20%, building satisfies **"Life Safety Performance Level"**, and in this condition inadequate walls should be reinforced, Other than the conditions above, it is accepted that the building is in **"Collapse Level"**. In the code, for these types of buildings, the foreseen minimum performance target is life safety performance level; the probability of exceedance of designed earthquake is equal to 10% in 50 years.

As can be seen in the Table 6, the structure of Tarlabaşı Residence is adjacent to the next building from one side and a masonry example of registered historical civil architecture. Determining of earthquake safety of the building is targeted in the conducted performance analysis. The building should be in the Life Safety Zone when the probability of exceedance of designed earthquake is equal to 10% in 50 years. The performance results of the existing building are shown in the Table 7. According to the results, basement of the building, ground storey, first and second stories are in Collapse Zone, third and fourth stories are in Life Safety zone, and the last two stories are in Ready for Use zone. When looking at the results of the building, it does not provide the safety performance targets set in its current form.

Table 7- Shear capacity control of the current state of the masonry walls of Tarlabaşı Residence

Story	X		Y		Increase Shear Capacity Control		
	Ve	Vr	Ve	Vr			
1	2388.78	383.09	304.44	763.60	76%	> %20	Collapse
2	2392.13	331.44	498.6	633.31	86%	> %20	Collapse
3	2453.09	331.44	467.38	534.49	86%	> %20	Collapse
4	418.63	331.44	432.06	534.49	21%	> %20	Collapse
5	403.90	331.44	375.81	534.49	18%	> %20	Life Safety
6	390.91	331.44	303.03	534.49	13%	> %20	Life Safety
7	226.36	410.99	219.76	336.17			Ready For Usage
8	173.98	386.23	116.31	343.77			Ready For Usage

Performance analysis of this structure is repeated for strengthened state. For strengthening, on the facade to the inner side, and on the other fronts to the outer side, a self-compacting concrete with 10-centimeter thickness is used. In the table 8, strengthening of Tarlabaşı residence structures repeated analysis results can be seen. All stories of the building were found to be of ready for use in the performance level. The performance level obtained according to these results with being better than the wanted life safety level, the reinforcement type applied is enough for this building.

Table 8 – Shear capacity control of the strengthened state of masonry walls of Tarlabaşı Residence

Story	X		Y		Increase Shear Capacity Control
	Ve	Vr	Ve	Vr	
1	589.47	895.01	964.65	1414.14	Ready For Usage
2	582.06	642.39	575.51	1483.19	Ready For Usage
3	546.81	592.05	533.68	1485.36	Ready For Usage
4	487.20	592.54	478.21	1469.09	Ready For Usage
5	422.29	592.54	408.99	1469.09	Ready For Usage
6	341.38	592.54	326.61	1469.09	Ready For Usage
7	243.08	592.54	230.12	1469.09	Ready For Usage
8	172.51	592.54	135.89	1485.36	Ready For Usage

Two layers added to the residential building project in Tarlabaşı over the last story. Performance analysis was repeated after layers added to the building. As shown in table 9 according to the obtained performance results, the basement is in the collapse zone, first, second and seventh stories are in life safety zone, and others are in ready for use zone. The performance level of all stories except the basement of the building, in terms of life safety performance level is higher, but the basement is a failure to ensure safety performance in the Y direction with extra storey added, and reinforcement of basement is inadequate

Table 9 – Shear capacity control of the masonry walls after reinforcement applied to Tarlabaşı Residence with addition of two stories

Story	X		Y		Increase Shear Capacity Control		
	Ve	Vr	Ve	Vr			
1	574.66	895.01	1833.15	1414.14	23%	> %20	Collapse
2	402.71	642.39	1814.40	1483.19	18%	< %20	Life Safety
3	354.10	592.05	1760.54	1479.84	16%	< %20	Life Safety
4	214.82	592.54	1630.69	1485.36	9%	< %20	Life Safety
5	211.64	592.54	1469.46	1469.09			Ready For Usage
6	244.34	592.5	1278.27	1469.09			Ready For Usage
7	317.10	592.54	1057.47	1469.09			Ready For Usage
8	459.86	592.54	806.46	1469.09			Ready For Usage
9	663.45	592.05	558.60	1485.36	11%	< %20	Life Safety
10	332.87	592.05	365.91	1485.36			Ready For Usage

Büyük Parmakkapı Hotel is adjacent to two buildings from two sides, a registered masonry example of historical civil architecture that is changed from residence to hotel in terms of usage. The present state of the static-dynamic analysis is performed. Design of earthquake safety is required to provide the level of building performance after the earthquake, if there is a potential of exceeding 10% over a period of 50 years. Analyses of the current condition of the building results are given in Table 10.

Table 10 – Shear capacity control of the current state of the masonry walls of Büyük Parmakkapı Hotel

	X		Y				
Story	Vr	Ve	Vr	Ve	Increase Shear Capacity Control		
1	309.47	466.69	290.88	466.69	100%	> %20	Collapse
2	275.71	43.47	545.45	463.47	95%	> %20	Collapse
3	207.65	449.70	455.84	449.70	100%	> %20	Collapse
4	202.73	417.17	404.08	417.17	100%	> %20	Collapse
5	179.25	363.84	347.14	363.84	100%	> %20	Collapse
6	175.03	295.44	320.36	295.444	100%	> %20	Collapse
7	156.97	211.56	299.31	211.56	69%	> %20	Collapse
8	185.22	113.37	328.06	113.37	10%		Life Safety

According to the results it was observed that all of the stories except for the last storey of the building are in the collapse zone. The last storey is in the life safety zone. The results suggest that the building does not provide the level of life safety performance with foreseen minimum performance level in its current form. Performance analysis was repeated for the enhanced state of the structure. In the scope of strengthening, reinforced concrete wall additions are made to the present state of the basement, voltaic slabs are repaired and renewed partly, 5 cm reinforced shotcrete and repair mortar is applied in the insides of some walls.

In Table 11 the repeated analysis results of reinforced state belonging to Büyük Parmakkapı Hotel structure is shown. The performance results except the last stories are all in the collapse zone, for the last storey it is in life safety zone. With the reinforcements inadequate walls of ground story, second story, third story and fourth story is decreased from 100% to 80%, in fifth story from 69% to 38% but this was not enough for it to achieve the wanted performance level. The other stories were found to be insufficient in terms of improvement in wall rates. Therefore, reinforcement done is not sufficient enough for this building.

Table 11 –Shear capacity control of the strengthened state of masonry walls of Büyük Parmakkapı Hotel

	X		Y				
Story	Vr	Ve	Vr	Ve	Increase Shear Capacity Control		
1	472.80	569.43	392.97	569.43	100%	> %20	Collapse
2	397.15	565.85	894.61	565.85	85%	> %20	Collapse
3	299.00	550.91	857.78	550.91	100%	> %20	Collapse
4	323.39	514.24	766.38	514.24	88%	> %20	Collapse
5	303.15	450.76	712.85	450.76	88%	> %20	Collapse
6	302.30	367.87	676.73	367.87	68%	> %20	Collapse
7	289.81	266.17	665.85	266.17	38%	> %20	Collapse
8	312.15	136.62	670.36	136.62	11%		Life Safety

Küçük Parmakkapı Hotel is adjacent to two buildings from two sides, a registered masonry example of civil architecture that is changed from residence to hotel in terms of usage. The present state of the static-dynamic analysis is performed. Design of earthquake safety is required to provide the level of building performance after the earthquake, if there is a potential of exceeding 10% over a period of 50 years. Analyses of the building results are given in Table 12.

Table 12 – Shear capacity control of the current state of the masonry walls of Küçük Parmakkapı Hotel

Story	X		Y		Increase Shear Capacity Control		
	Vr	Ve	Vr	Ve			
1	639.06	480.63	970.18	480.63	3%	<%20	Life Safety
2	327.62	466.07	419.0	466.07	84%	> %20	Collapse
3	435.10	426.51	363.28	426.51	70%	> %20	Collapse
4	472.67	369.75	366.81	369.75	67%	> %20	Collapse
5	373.88	292.52	346.77	292.52	54%	> %20	Collapse
6	321.76	194.80	320.94	194.80	16%	< %20	Life Safety
7	157.42	76.61	198.42	76.61	25%	> %20	Collapse

According to the results, the basement and fourth storey of the building satisfy the requirements of safety, and the other stories are in the collapse zone. Performance analysis was repeated for the enhanced state of the structure. In the scope of reinforcement, to some of the walls of the building 5 cm thick shotcrete, to some walls 3 layers of repair mortar is applied. The results of analysis are shown in table 13

Table 13– Shear capacity control of the strengthened state of the masonry walls of Büyük Parmakkapı Hotel

Story	X		Y		Increase Shear Capacity Control		
	Vr	Ve	Vr	Ve			
1	684.17	360.46	1145.29	360.46			Ready For Usage
2	403.40	349.54	575.73	349.54	30%	> %20	Collapse
3	604.23	319.88	508.44	319.88	13%	< %20	Life Safety
4	673.00	277.31	505.65	277.31	3%	< %20	Life Safety
5	614.89	219.38	482.34	219.38	3%	< %20	Life Safety
6	535.45	146.10	457.14	146.10			Ready For Usage
7	206.68	57.45	194.61	57.45			Ready For Usage

According to the results, the basement, fourth story and fifth story of the building are in ready for use level; they are over the required level of safety performance. The first, second and third story satisfy the life safety performance level. But on the ground story, the required wall ratio being insufficient puts it in the collapse zone. With the reinforcements, inadequate walls of ground story, second story, third story and fourth story is decreased from 100% to 80%, in fifth story from 69% to 38% but this was not enough for it to satisfy the wanted life safety performance level.

4. Overall Assessment and Results

Turkey is located on one of the most influential earthquake zones. Beyoğlu District in Istanbul is one of the most important historical districts that have many historical buildings that are faced with earthquake hazard at any moment in this area. When examining the Beyoğlu District's historical building stock, the historical civil architectures form majority of this stock. This type of structure of the structural system is masonry; it was found that the majority of them are privately owned. These structures are considered to be of secondary importance according to Turkish Protection Laws and in comparison to the primary important historical buildings they are more easily intervened and new structures can be built in their places. This historical building of privately owned historic properties in the region could be converted into economic value, especially negative impact on the structure used for commercial purposes in accordance with the spatial requirements of the structural system integrity is maintained. In regions where these structures cannot be converted into economic value and more difficult due to the maintenance and repair costs, it is expected to be abandoned to their fate. Therefore, architectural and structural integrity of these structures showed that most of the historical buildings are damaged and destroyed amongst historical buildings.

In this study, the case of preservation of historic masonry structures located in Beyoğlu examined and that these 17% of the buildings found out to be in good condition, 77% of them in medium condition and 7% was found out to be about to collapse. Especially, the buildings that are located on the axis of important trading and

tourism points, seems to be well-preserved structures. For transferring these medium level preserved structures to the future generations, maintaining and reinforcing is necessary.

In Turkish Earthquake Code, there is no section about evaluation and reinforcing of the historic and cultural registered buildings, also the section about masonry buildings are inadequate in the context of the evaluation of the historic buildings are for masonry structures to be built. Therefore, strengthening of historical masonry projects are done according to Earthquake Codes, which are made on account of the favorable conditions to ensure the desired level of performance. The examined three masonry-building samples under this study, the masonry building structures seem to not fit most of these masonry-building criteria of Turkish Earthquake Code. In the code, it is stated that there is no need to make separate calculations for structures according to specified criteria. Therefore earthquake safety performance analyzes were made according to the current state and reinforced versions of these structures was examined.

Performance analysis of the current situation was seen in all three structures, do not provide the expected level of performance specified in the earthquake regulations. Residential building converted to a hotel, in the vertical wall continuity and performance analysis of the situation in the enhanced state due to changes made in the inner wall has been shown not to provide the level of security is required. Load bearing walls shear capacity of these structures appeared to be quite insufficient and enhanced states also failed to provide the expected level of performance. The original function of the building is preserved and untouched, therefore with the continuity of the vertical wall is being adequate; the earthquake performance is sufficient with the reinforcement. However, due to the structure of the stories added later, this structure still remains below the level of performance specified in the regulations.

In conclusion, the buildings that original or highly preserved in terms of architecture and structural system, have better current earthquake performance, the wanted desired level of performance can be achieved with just wall reinforcements, the buildings do not reach the foreseen performance level after extensive reinforcement applications of structures that have seen numerous intervention.

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6. References

[1] Municipality of Istanbul Cultural Heritage Protection Directorate, Istanbul Cultural Inventory (2016): " http://www.kulturelmirasprojeleri.com/envanter/"
[2] The Study on A Disaster Prevention/ Mitigation Basic Plan in Istanbul Including Seismic Microzonation in the Republic of Turkey Final Report (2002): "Japan International Cooperation Agency (JICA), Istanbul Metropolitan Municipality (IMM)"
[3] Inventory Map of Natural and Cultural Heritage (2010): " Republic of Turkey Ministry of Environment and Urbanization, Istanbul, Turkey"
[4] Turkish Earthquake Code for Buildings (2007): "Ministry of Public Works and Resettlement, Ankara, Turkey"
[5] The European Council of Natural and Cultural Heritage Protection Inventory (2015): "http://www.envanter.gov.tr/"