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FIELD APPLICATIONS FOR RISK ASSESSMENT METHODS OF URBAN TRANSFORMATION LAW NO. 6306: A CASE STUDY OF BEYOĞLU

Özgür ANIL [1*], Mustafa K. KOÇKAR [1], Mustafa ŞAHMARAN [2]

[1] Civil Engineering Department, Engineering Faculty, Gazi University, Ankara, Turkey
[2] Civil Engineering Department, Engineering Faculty, Hacettepe University, Ankara, Turkey

ABSTRACT

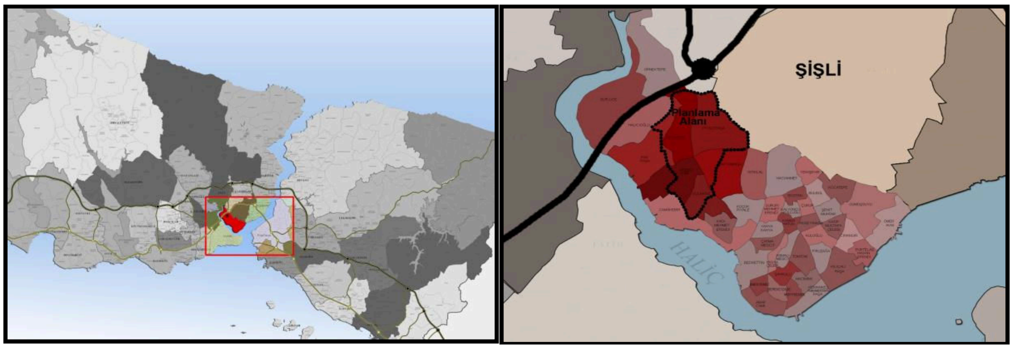
One of the most important risks in Turkey is the high seismic activity in the region. Therefore, identification of high risk structure inventory under earthquake conditions as a priority and reinforcement or demolishing/renovation within the scope of disaster risk planning is a priority subject. In this respect, Law no. 6306 of Transformation of Areas under the Disaster Risks and issued in 2013 includes highly important information and methodology regarding identification of risk level for either individual structures of or an area including numerous structures. The first of the methodology included in the appendices of the application instructions of this law describes regulations on identification of risk level of an individual structure and the second methodology regarding prioritization of risk level via expedited assessment of numerous structures within an area/region. Increase in probability of occurrence of an earthquake in cities such as Istanbul where numerous structures exist increases the necessity of conducting rapid assessment of earthquake risk of numerous structures and conducting necessary studies required for planning of renewal at regions where level of risk is higher. One of the most important risks in Turkey is the high seismic activity in the region. Therefore, identification of high risk structure inventory under earthquake conditions as a priority and reinforcement or demolishing/renovation within the scope of disaster risk planning is a priority subject. In this respect, the Regulation on the Implementation of Law no. 6306 includes highly important information and methodology regarding identification of risk level for either individual structures of or an area including numerous structures. The first of the methodology included in the appendices of the application instructions of this law describes regulations on identification of risk level of an individual structure and the second methodology regarding prioritization of risk level via expedited assessment of numerous structures within an area/region. Increase in probability of occurrence of an earthquake in cities such as Istanbul where numerous structures exist increases the necessity of conducting rapid assessment of earthquake risk of numerous structures and conducting necessary studies required for planning of renewal at regions where level of risk is higher. For this purpose, it is necessary to correlate the assessment methodologies of individual structures and of many structures in a rapid manner as explained in the Regulation on the Implementation of Law no. 6306 for studies of assessment of risk level for these areas and of prioritization. Therefore, in this study a new method is formed and proposed herein which combines the application of these two methodologies. This new methodology is applied at total of 5561 structures located in 6 different neighbourhoods of Okmeydanı region of Beyoğlu district (i.e., Fetihtepe, Kaptanpaşa, Keçeci Piri, Kulaksız, Piri Paşa and Piyale neighbourhoods) and one of the most comprehensive studies on application of the Law has been conducted. The method is developed as a general methodology that can be applied to identify risk status of any region based on superstructure distribution. The methodology supports the rapid assessment and detailed assessment methodologies given respectively in “Annex-A” and Annex-2 of the Regulation on the Implementation of the applicable law, and set forth based on scientific literature.
Keywords: Assessment of earthquake risk, Rapid assessment, Prioritization, İstanbul

1. RISK ASSESSMENT STUDIES

In this study, assessment of all buildings within the boundaries of 6 neighbourhood (Fetihtepe, Kaptanpaşa, Keçeci Piri, Kulaksız, Piri Paşa ve Piyale Districts) at Okmeydanı area of Beyoğlu district by using primary assessment (rapid assessment method) defined in Annex-A of the Regulation on the Implementation of Law no. 6306. Then a number of masonry and reinforced concrete buildings having quality and quantity to represent all the buildings in the area were selected by considering load-bearing

* Corresponding Author: Prof. Dr. Özgür ANIL, oanil@gazi.edu.tr

system, building performance point (PP), number of storeys etc. through a multi-layered statistical selection method. Later these selected sampling set were re-assessed through a secondary stage assessment method in accordance with the Circular on Detection of Risky Buildings (RYTE, 2013) given in Annex-2 of the Regulation on the Implementation of Law no. 6306. Approximate area of region assessed during this study was 123.25 hectares and number of blocks and parcels falling within Okmeydanı area of Beyoğlu District, İstanbul was 370 and 4395, respectively. There are total of 5585 structures in the area. According to Municipality records, these structures include 24000 units (residences). Although, Beyoğlu Municipality records had shown 5585 structures for the area, the fields observations have shown that there were abandoned and ruined structures in the area and therefore 24 structures were excluded from this study. District boundaries and study area is given in Figure 1. Assessment studies were performed at 6 neighbourhoods in the area. Number and type of structures within these neighbourhoods are given in Table 1.



(a) *(b)*

Figure 1. (a) Location of Beyoğlu District in İstanbul Province and (b) Study area.

Table 1. Neighbourhoods and Number of Structures within the Risk Assessment Area

Id No.	Name	Number of Reinforced Concrete Structures	Number of Masonry Structures	Total
1	Piyale Paşa	1604	505	2109
2	Piri Paşa	188	258	446
3	Keçeci Piri	562	254	816
4	Kaptanpaşa	413	131	544
5	Kulaksız	17	3	20
6	Fetihtepe	1064	562	1626
Summation		**3848**	**1713**	**5561**

As Table 1 is inspected, is can be observed that there are total of 5561 structures (buildings) in the area and 3848 of these are reinforced concrete while 1713 of these are masonry. Risk assessment area is located within İstanbul Provincial borders and the Province is located within 1st and 2nd degree earthquake hazard zone according to 2007 Earthquake Zonation Map of Turkey. The investigation area is Beyoğlu District of İstanbul Province is located within 2nd degree earthquake zone. According to records, no high magnitude earthquake has occurred within the İstanbul Provincial boundaries since instrumental recording period. However, it is known scientific that the character of the North Anatolian Fault System has an east to west migrating pattern. Following the 1999 İzmit and Düzce earthquakes, it is obvious that possibility of a rupture at segments of North Anatolian Fault System (NAFS) continuing within Marmara Sea increases with elapsing time which would have significant impact at Beyoğlu District. Scenarios on this possible earthquake are being heavily studies by various research institute and researchers. Studies on tectonic structure of NAFS within Marmara Sea and Marmara Islands region, crustal rupture/fracturing mechanism and estimated magnitude of a possible earthquake are ongoing and 4 different scenarios have been identified according to studies of National Institute for Earth Sciences and Astronomy, France (CNRS-INSU), İstanbul Technical University and The Scientific and Technological Research Council of Turkey (TUBİTAK). The scenario imposing the highest risk among these earthquake hazard scenarios for İstanbul and its vicinity is the scenarios 3 termed as "Model C" [1-6]. In case of a rupture of segment of NAFS passing through Marmara Sea for 170 km as predicted by Model C, it is an indisputable scientific fact that this earthquake would have significant destructive effect on İstanbul Province including Beyoğlu District. It is imperative to make immediate preparations by considering the worst case earthquake scenarios.

Soil classification of the study area has been performed according to borehole data from geotechnical investigation of Okmeydanı area and its vicinity compiled from Beyoğlu Municipality records. Total of 7 borehole and 6 test pits were used during geological and geotechnical investigation of Okmeydanı and its vicinity. Geological units observed within and in the vicinity of Okmeydanı area of Beyoğlu Province are composed of three units from older to younger as; Trakya Formation (Trf), Talus and Alluvium. The geological map of the study area along with borehole locations and soil classification of these boreholes area are given in Figure 2.

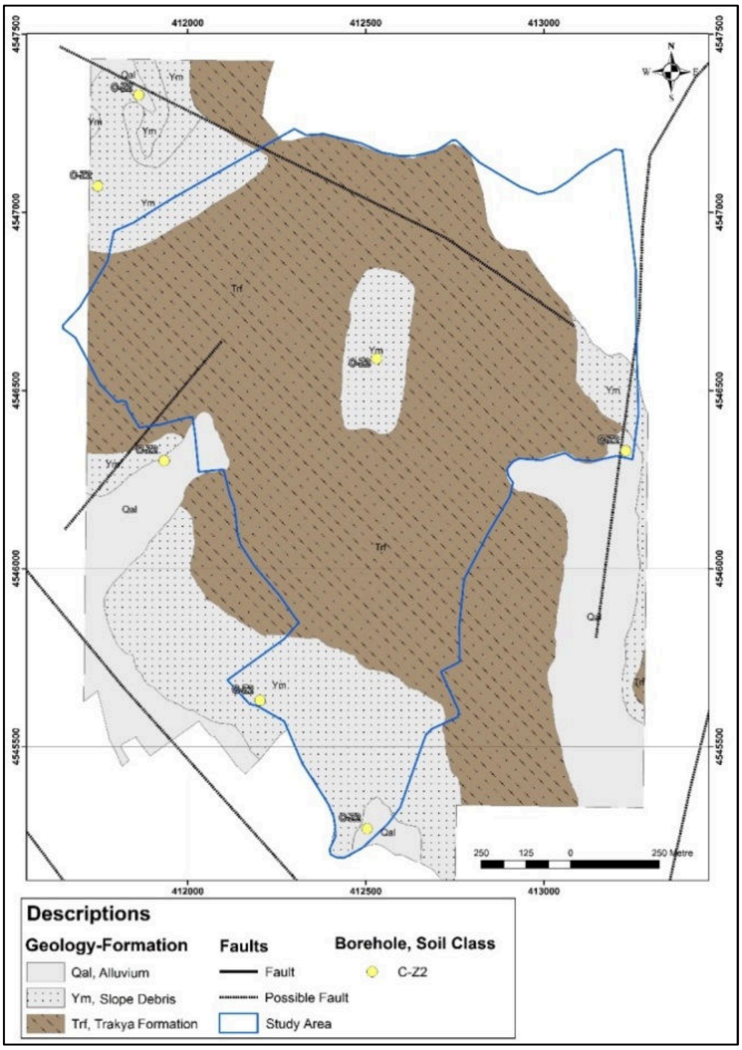


Figure 2. The geological map of the study area along with borehole locations and soil classification of these boreholes area.

As can be observed from geological framework and geotechnical investigation boreholes of the study area (Figure 2), units of Trakya Formation cover approximately three quarters of the area and this formation is present underlying the alluvium and talus units having approximately 10 to 13 m depth.

This unit is composed of sandstone, claystone and shale origin with gravel intercalations, weathered and fractured, weak to very weak rock units. As Class-C for alluvial and talus areas and Class-B for Trakya Formation areas can be assigned, local soil class of the area can be identified as Z2 (Class-C group soils with $h_1 \leq 15$ m and Class-B soils with $h_1 > 15$ m). Therefore, Z2 soil classes were considered during structural analyses.

2. FIRST STAGE ASSESSMENT METHOD MENTIONED IN ANNEX-A OF THE REGULATION ON THE IMPLEMENTATION OF LAW NO. 6306

Building performance points (PPs) of each of 5561 structure identified to be suitable for this study within the study area were calculated according to methodology specified in Annex A and filling the forms for masonry and concrete buildings presented also in Annex-A of the Regulation on the Implementation of Law No. 6306 of Transformation of Areas under the Disaster Risks. Method given in Annex A is a rapid assessment technique and is based on an information sheet to be filled in the field to identify earthquake risk level of reinforced concrete and masonry buildings. In order to apply this method, primarily information sheet given in Annex-A is filled for each building in the area which allows acquiring important information on these structures. The project teams performing the field work have taken minimum 2 photographs of each building. Performance points of each building is calculated as outlined in Annex-A. Special software was developed in Excel to expedite these calculations. This software allows automatic calculation of performance points for each building after all data in the data (information) sheets are presented as input to the system, and this software also allows transferring the data to suitable Geographical Information Systems (GIS) software as well. Transfer of data and performance points to GIS environment allows acquisition of various statistical interpretations and preparation of thematic maps. Example photographs from typical masonry and reinforced concrete buildings in the area are given in Figure 3.

Figure 3. Example Photographs from Masonry and Reinforced Concrete Buildings in the Area

According to investigations performed within the risk assessment area have shown that there are total of 5561 buildings within 6 neighbourhoods in the area and 3848 of these are reinforced concrete and 1713 are masonry. According to assessment of storey number of these buildings, it was observed that the reinforced concrete buildings are generally 4 storey and masonry buildings are generally single storey structures. Charts showing PPs of reinforced concrete and masonry buildings in the study area are given in Figure 4. High standard deviation value for reinforced concrete buildings shows that PPs of reinforced concrete buildings have wide distribution range and high difference. The PPs of reinforced concrete buildings have significant difference. According to mean and standard deviation of performance points of reinforced concrete buildings, it was observed that significant number of reinforced concrete buildings falls within -15 and 84 PP range. On the other hand, average PP value of total of 1713 masonry buildings was calculated as 54. This value can be considered to be low for masonry buildings composed mostly of single storey. It is known that number of storey is an important parameter in calculation of performance points of buildings. As the 50-60 range is considered as average and lower than average PP, total of 1410 masonry structures was observed to have lower than average performance points. The percent of masonry structures within average range or lower than average was found as 81%. Standard deviation calculated for PPs of masonry buildings is 11.5. This value is considerably lower than standard deviation calculated for reinforced concrete buildings. The lower standard deviation value of masonry buildings shows that PPs of masonry buildings have narrower range and have smaller difference. According to mean plus one standard deviation of the PPs of masonry structures, it was observed that most of the masonry buildings fall within 42-66 range. Thematic GIS map showing distribution of building PPs within the study area is given in Figure 5.

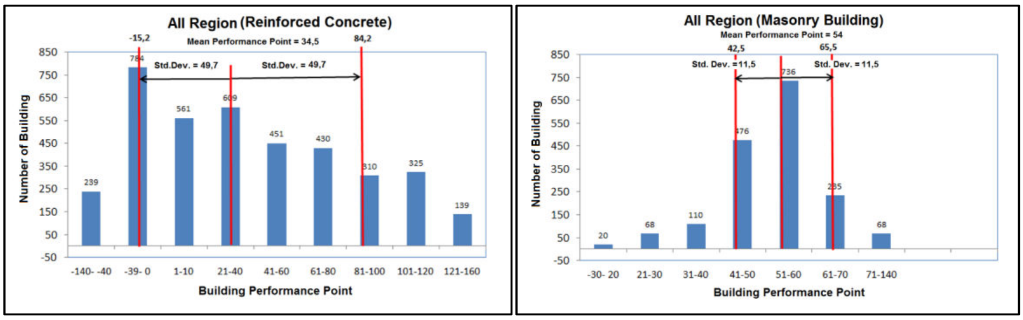


Figure 4. Performance Point Distribution of Reinforced Concrete and Masonry Buildings in the Study Area

3. ESTIMATION OF SAMPLING NUMBER WITH STATISTICAL ANALYSIS

The 3848 reinforced concrete and 1713 masonry buildings summarized in Table 1 form the two clusters of this study. The aim is to clearly present the risk status of the study area by selecting a representative sample set from all the buildings assessed through first stage assessment method given in Annex-A of the Regulation on the Implementation of Law No.6306 via performing the second stage assessment in accordance with the Principles on Detection of Risky Structures given in Annex-2 of the Regulation on the Implementation of the Law. The studies in the second stage assessment method include destructive, cost and time consuming tests requiring qualified personnel. Therefore, "Complete Assessment" (Complete Inventory in statistics) is not suitable and furthermore possible to be performed for all the structures in the area. It is known that, in this type of circumstances, rather than Complete Inventory, Sampling is preferred in statistics. For example, an n radius sample is subset from an N radius population (batch). Therefore, information with a cost and time effective method can be acquired from the population through statistical methods. It is necessary to apply suitable statistical methods to acquire the correct results and thus correct sampling set (subset) should be selected and the samples should be representative of the elements of the population. Sampling branch of statistics includes sampling from a population (batch) and methods to perform relevant statistics from this subset sampling set. The building performance statistics from the populations (reinforced concrete and masonry) has been estimated by utilizing sampling techniques in order to identify the number of buildings to be analyzed in detail through the second stage assessment method and the details are presented below.

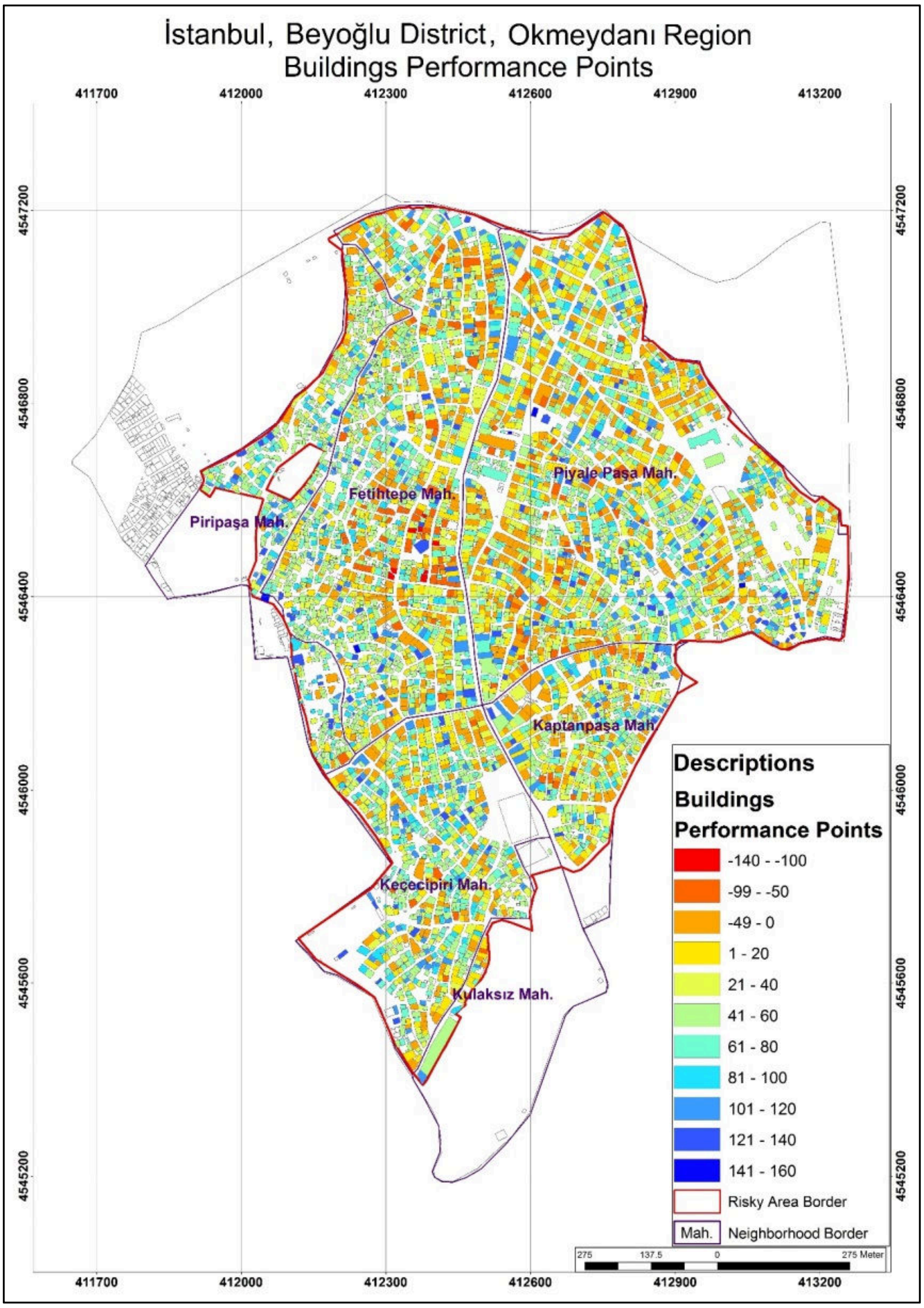


Figure 5. Performance Point Distribution Map of All the Building within the Study Area.

The sensitivity of the estimations to be made by using data from subset samples representing the population (batch) is directly proportional to radius of sampling set and inversely proportional to variance. As increasing the sampling radius increases the cost and time requirements and impairing in certain cases, it is considered that decreasing the variance is more suitable. The method to decrease variance is to subset (stratify, sub-population) the main population (batch). The sampling through stratification of the population is termed "Layered Sampling". "Layered Sampling" has different types. These are, Optimum Allocation, Proportional Layered Sampling, Simple Random Layered Sampling and Most Economic Allocation methods. As building risk points of each building within the population is available, standard deviation and standard error of the mean can be calculated. Therefore, estimation of sampling radius was considered to be more suitable through Optimum Allocation method and Proportional Layered Sampling. Building performance points of reinforced concrete structures range between -140 and 160. According to small variance values and value range between risky and highly secure, the performance points were divided into nine strata. Total of 90 and 109 buildings were selected from Optimum Allocation and Proportional Layered Sampling methods, respectively. Variance is high according to values of the first two strata. Optimum Allocation Method which considers variation during identification of sample number from strata can be taken as the basis. Distribution of number of samples per strata for each method can be seen in Table 2. The building risk points of masonry structures ranges between -30 and 140. The range is divided into 7 strata according to small variance value and highly risky and safe value range. According to performance points of masonry structures within the study area, the distribution of samples according to two sampling methods is given in Table 3.

Table 2. Summary of number of reinforced concrete buildings to be selected according to optimum allocation and proportional layered sampling.

Stratum No.	**Performance Point**		**Total Building Number**	**Optimum Allocation**	**Proportional Layered Sampling**
	Lower Bound	**Upper Bound**			
1	-140	-40	239	13	7
2	-39	0	784	28	22
3	1	20	561	10	16
4	21	40	609	11	17
5	41	60	451	7	13
6	61	80	430	7	12
7	81	100	310	6	9
8	101	120	325	5	9
9	121	160	139	3	4
Total Number of Buildings to be Sampled				90	109

Table 3. Summary of number of masonry buildings to be selected according to optimum allocation and proportional layered sampling.

Stratum Number	**Performance Point**		**Total Building Number**	**Optimum Allocation**	**Proportiona l Layered Sampling**
	Lower Bound	**Upper Bound**			
1	-30	20	20	1	0
2	21	30	68	1	1
3	31	40	110	1	2
4	41	50	476	5	9
5	51	60	736	9	14
6	61	70	235	3	5
7	71	140	68	4	1
Total Number of Buildings to be Sampled				24	33

4. ASSESSMENT ACCORDING TO PRINCIPLES ON DETECTION OF RISKY BUILDINGS GIVEN IN THE REGULATION ON THE IMPLEMENTATION OF OF LAW NO. 6306

In the previous sections, statistical results for the reinforced concrete and masonry buildings assessed through first stage assessment given in Annex-A of the Regulation on the Implementation of the Law and sampling methods to identify the number of buildings to be subset are presented. A cooperative study was performed with cooperation of Beyoğlu Municipality according to number of sample strata and buildings to be selected, and detailed second stage assessment and analyses were performed on the buildings satisfying the criteria and with the permission of the building owners according to the Circular on Detection of Risky Buildings given in Annex-2 of the Regulation on the Implementation of Law no. 6306. During identification of buildings for the second stage assessment number and quality of buildings presented in both statistical sampling methods summarized above were considered. The sampling through destructive test methods can be made only after permission of the building owners. Thus total of 150 buildings, reinforced concrete of 113 and masonry of 37, were selected and second stage risk assessment was performed. Example photographs taken during material strength and building surveys performed on reinforced concrete and masonry buildings during the second stage risk assessment are given in Figure 6. In assessment of reinforced concrete structures, concrete material strength, reinforcement quality, amount of longitudinal reinforcement, tie (stirrup) interval, length of structural elements and structural geometry defects are factors effecting earthquake performance of buildings. Considering these, it was observed that concrete material strength and reinforcement quality was observed to be considerably low in general. Average concrete compressive strength of 113 buildings is 9.4 MPa. Unchecked preparation of reinforced concrete elements of buildings, which are constructed between 1960 to 1970, with unwashed aggregate, inhomogeneous manual mixing, low binder dosage, high water/binder ratio and insufficient maintenance are the main reasons of low average concrete compressive strength. It was observed from core samples that concrete includes rock particles larger than 3 cm. The highest and lowest concrete compressive strength values of 113 inspected buildings were 21.7 and 3.5 MPa, respectively.

Figure 6. Data Collection from reinforced concrete and Masonry Buildings

Reinforcement class of 108 building is S220 unribbed reinforcement. Furthermore, in-situ investigations have shown that stirrup densification is not present in any of the inspected buildings. Stirrup hook detail of 135° was not present in the entire study area. These deficiencies in stirrups causes shear capacity of elements to be insufficient. Average reinforcement percentage is 0.92%. Shear wall elements are not present in the buildings except basements. As rigidity of earthquake shear walls is higher when compared with columns, they can bear earthquake loads more. Bending moments in columns is higher due to structural rigidity insufficiency. Low Concrete strength and insufficient longitudinal reinforcement causes bending capacity (strength) to be insufficient. 111 buildings out of 113 were identified as risky. The above summarized reasons were the main causes of these results. Low material strength and structural systems indicates structure risk status. Reinforced concrete buildings to be in high damage or collapse region in design spectrum indicates the risk status of building stock of the area.

Total of 37 masonry building was investigated according to RYTE, 2013 [7]. The investigation has shown that load bearing wall materials of the buildings are briquette, hollow briquette and horizontal coring brick. Only one building has vertically perforated brick as load-bearing wall material. Class of load bearing wall material is the main factor impacting strength of structure under stresses. Although it is mentioned in article 1.5 of RYTE 2013 [7] that "is risky report is given for buildings constructed with adobe and materials with no load bearing character, by indicating technical reasons, via institutions licensed by the ministry, then these structures are assumed to be risky under Law no. 6306.", structural analyses were performed for buildings with load bearing wall materials as briquette, hollow briquette and horizontal cored brick which have no load bearing character according to DBYBHY, 2007 [8] section 5. It was observed in some of the buildings that shear safety stress is not exceeded. It was identified that total length limit, load bearing wall longest unsupported length condition; load bearing wall hollowness rule stated in regulations is not satisfied in the buildings. Horizontal and vertical lintels to increase horizontal rigidity of walls and hinder out-of-plane movement are not present in any of the inspected buildings. It is obvious that no engineering service was procured and no planning was made for the buildings. Only 1 out of 37 masonry buildings were classified as unrisky in accordance with the detailed risk analyses.

5. CONCLUSIONS

There are only a few of building that are not risky within the area planned to be declared as risky and covered by Fetihtepe, Kaptanpaşa, Keçeci Piri, Kulaksız, Piri Paşa and Piyade neighbourhoods of Beyoğlu district. If structures with building points equal and lower than 40 according to first stage visual assessment is considered to have high risk status, then it was concluded that approximately 43% of the entire building stock in the area have high risk state and substantial damages may occur in case of an earthquake and/or another disaster. According to statistical results for the reinforced concrete and masonry buildings assessed through first stage assessment given in Annex-A of the Regulation of the Implementation of the Law, numbers of buildings to be subset for the second stage assessment were identified. Out of 113 reinforced concrete and 37 masonry buildings, 111 and 36 buildings, respectively, were identified as risky according to the Circular on Detection of Risky Buildings (RYTE, 2013) [7]. As a results, according to detailed structural analyses, almost entire building stock were identified as risky and it was concluded that severe damage is possible in case of an earthquake and/or another disaster.

Summary diagram of the above summarized methodology is given in Figure 7. The method is developed as a general methodology that can be applied to identify risk status of any region based on superstructure distribution. The methodology supports the rapid assessment and detailed assessment methodologies given respectively in Annex-A and Annex-2 of the Regulation on the Implementation of the applicable Law, and set forth based on scientific literature. There are studies which is necessary to increase the correlation between the above summarized three stage risky area assessment methods. The studies and detailed application performed by the authors have shown that research is required to increase correlation of results acquired by rapid assessment technique shown in Annex-A and RYTE, 2013 [7] methodology in Annex-2. It is considered that revision of certain aspects of scoring system of rapid assessment technique and addition of certain new scoring categories may increase correlation between two assessment techniques. It is considered that comparison of construction year of the building with earthquake regulations in place in Turkey is an important parameter to be included as additional criteria. Another important parameter is concrete compressive strength for reinforced concrete buildings. In order to avoid over-extending the application time of rapid assessment technique, a solution other than core sampling should be considered. It is considered that the risk area assessment approach with the addition of above summarized improvement points can be utilized at any region and can be considered as a scientifically supported method.

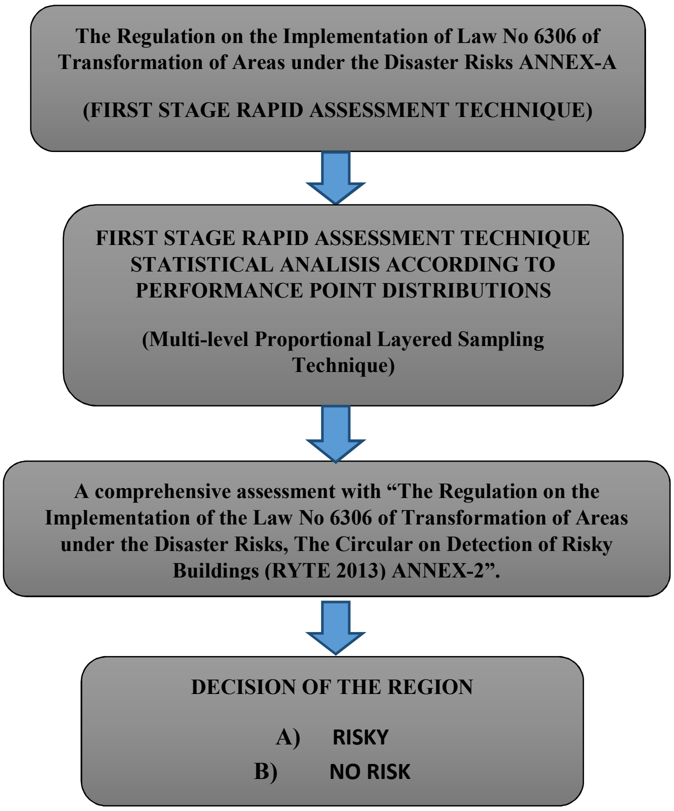


Figure 7. Flow Chart of Proposed Risk Area Assessment Method

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