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Research Article

Determination of Regional Soil Structure Earthquake Risk Distribution of Buildings by Street Survey Method: The Sample of Bilecik Province

Ali ATEŞ^a, Semiha POYRAZ^{b,*}, Ömer ÇOBAN^b

^aDepartment of Civil Engineering, Faculty of Engineering, Bolu Abant İzzet Baysal University, Bolu, TURKEY

^bVocational School, Bilecik Seyh Edebali University, Bilecik, TURKEY

* Corresponding author's e-mail address: semiha.poyraz@bilecik.edu.tr

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ABSTRACT

Earthquake is a natural phenomenon that cannot be ignored in Turkey as in the world. Since Turkey is located in the earthquake zone, research on these issues has increased in recent years in Turkey. In this study, the effects of the earthquake on the reinforced concrete and masonry/mixed buildings in the central neighborhoods of Bilecik province were examined by the Street Survey Method. In this context, a total of 1391 buildings including 1021 reinforced concrete and 370 masonry/mixed buildings on the central districts of Bilecik were examined. The average building earthquake scores for the reinforced concrete and masonry/mixed buildings of each neighborhood were calculated. In terms of reinforced concrete buildings, Bahçelievler, Cumhuriyet, Gazipaşa, İsmetpaşa and İstiklal neighborhoods were found to be at Low Risk in terms of Building Earthquake Safety, while Beşiktaş, Ertuğrulgazi and Hürriyet neighborhoods were found to be Safe in terms of Building Earthquake Safety. All masonry/mixed buildings were found to be Safe in terms of Building Earthquake Safety.

Keywords: Earthquake, Reinforced concrete buildings, Masonry/Mixed buildings, Street survey method, Bilecik province

Sokaktan Tarama Yöntemiyle Binaların Bölgesel Deprem Risk Dağılımının Belirlenmesi: Bilecik İli Örneği

ÖZ

Depremler dünyada olduğu gibi ülkemizde de göz ardı edilemeyecek bir doğa olayıdır. Ülkemizin deprem kuşağında yer alması sebebiyle bu hususlardaki araştırmalar son yıllarda artış göstermektedir. Bu çalışmada Bilecik ilinin merkez mahallelerinde, depremin betonarme ve yığma/karma binalar üzerinde oluşturabileceği etkiler Sokaktan Tarama Yöntemiyle ele alınmıştır. Bu kapsamda Bilecik ili merkez mahalleleri (Bahçelievler, Beşiktaş, Cumhuriyet, Ertuğrulgazi, Gazipaşa, Hürriyet, İsmetpaşa, İstiklal) üzerinde bulunan 1021 betonarme ve 370 yığma/karma olmak üzere toplam 1391 adet bina incelenmiştir. Her bir mahallenin betonarme ve yığma/karma binalar için ayrı ayrı ortalama Bina Deprem Puanları hesaplanmıştır. Betonarme binalar açısından Bahçelievler, Cumhuriyet, Gazipaşa, İsmetpaşa ve İstiklal mahalleleri Bina Deprem Güvenirliği açısından Düşük Riskli iken Beşiktaş, Ertuğrulgazi ve Hürriyet mahallelerinin Bina Deprem Güvenirliği açısından Güvenli olduğu tespit edilmiştir. Yığma/karma binalar açısından tüm mahalleler Bina Deprem Güvenirliği açısından Güvenli bulunmuştur.

Anahtar Kelimeler: Deprem, Betonarme binalar, Yığma/Karma binalar, Sokaktan tarama yöntemi, Bilecik ili

I. INTRODUCTION

Turkey is located in a seismic zone due to its geography. It can be said that the awareness of earthquakes and the awareness of architect and engineering professionals about earthquake resistant building design are not at the desired level in Turkey [1]. Earthquakes in the Marmara region in 1999 showed that the structures were not strong enough [2]. According to Turkey national earthquake research program (TUDAP), most part of Turkey is under the threat of earthquakes that could cause severe damage. Earthquakes that cause damage happen in Turkey every 8 months [3]. The two major earthquakes that occurred on the North Anatolian Fault Zone, which is one of the most active fault lines in the world, in 1999 and the transformation of a natural phenomenon into a disaster due to these two major earthquakes increased the importance and sensitivity of the earthquake issue in Turkey. The results of the earthquakes have necessitated determining the resistance of structures against earthquakes by examining the existing building stocks throughout the country [4]. The majority of the structures in the earthquake zones do not meet the seismic requirements of the regulation in Turkey.

Assessment of structures in an area in terms of the nature of the work (the excess of existing structures, the work to be done in buildings where people reside, etc.) and awareness (the fact that number of national and international studies related to the collective review of buildings is less except the studies conducted in the last few years) is difficult and requires a long time. In this context, it is obvious that rapid and effective methods are needed to determine the earthquake risk of existing buildings. For these reasons, after determining the risk in large areas that are required to be examined within the scope of the Law no. 6306, it is beneficial in terms of time, effort and financial conditions to elaborate the research in the places with higher priority by considering the result. In addition, since it will produce healthier outputs in terms of risk ranking, Appendix-A entitled “Methods for Determining Regional Earthquake Risk Distribution of Buildings” has been prepared within the scope of the Law [5].

In the Earthquake Master Plan for Istanbul, the staging assessment method has been adopted for details since there are a lot of buildings and detailed examination is difficult and time consuming. The stages consist of three parts and are as follows: The first stage: Street Survey, second stage: Pre-Assessment, third stage: comprehensive assessment. Assessment stages have been handled and proposed in different ways by universities such as METU, ITU, and BU. The first stage is referred as “street survey” and the goal of this stage is to make a preliminary grading of buildings with respect to their seismic performance, the number of the buildings at risk and the distribution of these buildings in the city by visual inspection from outside [6].

In the study conducted by Işık and Tozlu in 2015, the researchers chose the soil types, the type of structural system and the visual quality of structure parameters as variant for an existing five-flat buildings using the first stage assessment method mentioned in the rules related to determine the risky structures came into force in 2013, and calculated the structure performance scores according to these variants [7-20].

In their study in 2018, Okuyucu et al. examined reinforced concrete buildings located in Erzurum-Palandöken town in accordance with Law 6306 about Transformation of the Lands under Disaster Risk. Within the study, they examined 1177 reinforced concrete buildings and determined the fundamentals of building performance score calculation using the first stage assessment method of Law 6306. Then, they examined the buildings performance scores statistically and divided the buildings into 5 risk groups. They found that 7.2% of the buildings were at high-risk level; 62.4% was at moderate-risk level, 7.3% was at low-risk level, 22% was safe and 0.7% was very safe [8].

In the study conducted by Tokgöz and Bayraktar in 2015, the researchers determined the risk status of reinforced concrete and masonry buildings located in Kaynasli district of Duzce province against seismic hazards by street survey method, which is one of rapid survey methods. A limit value in terms of risk was determined by calculating risk scores of the buildings using street survey method. The

researchers stated that the findings obtained in the study may be useful in terms of reducing the costs after the earthquake and to prevent the loss of lives [9].

In his study conducted in 2014 Yakut stated that a number of procedures have been proposed over the last decade to assess seismic performance of existing reinforced concrete buildings. He also emphasized that the complexity and the accuracy of these procedures depend on the needs and targets; rapid survey procedures are generally preferred to determine vulnerability ranking of a group of buildings based on rapid assessments carried out from the street survey; and detailed assessment procedures aim to determine weaknesses and retrofit needs for existing buildings. In addition, he examined several seismic performance assessment procedures of reinforced concrete buildings from all three tiers, discussed the weakness of these procedures to assess seismic performance of existing reinforced concrete building and presented comparative evaluation on relative efficiency of the procedures [10].

In their study in 2016, Karaşin and Işık assessed an existing masonry construction in Sur district of Diyarbakır province using two different rapid assessment methods. They assessed the masonry construction determined within the Canadian Seismic scanning method and the first stage evaluation method included in the principles concerning the determination of risk-bearing buildings promulgated by the Ministry of Environment and Urbanization in 2013. As a result, they reported the usability of the first stage evaluation methods proposed for masonry structures [11].

II. MATERIAL AND METHOD

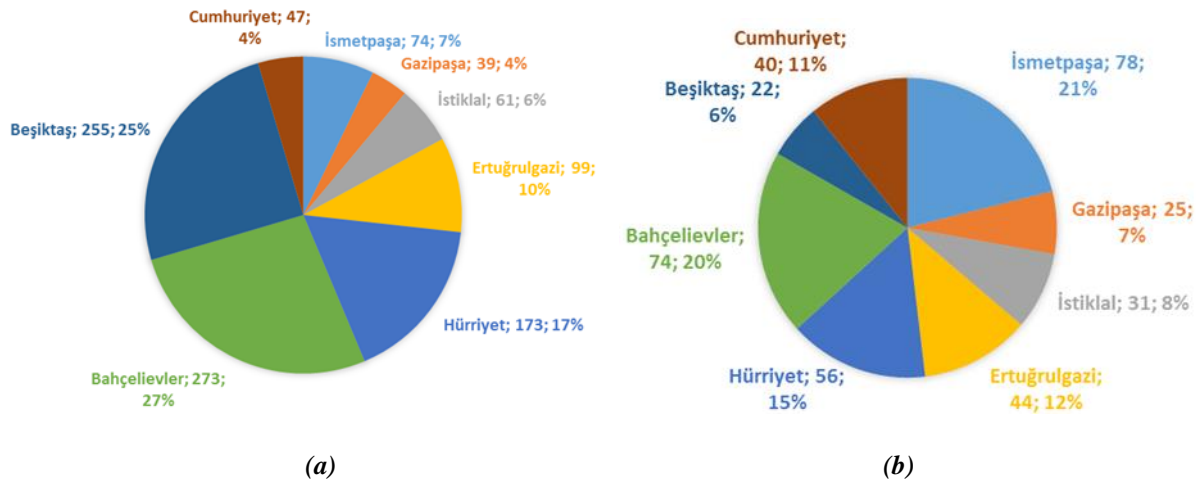
A. MATERIAL

Bilecik is located in the southeast of Marmara Region at the intersection point of Marmara, Black Sea, Central Anatolia and Aegean Regions. It is located between 39° and 40° 31' north latitudes and 29° 43' and 30° 41' east longitudes. Bolu and Eskişehir from the east, Kütahya from the south, Bursa from the west, Sakarya provinces are surrounded by the north (Figure 1). It has an area of 4321 km², and according to the address-based population registration system, the population in 2017 was determined as 221.693 [12].



Figure 1. Bilecik province map [13]

Reinforced concrete and masonry/mixed buildings in the center of Bilecik province (Hürriyet, Bahçelievler, İsmetpaşa, Ertuğrulgazi, Beşiktaş, İstiklal, Cumhuriyet, Gazipaşa) were selected as materials and the numerical distribution of the buildings separately examined according to the districts is given below (Figure 2).



Şekil 2. (Numerical and general percentage distributions of buildings between central neighborhoods of Bilecik province (a) Reinforced concrete buildings (b) Masonry / mixed buildings)

In the street surveys, it was determined that there were 1391 buildings in total in the central neighborhoods of Bilecik (Hürriyet, Bahçelievler, İsmetpaşa, Ertuğrulgazi, Beşiktaş, İstiklal, Cumhuriyet, Gazipaşa) and 1021 of these buildings had reinforced concrete carcass system and 370 had mixed and masonry systems. Figure 2 shows the numerical and percentage distribution of reinforced concrete and masonry/mixed buildings located in the center of Bilecik.

B. METHOD

The parameters of number of stories, existing condition and apparent quality, soft story/weak story, heavy overhangs, short column effect, building adjacency/striking effect, topographic effect, seismic hazard and soil type for 1-7 stories reinforced concrete buildings were considered within the First stage Assessment Method that takes into account the building characteristics and earthquake risk by regulation on the implementation of Transformation of High Risk Areas Law No. 6306. In masonry/mixed buildings, data were obtained by considering the number of stories, existing condition and apparent quality, wall space ratio, wall space arrangement, striking effect and seismic hazard.

B. 1. Building Earthquake Parameters

B.1.1. Number of Stories

The findings obtained after the 1999 Kocaeli and Düzce earthquakes show that there is an almost linear relationship between the number of stories in buildings and building damage. If the required strength is not provided with this increase, the building is damaged. As most of the buildings in Turkey do not have earthquake design, the number of stories and damage rate increases [14]. This characteristic was taken into consideration as a criterion in the assessment of reinforced concrete and masonry/mixed structures and was calculated by including basement story (if any).

B.1.2. Soft Story/ Weak Story

Soft-story refers to one level of a building that is significantly more flexible or weak in lateral load resistance than the stories above it. Soft story buildings are usually the buildings on the street. In this building type, the ground story is left empty of walls or with a reduced number of walls in comparison to the upper floors ground floor. In addition, these buildings have greater height than the rest of the floors. These conditions cause soft story/weak story formation [15]. This characteristic was taken into consideration as a criterion in the assessment of reinforced concrete buildings.

B.1.3. Heavy Overhangs

It represents the buildings that have overhangs in the upper floors for obtaining larger areas. Heavy overhangs cause rigid irregularities in the structure. It was obtained that in the previous earthquakes; the buildings with overhangs were damaged more than the building without overhangs [16]. This characteristic was taken into consideration as a criterion in the assessment of reinforced concrete buildings.

B.1.4. Existing Condition and Apparent Quality of the Structure

There is a close relationship between external appearance of the structure, the risk of damage and its quality. According to the external appearance of the structure, the building is classified as good quality, moderate quality and poor quality. It is expected that the material strength will be low in parallel with the low quality [14]. This characteristic is considered as a criterion in the assessment of reinforced concrete structures and masonry/mixed buildings.

B.1.5. Short Column Effect

It is the risk situation that arises from not filling the space inside the reinforced concrete frame in the outer columns with partition walls for different purposes such as tape windows [14]. This characteristic is considered as a criterion in the assessment of reinforced concrete structures.

B.1.6. Building Adjacency/Striking Effect

Due to the fact that the floor heights of the adjacent buildings are not at the same level, the movement that may occur in the event of an earthquake and that the adjacent buildings can collide to each other cause the striking effect [15]. This characteristic was taken into consideration as a criterion in the assessment of reinforced concrete building and masonry/mixed buildings.

B.1.7. Topographic Effect

The construction of the building on a high slope (at least 30 degrees) increases the earthquake effects significantly [14]. This characteristic was taken into consideration as a criterion in the assessment of reinforced concrete buildings.

B.1.8. Wall Space Ratio

One of the criteria for assessing masonry/mixed buildings is the wall space ratio. In the entrance facades of buildings, the wall space ratio is generally high, and the ratio of these spaces is classified as low, moderate and high. This classification can be made by the proportion of the length of the soaks on the floor to the length of the facade, and is defined as follow: if the ratio of the space is less than $1/3$, the space ratio is low, between $1/3$ and $2/3$ the space ratio is moderate and if it is more than $2/3$, the space ratio is high.

B.1.9. Wall Space Arrangement

In masonry/mixed buildings, spaces such as doors and windows should overlap and be in the same direction. If spaces are not in the same direction, damage to structures may be inevitable. In this respect, space projection should be checked. This characteristic is considered as a criterion in the assessment of masonry/mixed buildings.

B.1.10. Seismic Hazard and Soil Type

The northern part of Bilecik province is at risk due to the North Anatolian Fault line. In addition, the presence of active fault lines in the southern region carries the risk of earthquakes with high periods despite their relatively low magnitude [17].

The severity of the ground shake during the earthquake is related to the distance of the structure to the fault and the general ground conditions. Peak ground velocity is data representing ground conditions. Peak ground velocity PGV is the ground velocity that occurs when the fault line breaks. PGV, which has a direct connection with the soil type, has greater values in poor soil types. The center of Bilecik province is generally rock ground. For example, when Bilecik center coordinates in AFAD Turkey Earthquake Hazard Map are examined, PGV value is determined as < 40 cm/sec (Fig. 3), [18]. In this regard, PGV value indicates that Bilecik province is included in the Velocity Zone III.

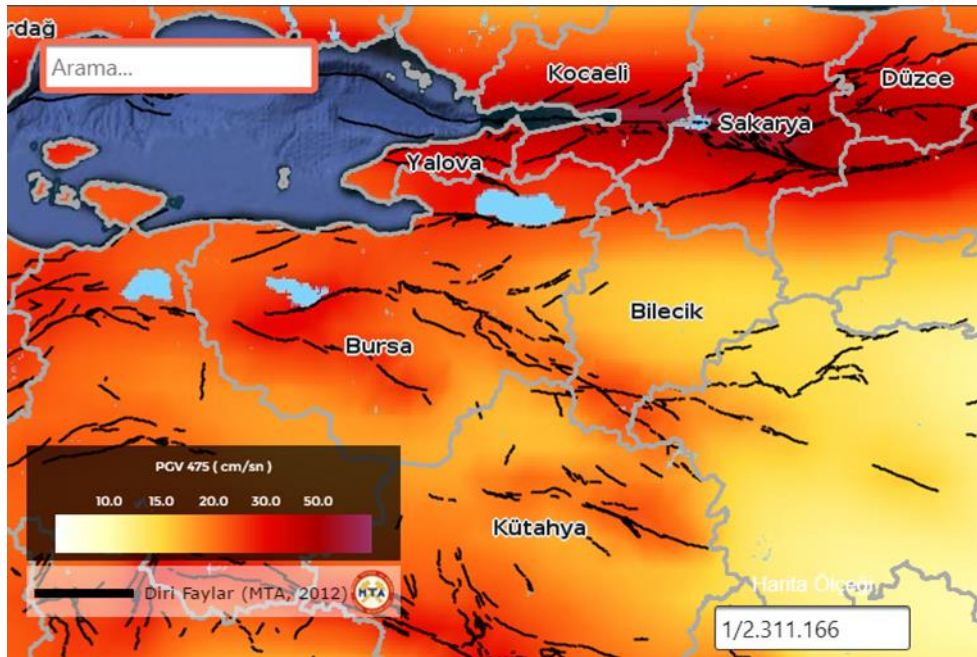


Figure 3. Earthquake map of Bilecik province and its distance to active faults [18]

The values for velocity zones are determined as follows:

Velocity Zone I : $PGV > 60$ cm/s

Velocity Zone II : $40 < PGV < 60$ cm/s

Velocity Zone III : $PGV < 40$ cm/s.

In the study the street survey data forms, which are included in Earthquake Council 2004 Investigation of Existing Structures and Building Inspection Commission Report and used in IDMP (2003), presented in Table 1 and 2 were used for reinforced concrete buildings and masonry/mixed buildings, respectively.

Table 1. First stage building scoring form in reinforced concrete structures

| FORM 1. STREET INFORMATION | | | |
|---|--|-----------------------------------|--------------------------------|
| Street Name | | | |
| Mahalle/District | | | |
| Geographical Coordinates 1 | | | |
| Geographical Coordinates 2 | | | |
| Velocity Zone | | | |
| Geographical Coordinates | | | |
| <i>Note: Geographical coordinates will be taken between the two ends of the street.</i> | | | |
| FORM 2. GENERAL BUILDING INFORMATION | | | |
| Door No | <input type="checkbox"/> Reinforced concrete | <input type="checkbox"/> Masonry | <input type="checkbox"/> Mixed |
| FORM 3. REINFORCED CONCRETE BUILDING INFORMATION | | | |
| Number of stories (basement is included): | | | |
| Soft story | <input type="checkbox"/> No | <input type="checkbox"/> Yes | |
| Heavy overhangs | <input type="checkbox"/> No | <input type="checkbox"/> Yes | |
| Apparent quality | <input type="checkbox"/> Good | <input type="checkbox"/> Moderate | <input type="checkbox"/> Poor |
| Short columns | <input type="checkbox"/> No | <input type="checkbox"/> Yes | |
| Pounding effect | <input type="checkbox"/> No | <input type="checkbox"/> Yes | |
| Topographic Effect | <input type="checkbox"/> No | <input type="checkbox"/> Yes | |

Table 2. First level building scoring form in masonry/mixed buildings

| FORM 1. STREET INFORMATION | | | |
|---|--|-----------------------------------|--------------------------------|
| Street name | | | |
| Mahalle/District | | | |
| Geographical Coordinates 1 | | | |
| Geographical Coordinates 2 | | | |
| Velocity Zone | | | |
| Geographical Coordinates | | | |
| <i>Note: Geographical coordinates will be taken between the two ends of the street.</i> | | | |
| FORM 2 GENERAL BUILDING INFORMATION | | | |
| Door No | <input type="checkbox"/> Reinforced concrete | <input type="checkbox"/> Masonry | <input type="checkbox"/> Mixed |
| FORM 3 MASONRY/MIXED BUILDING INFORMATION | | | |
| Number of stories (Basement is included): | | | |
| Wall space ratio | <input type="checkbox"/> Less | <input type="checkbox"/> Moderate | <input type="checkbox"/> High |
| Wall space arrangement | <input type="checkbox"/> Less | <input type="checkbox"/> Moderate | <input type="checkbox"/> High |
| Apparent quality | <input type="checkbox"/> Good | <input type="checkbox"/> Moderate | <input type="checkbox"/> Poor |
| Pounding effect | <input type="checkbox"/> No | <input type="checkbox"/> Yes | |

B. 2. Calculation of Building Earthquake Score

The criteria included in the calculation of the reinforced concrete building earthquake score are the velocity zone where the structure is located, soft story, heavy overhangs, apparent quality, short column, striking effect, topographic effect (Table 3). The criteria included in the calculation of masonry/mixed building earthquake score are the velocity zone where the structure is located, wall space ratio, wall space arrangement, apparent quality, striking effect (Table 4).

Table 3. Negative parameter coefficients used in concrete building calculations

| Negative parameters | Parameter coefficient | | |
|---------------------|-----------------------|-------------|---------|
| Soft story | No→ 0 | Yes→ 1 | |
| Heavy overhangs | No→ 0 | Yes→ 1 | |
| Apparent quality | Good→ 0 | Moderate→ 1 | Poor→ 2 |
| Short column | Good→ 0 | Yes→ 1 | |
| Pounding effect | No→ 0 | Yes→ 1 | |
| Topographic Effect | No→ 0 | Yes→ 1 | |

Table 4. Negative parameter coefficients used in masonry/mixed building calculations

| Negative parameters | Parameter coefficient | | |
|------------------------|-----------------------|---------------------|--------------|
| Apparent quality | Good→ 0 | Moderate→ 1 | Poor→ 2 |
| Wall space ratio | Less→ 0 | Moderate→ 1 | High→ 2 |
| Wall space arrangement | Regular→ 0 | Slightly Regular→ 1 | Irregular→ 2 |
| Pounding effect | No→ 0 | Yes→ 1 | |

The negative parameter coefficients were multiplied by the negative parameter scores, and therefore the scores of the buildings were calculated. Parameter points in reinforced concrete buildings are given in Table 5, and parameter points in masonry/mixed buildings are given in Table 6.

Table 5. Recommended velocity zone and negativity parameter scores depending on the number of stories in reinforced concrete buildings

| Number of stories | Velocity Zone I. | Velocity Zone II. | Velocity Zone III. | PGV<40 | Soft Story | Heavy Overhangs | Apparent Quality | Short Column | Pounding Effect | Topographic Effect |
|-------------------|------------------|-------------------|--------------------|--------|------------|-----------------|------------------|--------------|-----------------|--------------------|
| 1,2 | 100 | 130 | 150 | 0 | 0 | -10 | -5 | 0 | 0 | |
| 3 | 90 | 120 | 140 | -10 | -5 | -10 | -5 | -2 | 0 | |
| 4 | 75 | 100 | 120 | -15 | -10 | -10 | -5 | -3 | -2 | |
| 5 | 65 | 85 | 100 | -20 | -10 | -10 | -5 | -3 | -2 | |
| 6,7 | 60 | 80 | 90 | -20 | -10 | -10 | -5 | -3 | -2 | |

Table 6. Recommended velocity zone and negativity parameter scores depending on the number of floors in masonry/mixed buildings

| Number of stories | Velocity Zone I. Zone PGV>60 | Velocity Zone II. Zone 40<PGV<60 | Velocity Zone III. Zone PGV<40 | Apparent Quality | Wall space Ratio | Wall Space Arrangement | Pounding Effect |
|-------------------|------------------------------|----------------------------------|--------------------------------|------------------|------------------|------------------------|-----------------|
| 1,2 | 100 | 130 | 150 | -10 | -5 | -2 | 0 |
| 3 | 85 | 110 | 125 | -10 | -5 | -5 | -3 |
| 4 | 70 | 90 | 110 | -10 | -5 | -5 | -5 |
| 5 | 50 | 60 | 70 | -10 | -5 | -5 | -5 |

In the light of the above data, earthquake scores of reinforced concrete and masonry/mixed buildings can be calculated with the following equation, as stated in Eq. 1.

$$\text{Building earthquake scores} = \text{Velocity Zone} - \sum_1^n (\text{negative parameter}) \times (\text{negative score})$$

(Eq. 1.)

The earthquake risk score of a building whose parameters are obtained by visual inspection from street and whose geographical coordinates are known, thus whose zone (PGV: Peak Ground Velocity) is known is obtained by scoring method (Table 7). In this method, a base point is given to the building according to the number of stories and the seismic hazard of the region where it is located (e.g. according to the velocity zone to be determined from the micro-zone maps). Then, the score is reduced to a certain extent for each negativity parameter. As a result, the lower the earthquake score is, the higher the risk of the building is. According to these data, earthquake score limit values were used to determine earthquake priority of buildings (Table 8).

Table 7. Risk groups of buildings according to earthquake scores

| Building Earthquake Score Interval | BDP≤30 | 30<BDP≤60 | 60<BDP≤100 | 100≤BDP |
|------------------------------------|-----------|---------------|------------|---------|
| Building Earthquake Reliability | High Risk | Moderate Risk | Low Risk | Safe |

Table 8. Priority earthquake scoring in buildings

| Building priority | Earthquake Score |
|--------------------------|------------------|
| 1 th priority | 0 – 65 |
| 2 nd priority | 66 - 80 |
| 3 rd priority | 81 - 100 |

III. RESULTS

In this study, the findings obtained from the parameters in the methods section in the central neighborhoods of Bilecik province are given below in tables for all neighborhoods.

A. The Findings Obtained from the Central Neighborhoods of Bilecik Province

A. 1. Apparent Quality Findings for Structures of Central Neighborhoods

The findings obtained as a result of the examination of the apparent quality status of reinforced concrete buildings in the central neighborhoods of Bilecik province (Hürriyet, Bahçelievler, İsmetpaşa, Ertuğrulgazi, Beşiktaş, İstiklal, Cumhuriyet, Gazipaşa) are given in Figure 4 below.

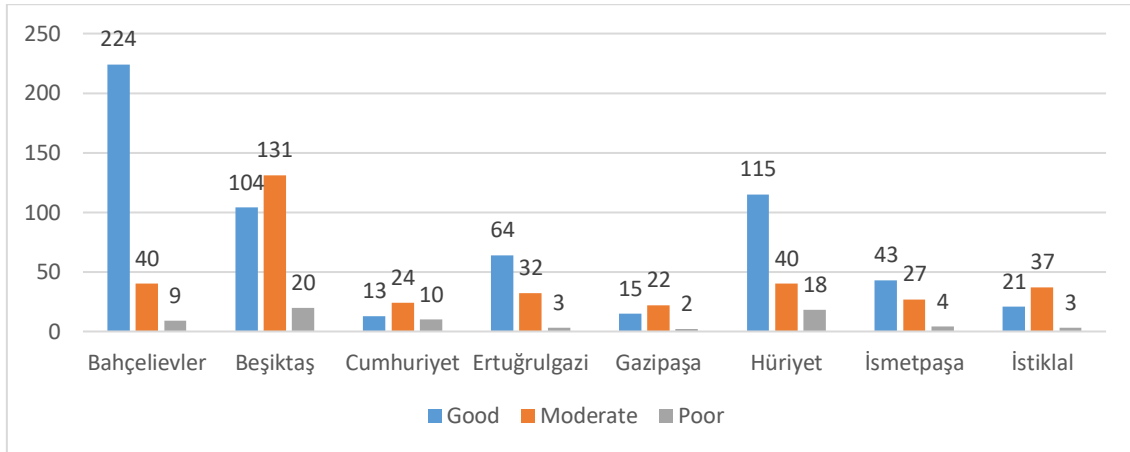


Figure 4. The apparent quality status of reinforced concrete buildings in the central neighborhood of Bilecik province, 1021 buildings.

When Figure 4 is examined, the ratio of good, moderate and poor appearance quality of reinforced concrete buildings in each neighborhood in the central neighborhoods was obtained as follows, respectively: 82%, 15%, 3% in Bahçelievler; 41%, 51%, 8% in Beşiktaş; 28%, 51%, 21% in Cumhuriyet; 65%, 32%, 3% in Ertuğrulgazi; 39%, 56%, 5% in Gazipaşa; 67%, 23%, 10% in Hürriyet; 58%, 37, 5%, %5 in İsmetpaşa and 34%, 61% and 5% in İstiklal.

The findings obtained as a result of examining the apparent quality status of masonry/mixed buildings in the central neighborhoods of Bilecik province (Hürriyet, Bahçelievler, İsmetpaşa, Ertuğrulgazi, Beşiktaş, İstiklal, Cumhuriyet, Gazipaşa) were given in Figure 5 below.

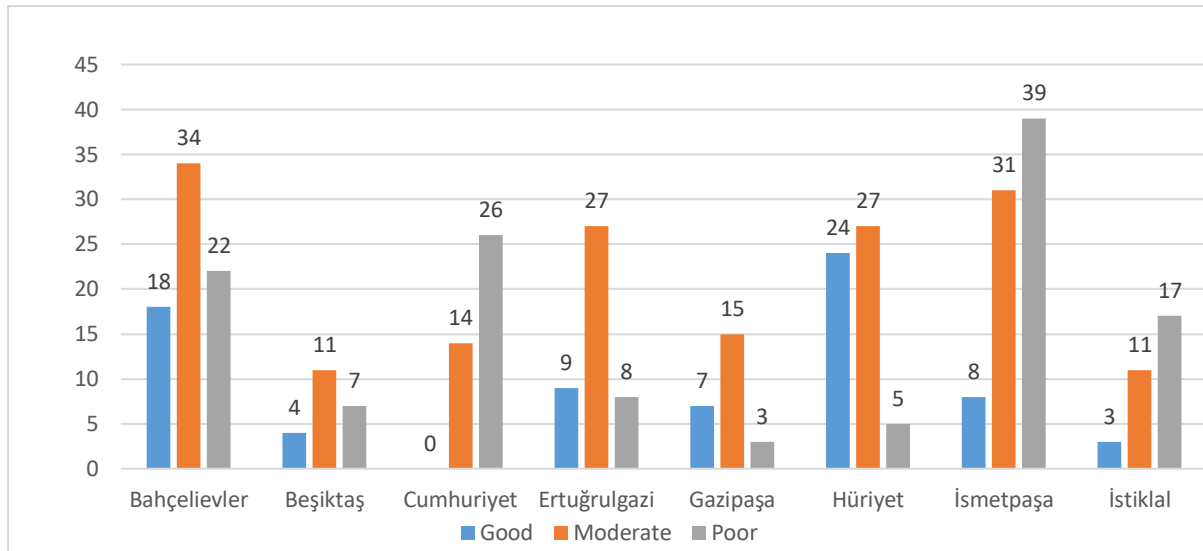


Figure 5. The apparent quality of the masonry/mixed buildings in the central neighborhoods of Bilecik province, 370 buildings.

When Figure 5 was examined, the good, moderate and poor apparent quality ratios of the masonry/mixed buildings in the central neighborhoods of Bilecik province were obtained as follows, respectively: 24%, 46%, 30% in Bahçelievler; 18%, 50%, 32% in Beşiktaş; 0%, 35%, 65% in Cumhuriyet; 21%, 61%, 18% in Ertuğrulgazi; 28%, 60%, 12% in Gazipaşa; 43%, 49%, 8% in Hürriyet; 10%, 40%, 50% in İsmetpaşa and 9%, 36%, 55% in İstiklal.

A. 2. Striking Effect Findings for Structures of Central Neighborhoods

The findings of striking effect of reinforced concrete buildings in the central districts of Bilecik province (Hürriyet, Bahçelievler, İsmetpaşa, Ertuğrulgazi, Beşiktaş, İstiklal, Cumhuriyet, Gazipaşa) were given in Figure 6 below.

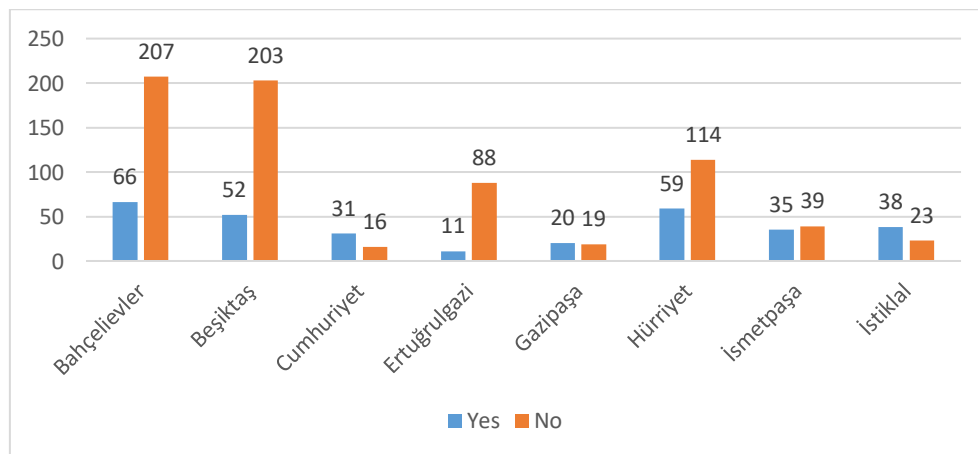


Figure 6. Pounding effect conditions of reinforced concrete buildings in central neighborhoods of Bilecik province, 1021 buildings

As can be seen in Figure 6, pounding effect of the reinforced concrete buildings in each central districts of Bilecik was obtained as follows: 24% in Bahçelievler, 20% in Beşiktaş, 66% in Cumhuriyet, 11% in Ertuğrulgazi, 51% in Gazipaşa, 34% in Hürriyet, 47% in İsmetpaşa and 61% in İstiklal.

The findings of striking effect of masonry/mixed buildings in central neighborhoods of Bilecik province (Hürriyet, Bahçelievler, İsmetpaşa, Ertuğrulgazi, Beşiktaş, İstiklal, Cumhuriyet, Gazipaşa) were presented in Figure 7 below.

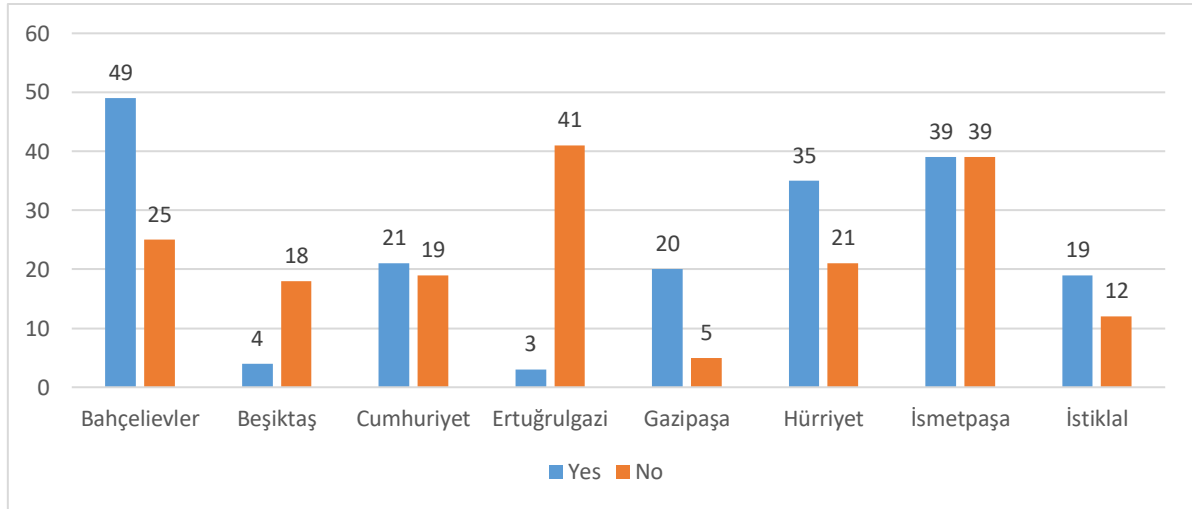


Figure 7. Pounding effect condition of masonry/mixed buildings in central neighborhoods of Bilecik province, 370 buildings

As can be seen in Figure 6, striking effect of the masonry/mixed buildings in each central districts of Bilecik was obtained as follows: 66% in Bahçelievler, 18% in Beşiktaş, 53% in Cumhuriyet, 7% in Ertuğrulgazi, 80% in Gazipaşa, 63% in Hürriyet, 50% in İsmetpaşa and 46% in İstiklal.

A. 3. Soft Story Findings for Structures of Central Neighborhoods

The findings of soft story condition of reinforced concrete buildings in the central districts of Bilecik province (Hürriyet, Bahçelievler, İsmetpaşa, Ertuğrulgazi, Beşiktaş, İstiklal, Cumhuriyet, Gazipaşa) were presented in Figure 8 below.

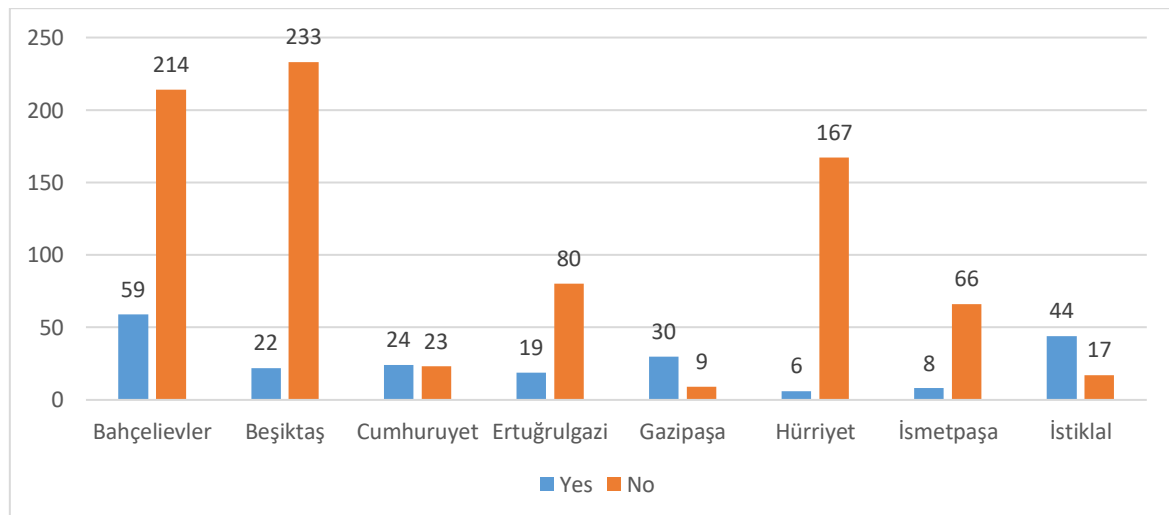


Figure 8. Soft story condition of reinforced concrete buildings in central neighborhoods of Bilecik province, 1021 buildings

When Figure 8 was examined, it was seen that soft story negativity parameter ratio of reinforced concrete buildings in each central districts of Bilecik was obtained as 21% in Bahçelievler, 9% in

Beşiktaş, 51% in Cumhuriyet, 19% in Ertuğrulgazi, 77% in Gazipaşa, 4% in Hürriyet, 11% in İsmetpaşa and 72% in İstiklal.

A. 4. Heavy Overhangs Findings for Structures of Central Neighborhoods

The findings of heavy overhangs condition of reinforced concrete buildings in the central districts of Bilecik province (Hürriyet, Bahçelievler, İsmetpaşa, Ertuğrulgazi, Beşiktaş, İstiklal, Cumhuriyet, Gazipaşa) were presented in Figure 9 below.

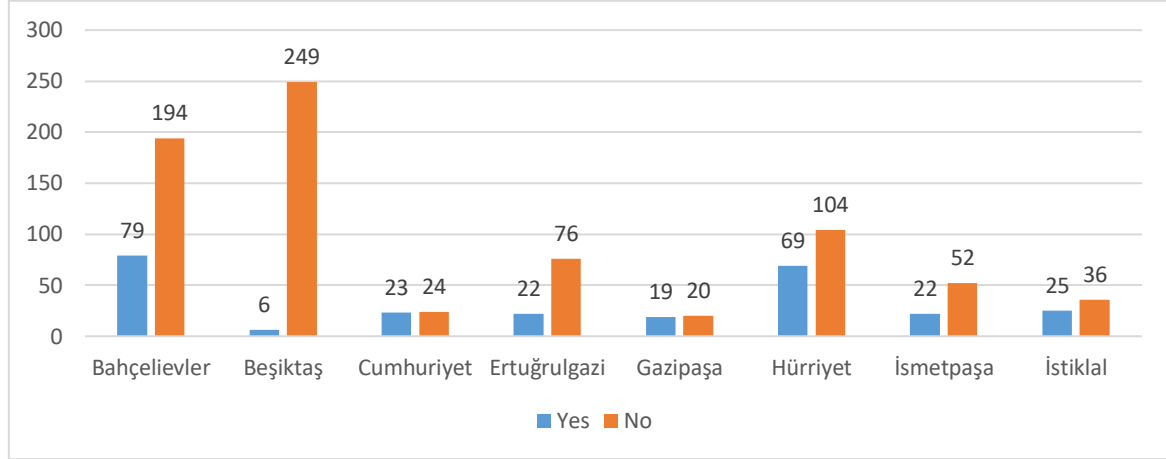


Figure 9. Heavy overhangs condition of reinforced concrete buildings in the central neighborhoods of Bilecik province, 1021 buildings

When Figure 9 was examined, it was seen that heavy overhangs ratio of reinforced concrete buildings in each central districts of Bilecik was obtained as 29% in Bahçelievler, 2% in Beşiktaş, 49% in Cumhuriyet, 23% in Ertuğrulgazi, 49% in Gazipaşa, 40% in Hürriyet, 30% in İsmetpaşa and 41% in İstiklal.

A. 5. Short Column Findings for Structures of Central Neighborhoods

The findings of short column condition of reinforced concrete buildings in the central districts of Bilecik province (Hürriyet, Bahçelievler, İsmetpaşa, Ertuğrulgazi, Beşiktaş, İstiklal, Cumhuriyet, Gazipaşa) were presented in Figure 10 below.

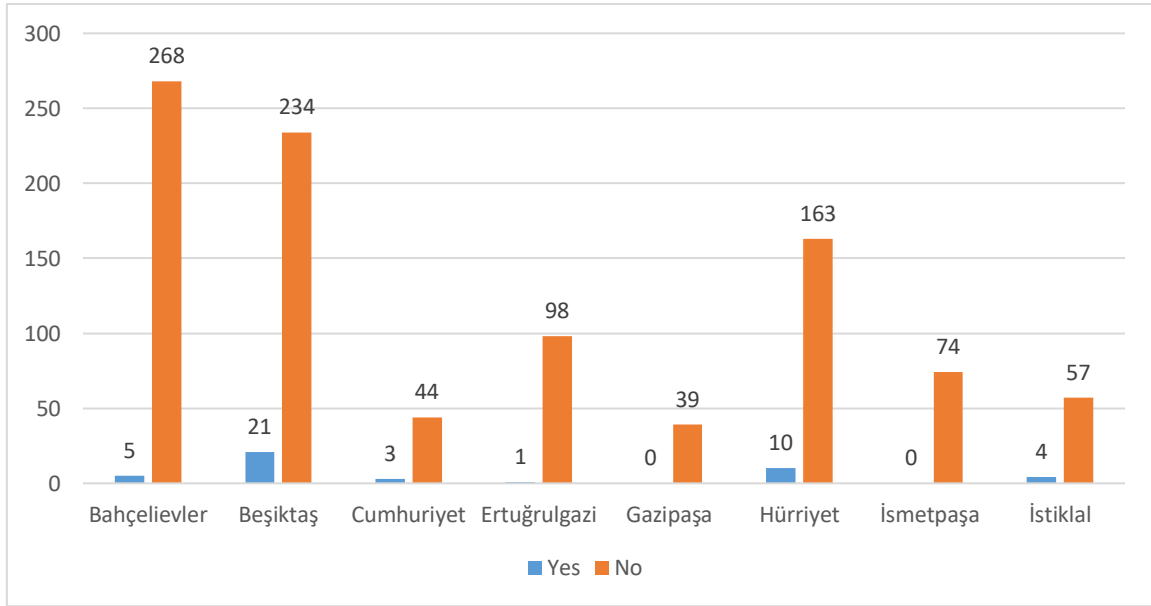


Figure 10. Short column conditions of reinforced concrete buildings in central neighborhoods of Bilecik province, 1021 building

As can be seen in Figure 10, short column ratio of reinforced concrete buildings in each central districts of Bilecik was obtained as 2% in Bahçelievler, 8% in Beşiktaş, 6% in Cumhuriyet, 1% in Ertuğrulgazi, 0% in Gazipaşa, 6% in Hürriyet, 0% in İsmetpaşa and 7% in İstiklal.

A. 6. Topographic Effect Findings for Structures of Central Neighborhoods

The findings of topographic effect condition of reinforced concrete buildings in the central districts of Bilecik province (Hürriyet, Bahçelievler, İsmetpaşa, Ertuğrulgazi, Beşiktaş, İstiklal, Cumhuriyet, Gazipaşa) were presented in Figure 11 below.

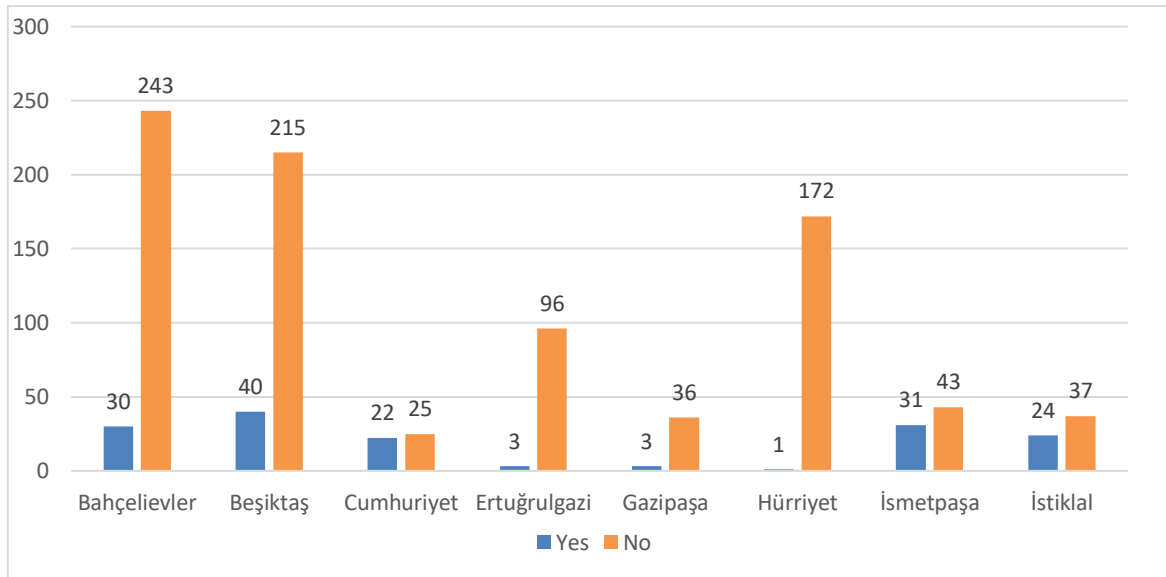


Figure 11. Topographic effect conditions of reinforced concrete buildings in central neighborhoods of Bilecik province, 1021 buildings

As can be seen in Figure 11, topographic effect ratio of reinforced concrete buildings in each central districts of Bilecik was obtained as 11% in Bahçelievler, 16% in Beşiktaş, 47% in Cumhuriyet, 3% in Ertuğrulgazi, 8% in Gazipaşa, 1% in Hürriyet, 42% in İsmetpaşa and 38% in İstiklal.

A. 7. Wall Space Ratio for Structures of Central Neighborhoods

The findings of wall space condition of masonry/mixed buildings in the central districts of Bilecik province (Hürriyet, Bahçelievler, İsmetpaşa, Ertuğrulgazi, Beşiktaş, İstiklal, Cumhuriyet, Gazipaşa) were presented in Figure 12 below.

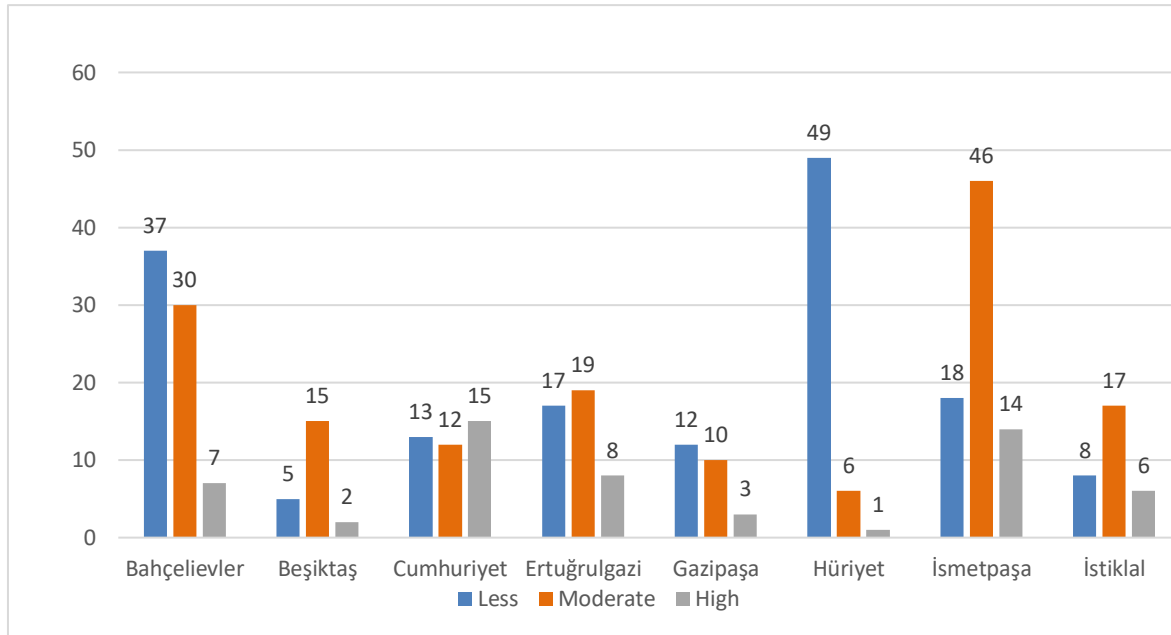


Figure 12. Wall space ratio of masonry/mixed buildings in central neighborhoods of Bilecik province, 370 buildings

When Figure 12 was examined, it was seen that the less, moderate and high level wall space ratios of the masonry/mixed buildings in the central neighborhoods of Bilecik province were obtained as follows, respectively: 50%, 41%, 9% in Bahçelievler; 23%, 68%, 9% in Beşiktaş; 33%, 30%, 37% in Cumhuriyet; 39%, 43%, 18% in Ertuğrulgazi; 48%, 40%, 12% in Gazipaşa; 88%, 10%, 2% in Hürriyet; 22%, 59%, 19% in İsmetpaşa and 26%, 55%, 19% in İstiklal.

A. 8. Wall Space Arrangement for Structures of Central Neighborhoods

The findings of wall space arrangement of masonry/mixed buildings in the central districts of Bilecik province (Hürriyet, Bahçelievler, İsmetpaşa, Ertuğrulgazi, Beşiktaş, İstiklal, Cumhuriyet, Gazipaşa) were presented in Figure 13 below.

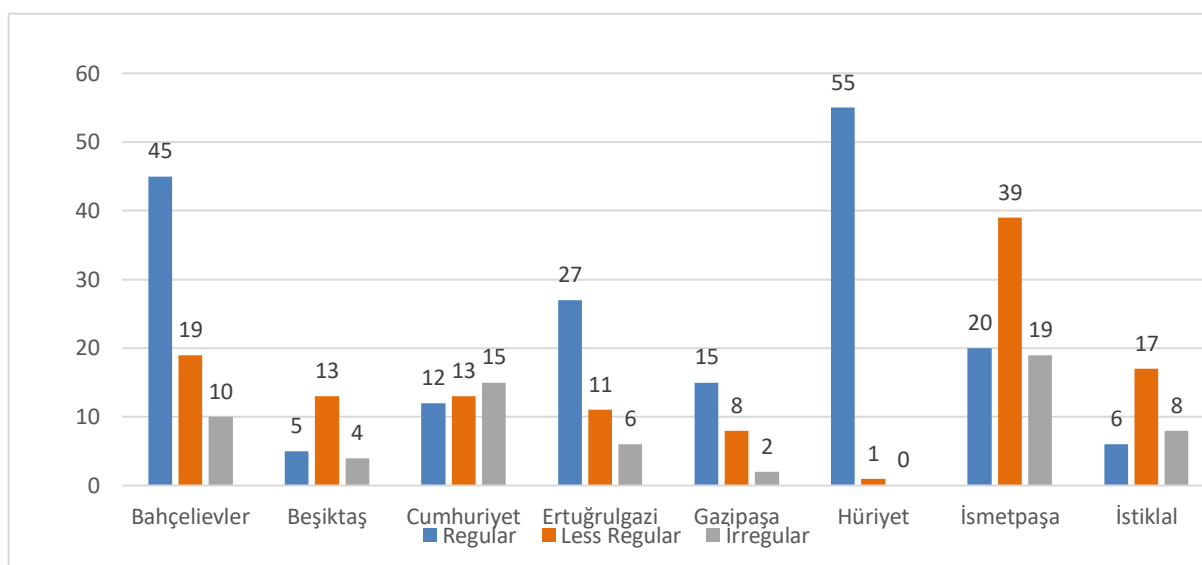


Figure 13. Wall space arrangement of masonry/mixed buildings in central neighborhoods of Bilecik province, 370 buildings.

The findings of wall space arrangement condition of the masonry/mixed buildings in central neighborhoods of Bilecik province, which were determined as regular, less regular and irregular, were obtained as follows: 61%, 26%, 13% in Bahçelievler; 23%, 59%, 18% in Beşiktaş; 30%, 33%, 37% in Cumhuriyet; 61%, 25%, 14% in Ertuğrulgazi; 60%, 32%, 8% in Gazipaşa; 98%, 2%, 0% in Hürriyet; 26%, 50%, 24% in İsmetpaşa and 19%, 55%, 26% in İstiklal.

A. 9. Earthquake Scores and Risk Findings for Structures of Central Neighborhoods

As a result of the Street Survey Method evaluation of the central neighborhoods of Bilecik province, the factors as the earthquake velocity, short column effect, soft story formation, apparent quality condition, topographic effect, heavy overhangs effect were calculated as a result of the calculations in the equation, and the average seismic scores and building seismic safety risk class were determined. The obtained findings were presented in Table 9.

Table 9. Building seismic scores of reinforced concrete buildings examined in the assessment of street survey method

| Name of District | Average Seismic Score | Building Seismic Safety |
|------------------|-----------------------|-------------------------|
| Bahçelievler | 98 | Low Risk |
| Beşiktaş | 117 | Safe |
| Cumhuriyet | 91 | Low Risk |
| Ertuğrulgazi | 101 | Safe |
| Gazipaşa | 75 | Low Risk |
| Hürriyet | 108 | Safe |
| İsmetpaşa | 99 | Low Risk |
| İstiklal | 84 | Low risk |

The data obtained from the street survey method evaluation of the central neighborhoods of masonry/mixed buildings in Bilecik province for the factors as earthquake velocity, apparent quality, wall space ratio, wall space arrangement, striking effect and the calculations in the equation were used to

determine the average seismic scores and general building seismic safety risk class. The findings were presented in Table 10.

Table 10. Seismic scores of masonry/mixed buildings examined in the assessment of street survey method

| Name of District | Average Seismic Score | Building Seismic Safety |
|-------------------------|------------------------------|--------------------------------|
| Bahçelievler | 120 | Safe |
| Beşiktaş | 126 | Safe |
| Cumhuriyet | 125 | Safe |
| Ertuğrulgazi | 124 | Safe |
| Gazipaşa | 120 | Safe |
| Hürriyet | 134 | Safe |
| İsmetpaşa | 116 | Safe |
| İstiklal | 123 | Safe |

IV. CONCLUSIONS

In this study, the existing reinforced concrete structure stock in Bahçelievler, Beşiktaş, Cumhuriyet, Ertuğrulgazi, Gazipaşa, Hürriyet, İsmetpaşa, İstiklal neighborhoods from the central districts of Bilecik was investigated by street survey method and the following results were obtained considering the probability of being affected by earthquakes. The assessment was made on a total of 1391 buildings, including 1021 reinforced concrete and 370 masonry/mixed.

- Bilecik city center is located in an area with active fault lines, but it is located in Velocity Zone III due to the fact that the ground structure is generally rocky. This is a factor that increases the seismicity score of reinforced concrete and masonry/mixed buildings.
- In terms of earthquake behavior of the buildings, the less irregularity is, the better the performance is. When the soft story condition is evaluated, it is seen that 212 reinforced concrete buildings in the center of Bilecik have soft stories. When the reinforced concrete structure stock of the each neighborhood is evaluated within itself, it is seen that the lowest rate is in Hürriyet neighborhood by 4% and the highest rate is in Ertuğrulgazi neighborhood by 77% and İstiklal neighborhood by 72%. The reason for this is that Ertuğrulgazi and İstiklal neighborhoods are located in the bazaar area and most of the reinforced concrete buildings are as shops. It is foreseen that taking the necessary measures to reduce the soft story effect will be beneficial in reducing the risk of damage during the earthquake.
- The apparent quality is directly related to the service life of the building. Service life is usually defined as the period of time during which the performance of the building meets or exceeds initial requirements. This period directly affects material quality and performance. In this respect, the structures examined are directly related to the life and maintenance of the building and provide information on the quality of the buildings. Among the reinforced concrete buildings, the highest apparent quality rate was obtained for Bahçelievler neighborhood by 82%, and the poorest apparent quality rate was obtained for Cumhuriyet neighborhood with a rate of 24%. Among the masonry / mixed buildings, Hürriyet Neighborhood is in the first place with 43% among other neighborhoods in terms of the apparent quality, while the structures with poor quality are in Cumhuriyet Neighborhood with 55%. The fact that the number of buildings with high concrete and masonry/mixed construction age in Cumhuriyet district is higher may explain this situation.
- Among the central districts of Bilecik, Beşiktaş had the lowest rate of heavy overhangs (2%), while Cumhuriyet (49%) and Gazipaşa (49%) had the highest heavy overhangs ratios. Since Cumhuriyet and Gazipaşa Neighborhoods are shopping and bazaar districts, it is thought that this application was used to expand the residence and service area of the district.

- Although short-columned structures in central districts of Bilecik Province were not found in İsmetpaşa and Gazipaşa neighborhoods, they were mostly found in İstiklal Neighborhood (7%). When these ratios are taken into consideration, it is observed that short column construction is taken into consideration and short column manufacturing is avoided. These results are pleasing since the probability of damage due to short column effect during earthquake is low.
- Among the reinforced concrete buildings in central districts of Bilecik province, Ertuğrulgazi (24%) had the lowest striking effect ratio, while Cumhuriyet (66%) and İstiklal (61%) had the highest pounding effect ratio. When the pounding effect ratio of masonry/mixed structures is examined, the neighborhood with the highest striking effect was found as Bahçelievler by 66%. In terms of reinforced concrete buildings, Cumhuriyet and İstiklal buildings and in masonry/mixed buildings in Bahçelievler neighborhoods are allowed to be built with adjacent regulations, however it is necessary to draw attention to the building level equality. It is also important to leave an earthquake joint between buildings.
- In terms of wall space arrangement of the masonry/mixed buildings, Hürriyet neighborhood was found to have the highest regular wall space arrangement by 98%. On the other hand, the neighborhood with the highest rate of irregular walls was Cumhuriyet neighborhood by 37%. It is desirable that the spaces be projected in the same direction in terms of bearing in masonry/mixed structures.
- When the wall space ratio in masonry/mixed buildings was examined, the lowest wall space rate was found in Hürriyet by 88%. On the other hand, Cumhuriyet neighborhood was found to have the highest rate of wall space by 37%. It is desirable that the wall space ratio is low in the masonry/mixed structure types as the walls are bearing elements.
- Cumhuriyet neighborhood was found to have the highest topographic effect ratio by 47%. It can be suggested that the construction should be made on the areas where the slope is less. Based on the average scores obtained by calculating the existing reinforced concrete building stocks building seismic scores of Bahçelievler, Besiktas, Cumhuriyet, Ertugrulgazi, Gazipasa, Hurriyet, Ismetpasa, Istiklal neighborhoods, it was obtained that Bahçelievler, Cumhuriyet, Gazipaşa, İsmetpaşa and İstiklal neighborhoods were low risky and Beşiktaş, Ertuğrulgazi and Hürriyet neighborhoods were safe. The low risky and safe neighborhoods do not mean that the buildings are 100% compliant with the earthquake regulations.

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