DOI: https://doi.org/10.14256/JCE.3436.2021
Građevinar 3/2023

Primljen / Received: 16.12.2021.
Ispravljen / Corrected: 31.7.2022.
Prihvaćen / Accepted: 12.8.2022.
Dostupno online / Available online: 10.4.2023.

Determining the regional disaster risk analysis of buildings in Erzincan

Authors:

Ayşe Başgöze, MCE
Erzincan Binali Yıldırım University, Turkey
Department of Interior Design
ayse.basgoze@erzincan.edu.tr
Corresponding author

Assist.Prof. **Arzu Güncü**, PhD. CE
Erzincan Binali Yıldırım University, Turkey
Department of Civil Engineering
aguncu@erzincan.edu.tr

Professional paper

Ayşe Başgöze, Arzu Güncü

Determining the regional disaster risk analysis of buildings in Erzincan

Erzincan is located in a region sensitive to seismic activities, which can destroy buildings and lead to loss of life because of severe earthquakes. Furthermore, analysing and determining structural risks is important because it reduces possible disaster risks and provides mitigation strategies. This study aims to assess the seismic vulnerability of existing buildings in Erzincan using a rapid visual screening method and create a regional-scale inventory. Furthermore, 490 residential reinforced concrete buildings in five neighbourhoods were analysed using a street scanning method (first-level evaluation) developed by METU, and maps were created using the ArcGIS program. The results revealed that poor construction quality, soft ground, and heavy overhang are the main vulnerability parameters that change the risk priority range of reinforced concrete residential buildings. Conversely, poor construction quality affected most first-priority buildings. Therefore, there is a need for effective seismic mitigation planning for Erzincan, as 49 % of buildings in the surveyed neighbourhoods required a second-stage assessment. In addition, the method ranks the buildings according to their risk priorities, and the obtained data on the map provided useful information for effective strategies for implementing risk reduction policies in Erzincan.

Key words:
Erzincan, earthquake, disaster risk analysis, street screening method, geographical information system

Stručni rad

Ayşe Başgöze, Arzu Güncü

Određivanje regionalne analize rizika od katastrofa za zgrade u Erzincanu

Erzincan se nalazi u regiji podložnoj seizmičkim aktivnostima, koje zbog jakih potresa mogu razoriti zgrade i dovesti do ljudskih žrtava. Analiza i određivanje strukturnih rizika su ključni jer smanjuju moguće rizike od katastrofa i pružaju strategije ublažavanja. Cilj je ovog istraživanja procijeniti seizmičku oštetivost postojećih zgrada u Erzincanu metododom brzog vizualnog pregleda i izraditi bazu podataka na regionalnoj razini. Analizirano je 490 stambenih armiranobetonskih zgrada u pet naselja pomoću metode uličnog pregleda (evaluacija prve razine) koju je razvio METU, a karte su izrađene pomoću programa ArcGIS. Rezultati su pokazali da su loša kvaliteta gradnje, meko tlo i veliki prepusti glavni parametri oštetivosti koji mijenjaju razine prioriteta rizika armiranobetonskih stambenih zgrada. S druge strane, loša kvaliteta gradnje utječe na većinu zgrada koje se ubrajaju u zgrade visokog prioriteta. Stoga postoji potreba za učinkovitim planiranjem ublažavanja rizika od potresa za Erzincan, budući da je 49 % zgrada u ispitanim četvrtima zahtijevalo drugu fazu procjene. Osim toga, metoda rangira zgrade prema njihovim prioritetima rizika, a dobiveni podaci na karti pružili su korisne informacije za razvoj učinkovitih strategija za provedbu politika smanjenja rizika u Erzincanu.

Ključne riječi:
Erzincan, potres, analiza rizika od katastrofa, metoda uličnog pregleda, geografski informacijski sustav

1. Introduction

Disasters caused by natural disasters, such as floods, landslides, and earthquakes, have resulted in loss of life and property in many parts of the world. Most of these losses have been caused by earthquakes [1]. The Alpine-Himalayan orogenic belt in Turkey is the most active fault line in the world. This earthquake ranks first in terms of socio-economic losses and structural damage. The North Anatolian Fault Zone (NAFZ), East Anatolian (EAFZ), and Northeast Anatolian Fault Zones (NAFZ) are the three central tectonic units that shape the earthquake distribution in Turkey [2, 3]. The NAFZ, approximately 1500 km long, causes a series of dangerous earthquakes greater than 7.0 (Mw) [3], such as the 1939 Erzincan [4] and 1999 Izmit Earthquakes [5, 6]. Furthermore, many earthquakes have occurred near the EAFZ in the historical record, despite only a few occurring at the NAFZ [7]. The 2010 Doğanyol-Sivrice Earthquake (Mw = 6.7) and the 1992 Erzincan Earthquake (Mw = 6.7) are some of the devastating earthquakes that occurred in the NAF Zone [6]. Conversely, the 2011 Van earthquake [Mw = 7.1], the 2020 Elazig earthquake [Mw = 6.8] and the Izmir earthquake [Mw = 6.9] have been recorded as the four major earthquakes to have occurred over the past 15 years with the most loss of life and structural damage [8-10]. Additionally, Turkey experiences a devastating earthquake approximately every two years owning to this tectonic structure and has the highest earthquake occurrence rate in the world [11]. 86,456 people lost their lives, and 603,131 buildings were entirely or heavily damaged in all these earthquakes. Furthermore, an average of 1003 people lose their lives annually, and 7094 buildings are damaged because of earthquakes [12]. In addition, earthquakes cause the loss of more than 1% of the average national income every year [13]. Conversely, structural damage in earthquakes in Turkey is much heavier than what would generally be expected in a disaster-prepared country, considering the magnitude of seismic events [14, 15].

The interaction of earthquake hazards with vulnerable, unprepared societies and physical environments causes disaster [16]. Therefore, it is important to determine disaster risks in earthquake-prone settlements and to conduct necessary mitigation and recovery studies on buildings [17]. One of Turkey's most critical steps over the past 20 years within this framework has been the legal regulation of new buildings. The "*Regulation on Buildings to be Constructed in Disaster Areas*" (RBCDS) was issued in 1997 and revised in 2007 and 2018, respectively. While all these legal regulations primarily focus on ensuring earthquake safety in new buildings, risk assessments for existing buildings require more detailed experimental and analytical studies.

There are more than 20,000,000 buildings in the earthquake-prone settlements in Turkey [18]. Earthquake safety must be determined by screening this building stock. However, it seems impossible to analyse these structures with analytical methods involving linear static, linear dynamic, nonlinear static, and nonlinear dynamics analyses as defined in the literature [19] and the regulations in terms of time and finance [20, 21]. These assessment methods [22-25] are suitable for a small number of buildings because they require a complex analysis process and detailed knowledge of structural features and components. Therefore, simple and rapid risk assessment methods are required for the preliminary evaluation before such a detailed seismic assessment of large building stock. Thus, the number of buildings that need to be evaluated with analytical and code-based evaluation techniques has been reduced [19, 26].

Rapid visual screening (RVS) methods have been used in countries such as America (FEMA 154) [27], New Zealand (NZSEE) [28], İtaly (GNDT) [29], Canada (NRCC) [30], and Japan (JBDPA) [31]. These methods identified as "first-level assessment" or "street screening" were developed in Turkey, benefiting from local conditions, construction characteristics, and past earthquake experiences. The methods (METU [32], Sucuoğlu et al. (2007) [33], and RBTE-2019 methods [34]) have been used in various provincial settlements such as İstanbul [32], İzmir-Radius Project [35], Düzce-Kaynaşlı [1], Antalya-Muratpaşa [36], Erzurum [18], Bitlis [37], Tatvan [21], İstanbul-Esenler [38], and Bilecek [39]. The street scanning method is based on the evaluation of risk priorities according to the earthquake performance score calculated for each building and data collection with the observations of experts from outside the building. However, it is not suitable for risk assessment purposes in a single building, despite the ability to perform this method in areas with a statistically significant number of buildings [33].

Conversely, a "*geographical information system*" (GIS) has become an indispensable tool for disaster risk analyses owning to its ability to store data and for production and analysis [40, 41]. Furthermore, it is possible to determine and compare disaster risks regionally in residential areas with these systems. Pre-disaster risk analyses for residential areas enable the carrying out of post-disaster damage assessments and the creation of risk maps [41, 42]. Additionally, Bayraktar [1], Kassem et al. [43], Mohamad et al. [44], Catula et al. [45], Rajarathnam and Santhakumar [46], Illic et al. [47], Tokgöz and Bayraktar [48], Columbro et al. [49], and Işık et al. [3] have recently applied rapid visual screening methodologies in a specific region, city, or country by integrating them with GIS technology.

Each city in Turkey has different physical environments and constructional characteristics; therefore, disasters affect each city differently. The province of Erzincan is the study subject and is one of the critical urban settlements that have been exposed to many earthquake-related disasters and experienced social, physical, and economic losses during its history (1011, 1045, 1254, 1268, 1289, 1374, 1576, 1784, etc.) because of its tectonic structure. The 1939 earthquake of 7.9 magnitude damaged the residential area, and the city was rebuilt in a new location [50]. In 1992, an earthquake of 6.8 magnitude occurred in the city center and damaged many buildings. Furthermore, based on the findings of post-earthquake the damage assessment studies, basic engineering services were not followed in the buildings, and structural defects such as soft storey, heavy overhang and pounding effect caused damage in reinforced concrete structures [51]. These results revealed the importance of disaster risk reduction and mitigation studies in the city.

A risk analysis study to be conducted for the existing building stock is a crucial step in preventing possible disasters and producing appropriate pre-disaster solutions. This study aims to assess the seismic vulnerability of the existing buildings in Erzincan with the rapid visual screening method and to create a regional scale inventory. Recently, it has become a priority for local governments to reduce the seismic risk and ensure the economic and social security of the local people [14]. Therefore, decision-makers need a tool or dataset to develop risk reduction strategies and safety measures for future earthquakes. Furthermore, seismic vulnerability assessments at urban scale are critical. This research is important for Erzincan because it can guide the local authorities in determining regional response priorities, developing disaster risk mitigation programs, and managing information for the city's risk profile.

In this study, the METU [32] street scanning method, which ranks buildings according to their risk priorities on a regional scale, and the ArcGIS program, which stores and maps databases, were used. Furthermore, we proposed a GIS-based risk assessment approach that presents the results of the rapid screening method on a regional scale. Particularly, it is possible to determine risk priorities among buildings and neighbourhoods with maps. The results and maps obtained in the study provide essential information for further research in Erzincan and strengthen other studies previously published in the literature.

However, it is difficult to analyse the entire building stock in the urban settlement of Erzincan. Because of that five neighbourhoods in Erzincan (Yunus Emre, Fatih, Akşemsettin, Barbaros, and Kızılay) that were most affected in the 1992 earthquake. Therefore, they were selected as the pilot area. Conversely, the study was limited to RC buildings because reinforced concrete (RC) residential buildings were more damaged than masonry buildings during the 1992 earthquake [51].

2. Research area and method

2.1. Research area

The study was conducted in Erzincan province, in the Upper Euphrates Basin of the northwest part of the Eastern Anatolia Region. Erzincan Basin is located at the intersection of three groups of strike-slip fault lines, including the North East Anatolia Fault Zone (NEAFZ), North Anatolian Fault Zone (NAFZ), and Ovacık Fault (OF) [52].

Furthermore, the city was exposed to 32 recorded earthquakes with a magnitude of four or more from 1011 to the present (Table 1). Two major earthquakes in the Erzincan Basin that broke the NAFZ and caused significant damage occurred in the last century (1939 Ms = 8.0 and 1992 Ms = 6.8) [54]. The 1939 Erzincan Earthquake was recorded as the earthquake that created the most prolonged surface rupture, with 360 km in five different segments. 32,962 people lost their lives during this earthquake [55].

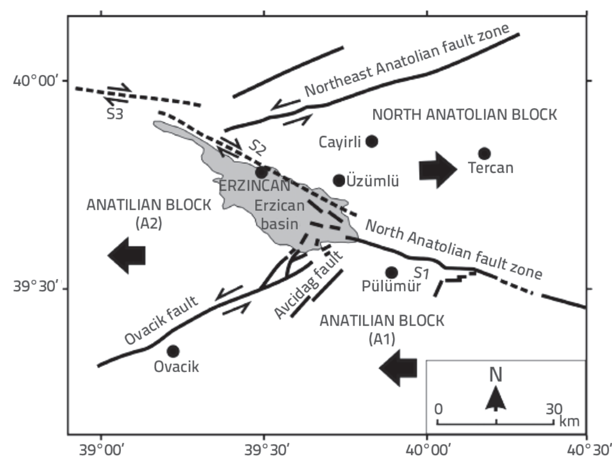

Figure 1. Tectonic structure in Erzincan Basin [53]

The 1992 earthquake occurred in the 350 m long rapture zone at the eastern end of the 1939 earthquake. 541 people lost their lives in the 1992 earthquake [56]. 8 % of the buildings were heavily or entirely damaged, 12 % were moderately damaged, and 15 % were slightly damaged as a result of the earthquake's impact [51]. The damage rate in residences was 25 % and 43 % in commercial areas, and the average damage rate in the city was 16 % [57].

The seismic hazard in the NAFZ is significant because the unconsolidated sedimentary basin can increase ground motion during an earthquake [58]. According to Bayrak et al. [59], the probability of an earthquake with a magnitude of 7.5 in the Erzincan Basin is relatively high.

2.2. Method

The street screening method and ArcGIS programme were used in this study, which aims to create a GIS-based inventory by investigating the seismic risk of the existing building stock in Erzincan. The study was conducted in two environments: the site and the office. The buildings' data were obtained on the site using the "*street screening*" method. In the office, the data were analysed, and the risks were assessed and mapped.

Yunus Emre, Kızılay, Fatih, Barbaros, and Akşemsettin neighbourhoods in the city were selected as sample areas within this framework. The reason for choosing these areas is that these areas include the residential areas most affected by the disaster, with loss of life and building damage, according to the damage reports after the March 13, 1992, earthquake [57]. Regarding the fieldwork and current data obtained from the Erzincan Municipality City Planning Directorate, another reason for this selection is that these neighbourhoods contain housing. The city centre location map and satellite image of these regions are shown in Figure 2.

Table 1. Erzincan Earthquakes [60]

History	Latitude	Longitude	Severity	Properties
1011.	39 80	39 50	VIII	The city was devastated by the severe earthquake.
1045.	39 75	39 50	IX	Very strong earthquake, many deaths occurred.
1161.	39 75	39 50	VII	
1168.	39 75	39 50	VIII	
1236.	39 75	39 50	VII	
1254.	39 75	39 50	VIII	16000 people died.
1268.	39 75	40 40	IX	15000 people died. Erzincan was destroyed.
1281.	39 75	39 50	VI	Strong shaking, no casualties.
1287.	39 75	39 50	VIII	Many people died
1289.	39 75	39 50	VII	Extensive damage, several thousand died.
1290.	39 75	39 50	VI	Strong shaking, no casualties.
1308.	39 75	39 50	VII	Strong shaking, no casualties.
1345.	39 75	39 50	VI	
1356.	39 75	39 50	VI	The earthquakes lasted for a few days, since the settlement was far away, there were no casualties.
1366.	39 75	39 50	VI	Shake
1374.	39 75	39 50	VIII	Even the city walls were destroyed in the earthquake that lasted for 1 h.
1422.	39 75	39 50	VIII	Heavy earthquakes and many deaths occurred.
1433.	39 75	39 50	VI	
1456.	39 75	39 50	VIII	The city was partially destroyed.
1458.	39 75	39 50	X	Major damage in Erzincan and Erzurum.
1482.	39 75	39 50	IX	Major damage in Erzincan and Erzurum.
1543.	39 75	39 50	VII	Villages were damaged, the city was partially destroyed.
1576.	39 75	39 50	VII	1500 people died.
1579.	39 75	39 50	VIII	
1584.	39 75	39 50	IX	
1667.	39 75	39 50	VIII	
1784.	39 75	39 50	VIII	It is one of the very strong earthquakes, many people died and the tremors lasted for four months.
1787.	39 75	39 50	VIII	
1888.	39 75	39 50	VII	Damage
1939.	39 75	39 50	X	7.8 magnitude earthquake, about 33,000 casualties
1983.	36 80	39 50	VII	There was no loss of life, and structural damage occurred in many buildings.
1992.	39 70	39 30	VIII	500 people lost their lives and 11,000 houses were damaged.

Table 2. Number of damaged buildings related to the neighbourhood in the 1992 Earthquake [61]

Neighbourhoods	Number of houses	Number and percentage of damaged houses						Rate [%]
		Completely + heavily		Medium		Slightly		
			[%]	Number	[%]	Number	[%]	
Akşemsettin	1200	88	6.5	261	9.1	47	1.1	7
Fatih	1415	353	26.2	456	15.8	97	2.3	25
Yunus Emre	1500	12	0.9	94	3.3	568	13.5	1
Kızılay	893	55	4.1	144	5.0	294	7.0	6
Barbaros	813	33	2.5	25	0.9	5	0.1	4

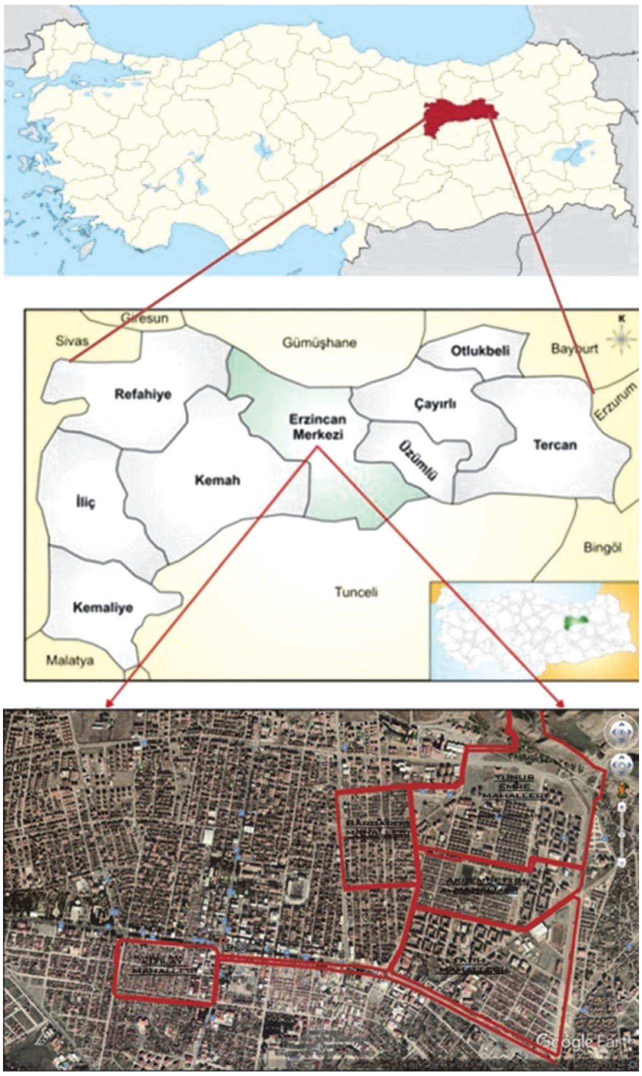

Figure 2. Location map of Erzincan city centre and sample neighbourhoods

2.2.1. The Street screening method

The street scanning method is the fastest and simplest rapid vulnerability assessment approach [43]. This method is intended to determine the priorities of buildings for the second stage of assessment. Generally, the scoring system, or seismic index method, is used to determine the building performance score and consists of basic calculations. After the performance score calculation, the buildings are ranked according to detailed evaluation priorities [26, 32, 62]. This scoring system allows practitioners to evaluate structural systems based on a predetermined vulnerability parameter for a specific building type [63]. Furthermore, the street screening method generally requires typical building data such as building location, age, structural system, number of floors, structural irregularities, and construction quality that can be simply observed from the street. This visual observation can be made with the help of a questionnaire form. Therefore, many buildings can be examined in a short time. This method is generally based on expert opinion and statistical data [19].

In this study, the method developed by METU within the scope of the Earthquake Master Plan of Istanbul was used. This method is designed for 1–7 story reinforced concrete buildings [32]. In this method, the seismic performance of reinforced concrete buildings, the local soil class and peak velocity area where the building is located, and vulnerability parameters are considered.

The data required to use this method are listed below.

The number of stories**:** The number of stories in the building has a linear relationship with the seismic force. The total number of floors on the foundation for this parameter is considered [38].

Apparent building quality: The quality of workmanship and materials used in the construction of any building and the care shown in its maintenance reveal the obvious construction quality of the building to be examined. It is possible to consider the concept of quality in a building in a wide range, but a well-trained observer can classify the apparent quality of the building as good, medium, or bad. Conversely, the apparent quality observations can be associated with the age of the structure, although the year of construction is not a parameter of the method, which indirectly affects the seismic performance [38].

Soft story: The fact that the stiffness and strength of any floor in the building are significantly less than the other floors creates the concept of a "soft floor." There are shops, restaurants, banks, etc. on the ground floors of the buildings. Infill partition walls are not built for commercial purposes. Therefore, the ground floor in such buildings is relatively weak compared to the upper floors in lateral displacements. Soft columns cause probable shear failures [64].

Short column: Filling reinforced concrete frames with half-height partition walls, creating band windows, and using intermediate beams on stairwells are the main reasons for forming short columns because it is easily identifiable by visual inspection [38].

Pounding effect: Pounding effect is a parameter valid for adjacent structures. The pounding effect occurs when the number of storey or floor levels of adjacent structure or building blocks are at different levels [38, 65].

Heavy overhangs: Heavy overhangs create irregularities in reinforced concrete buildings with large balconies or overhangs arranged outside the frame system [66].

Topographic effect (peak/slope effect): Because seismic forces are not transferred uniformly to the foundations of buildings on sloping ground, they may not work properly and cause high-intensity damage. This effect depended on the location of the buildings relative to the local ground level and slope [36].

Local soil conditions: The shaking intensity experienced by the structures during the earthquake depends mainly on the distance of the structure from the fault and the mechanical properties of the local ground. Therefore, the method's basic parameters are the peak velocity area and the site's ground class. According to the Turkish Seismic Design Code (TSDC 2018) [67], the soil groups are classified as ZA, ZB, ZC, ZD, ZE, and ZF, depending on the design acceleration spectrum.

If the soil profile belongs to the ZA soil group, the ground displays a solid, hard rock form; ZB local soil classes displays a less weathered, medium-solid rock texture; ZC local floor grade: very tight sand,

Table 3. Data collection form for reinforced concrete buildings

<table>
<tr><td colspan="2">ADDRESS INFORMATION</td><td>BUILDING CODE:</td></tr>
<tr><td>Neighbourhood</td><td>Fatih</td><td rowspan="5"></td></tr>
<tr><td>Street/Avenue</td><td>700</td></tr>
<tr><td>Door No/building name</td><td>8</td></tr>
<tr><td colspan="2">LAND REGISTER INFO</td></tr>
<tr><td>Block/Plot/Layout</td><td>1420/78/5</td></tr>
<tr><td colspan="3">SOIL PROPERTIES</td></tr>
<tr><td colspan="3">Peak velocity area
☐ Velocity area I: PGV>60 cm/s ☐ Velocity area II: 40<PGV<60 cm/s ☐ Velocity area III: PGV<40 cm/s</td></tr>
<tr><td colspan="3">Class of soil: ☐ ZA ☐ ZB ☐ ZC ☐ ZD ☐ ZE ☐ ZF</td></tr>
<tr><td colspan="3">BUILDING PROPERTIES</td></tr>
<tr><td colspan="3">Construction year: ☐ >2018 ☐ 2007-2017 ☐ 1997-2006 ☐ 1976-1996 ☐ <1975</td></tr>
<tr><td colspan="3">Number of storey: ☐ 2 floors ☐ 3 floors ☐ 4 floors ☐ 5 floors ☐ 6 floors ☐ 7 floors</td></tr>
<tr><td colspan="3">Type of building: ☐ Residential ☐ Residential + commercial ☐ Commercial ☐ Industrial ☐ Office ☐ Derelict</td></tr>
<tr><td colspan="3">VULNERABILITY PARAMETER OF BUILDING</td></tr>
<tr><td colspan="3">Ordinance of building: ☐ Detached ☐ Adjacent ☐ Block</td></tr>
<tr><td>Heavy overhang</td><td colspan="2">☐ Present ☐ Absent</td></tr>
<tr><td>Weak/Soft floor</td><td colspan="2">☐ Present ☐ Absent</td></tr>
<tr><td>Short column</td><td colspan="2">☐ Present ☐ Absent</td></tr>
<tr><td>Pounding effect</td><td colspan="2">☐ Present ☐ Absent</td></tr>
<tr><td>Peak/Slope effect</td><td colspan="2">☐ Flat ☐ Sloping (Slope >30°)</td></tr>
<tr><td>Apparent building quality</td><td colspan="2">☐ Good ☐ Moderate ☐ Poor</td></tr>
</table>

gravel, and hard clay layers; ZD local ground grade: gravel or clay layers; ZE local soil grade: loose sand and soft clay floors; the ZF soil layers require site-specific preparation.

Building data collection

The data were collected with the street scanning method using the form recommended in "Annex-A of the Law on Renewal of Areas at Disaster Risk No. 6306" (Table 3). The form consists of four subsections:

Address Information: Data on each building's urban context, including the geographic location, and a photograph of the facade.

Building Construction Information: It contains data on the number of floors, occupancy, and construction year of the building. The year intervals are determined according to the revised regulations in Turkey.

Soil Properties: Local soil class and Peak ground velocity data are shown in this section.

Vulnerability parameters: Data on vulnerability parameters such as the soft floor, pounding effect, etc., directly affecting the building earthquake score, are included.

The vulnerability parameters of the building were provided in the questionnaire form and by the visual method in the field, and other parameters (address information and construction year) were obtained from the database of the Erzincan Municipality City Planning Directorate. Local soil class and peak velocity area data for each building were obtained from the Erzincan geologic report and Turkey earthquake hazard map [68]. The earthquake score of each building was calculated after collecting all the necessary information and data.

Calculating "Building Earthquake Score"

The building earthquake score is the basic indicator that determines the seismic risk ranking of the building in the examined region and its priority in the second-degree evaluation. This score is calculated in terms of the base score (peak velocity area score), vulnerability (negativity) parameter score multipliers, and vulnerability (negativity) score using the following formula [32]:

$$BES = VAS - \sum_{i=1}^{n} VPV_i \cdot VS_i \quad (1)$$

Where BES is the building earthquake score, VAS is the velocity area score, VPV is the vulnerability (negativity) parameter value, and VS is the vulnerability (negativity) score. Furthermore, n represents the number of vulnerability parameters.

The peak gravity velocity (PGV) area was primarily determined according to the solid class of the site where the buildings were located. A base score (VAS) was determined according to the determined peak velocity area and the number of stories of the building, which are given in Table 4. Each VPV is decided by choosing the corresponding values from Table 5 after inspecting the collected data in Table 3 for each building. VS is given in Table 4. The lower

Table 4. Velocity area scores and vulnerability scores [32]

Story	Velocity area scores (VAS)			Vulnerability Scores (VS)					
	Velocity area I PVG > 60 [cm/s]	Velocity area II 40 < PGV < 60 [cm/s]	Velocity area III PGV < 40 [cm/s]	Soft floor	Heavy overhang	Apparent quality	Short column	Pounding effect	Peak/ Slope effect
1, 2	100	130	150	0	0	-10	-5	0	0
3	95	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 5. Vulnerability (negativity) parameter values [32]

Negativity parameter No	Negativity parameter	Case 1		Case 2	
		Parameter detection	Parameter value	Parameter detection	Parameter value
1	Soft floor	Present	0	Absent	1
2	Heavy overhang	Absent	0	Present	1
3	Apparent quality	Good	0	Moderate; Poor	1; 2
4	Short column	Absent	0	Present	1
5	Pounding effect	Absent	0	Present	1
6	Peak/slope effect	Absent	0	Present	1

Table 6. Priority levels vs. building earthquake score

Priority levels	Building earthquake score (BES) ranges	Colour indicator
1st Priority (highest risk)	BES < 85	
2nd Priority (moderate risk)	86 < BES < 105	
3rd Priority (lowest risk)	106 < BES < 130	

the BES obtained in the calculation, the higher the building risk. Parameters that affect the VAS are the number of stories and the local soil class, which affect the intensity of the ground motion in terms of the PGV divided into three zones, as shown:

- Peak Ground Velocity I: PGV > 60 cm/s
- Peak Ground Velocity II: 40 > PGV < 60 cm/s
- Peak Ground Velocity III: PGV< 40 cm/s.

The numerical values assigned to the VAS and VS are given in Table 4. For all VP, except the apparent quality, determinations are made as "present" or "absent." VPV corresponding to these determinations is taken as 1 and 0 for "present" and "absent" states, respectively. If the apparent quality rating is "good," VP is taken as 0, if it is "moderate," 1 is assigned, and if it is "poor," 2 is given to VP. VP is indicated in Table 5.

Determining the risk classes

According to the risk status of each building earthquake score of which was calculated with Equation (1) in the study, the buildings were classified as the:

- 1st priority
- 2nd priority
- 3rd priority.

In determining the risk classes of the buildings, the assessment approach suggested by Işık [37] was beneficial, and the limit values were determined according to the results of the analysis, indicating a reliable correlation between the preliminary evaluation and the method. Sucuoğlu [33] stated that the choice of the limit value could be left to the decision-makers since the main purpose of the street screening method was to sort the buildings according to their risks and separate the high-risk buildings for a more comprehensive analysis. The limits were determined according to the highest and lowest risk scores for 490 buildings for which earthquake scores were calculated in this study within this scope (Table 6). According to Equation (1), the highest risk value was calculated to be 120, and the lowest risk value was determined to be 60. According to the risk priority:

- 1st priority indicates the buildings with second-level assessment (detailed assessment) priority
- 2nd priority indicates the buildings with second-level assessment priority at the moderate level
- 3rd priority indicates the buildings with second-level assessment priority at the lowest level

Conversely, considering the distribution of the buildings in the neighbourhood according to the risk level.

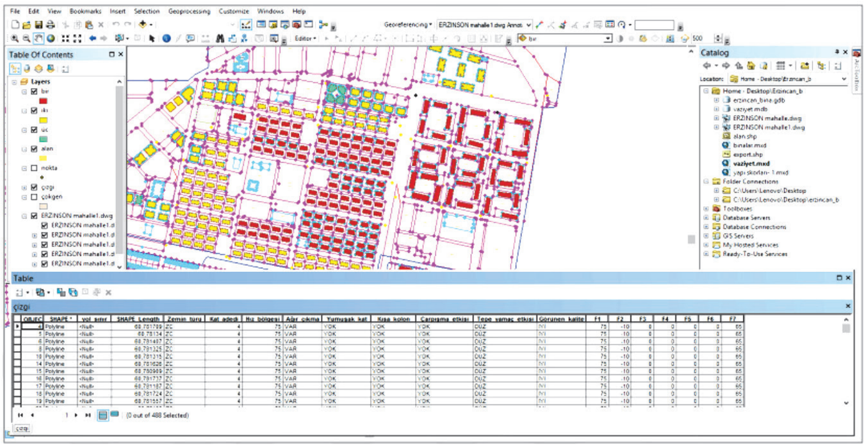

Figure 3. Processing ArcGIS building parameters

- The areas where the 1st priority buildings were concentrated indicated the areas that needed to be responded to primarily in any earthquake that could occur.
- The areas where the 2nd priority buildings were concentrated indicated the areas that needed to be responded to secondarily in any earthquake that could occur.
- The areas where the 3rd priority buildings were concentrated indicated the areas that were safe in terms of an earthquake and had no risk from a possible earthquake.

2.2.2. Creating the risk maps with the ArcGIS program

Geographical Information Systems (GIS) also benefited from mapping the regional distributions of the buildings for which risk analysis was performed. Besides serving many disciplines, this system was also used in geography, software engineering, and many other areas that dealt with geographic data [65]. In the study, the ArcGIS programme was used for mapping.

In the study, the neighbourhoods' ground conditions were assessed using Erzincan's geological-geotechnical survey report. The district data was digitised using the ArcGIS programme on the created city raster plan. The diverse maps of slope and suitability for settlement and soil classes, were used as a base for the risk distribution of buildings. Furthermore, the data obtained by the street screening method was transferred to the ArcGIS program, and maps were created. These maps consist of:

- Regional Vulnerability.
- Regional distribution of buildings according to risk priorities.

3. Results

In the study, risk analyses of 490 residential reinforced concrete (RC) buildings in five neighbourhoods including Yunus Emre, Fatih, Akşemsettin, Barbaros, and Kızılay located in Erzincan, were performed within the scope of the street screening method. The obtained data were digitised in the programme, and maps were presented.

3.1. Digitisation of Erzincan geological raster maps in the ArcGIS program

The slope, suitability for settlement, ground class, and liquefaction analysis of the buildings in the neighbourhood were performed according to the "Geological/Geotechnical Survey Report Based on the Zoning Plan" of the Erzincan, and the following results were obtained:

The slope map of Erzincan city settlement was between 0 and 10 %, and did not vary much within the urban territory (Figure 4). Furthermore, the RC buildings and all the neighbourhoods were located on the slope of 0-10 % when the regions analysed with the slope map overlapped.

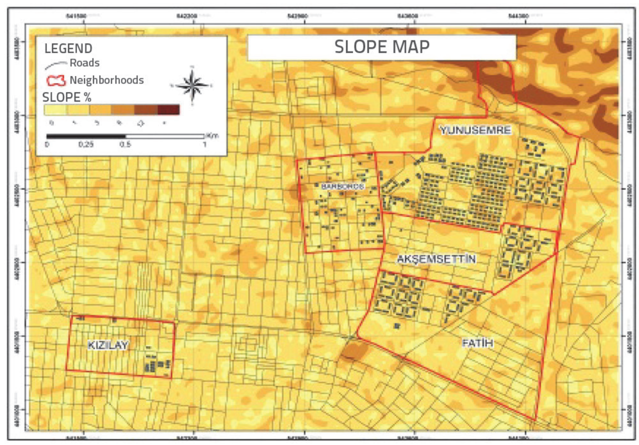

Figure 4. Raster slope map of the study area

A total of two regions were identified on the suitability map of Erzincan: PA1 (precautionary area 1) and PA2 (precautionary area 2). The precautionary areas were suitable for settlement if the appropriate action recommended by the report was considered regarding the construction of buildings. All analysed neighbourhoods and RC buildings were located in Precautionary Area-1 (Figure 5).

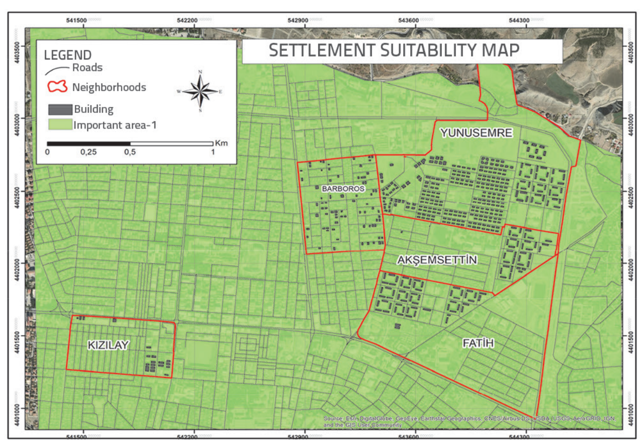

Figure 5. Settlement suitability map of the study area

Table 7. Distribution of buildings in neighbourhoods according to soil classes

Soil classes	Yunus Emre	Akșemsettin	Barbaros	Fatih	Kızılay	Total
ZC	300	38	73	60	-	471
ZD	-	-	-	-	19	19

In Erzincan's suitability map, there are two regions, Precautionary Area 1(PA1) and Precautionary Area 2 (PA2). Precautionary areas are suitable for settlement if the appropriate construction is considered. All the neighbourhoods and RC buildings examined are located in PA1. The grounds in the urban settlements were classified according to the soil classification in the same report. Furthermore, the soil classes of the studied areas were ZC (very dense sand, gravel, and complex clay layers or weak, weathered rocks with many cracks) and ZD (medium dense-dense sand, gravel, or substantial clay layers). Additionally, 96 % of the buildings analysed in the study were in ZC class, and 4 % were in ZD ground class (Table 7). As shown in the map presented in Figure 6, the buildings in the ZD class are located in the Kızılay neighbourhood.

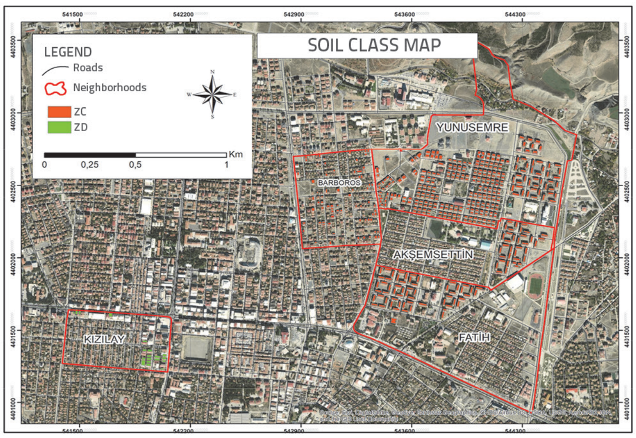

Figure 6. Soil classes map of the study area

According to the report, geologically loose soils and fine-grained materials such as sand and areas with shallow groundwater are the most suitable areas for liquefaction. Accordingly, the groundwater level in the city is low in the south and deep. While the water level is below 15 m in the north, it rises to 8 m in the south. Therefore, there is no serious liquefaction risk in the studied areas.

3.2. Evaluation and comparison of risk priorities in neighbourhoods

The risk analysis of RC residential buildings in five neighbourhoods was conducted in the study using the street screening method. The neighbourhoods, according to the analysis results, were compared within the framework of:

- General assessment (structural system, type of use, etc.)
- Vulnerability parameters (soft floor, pounding effect, etc.)
- Number and distribution of risky buildings.

General assessment

When the buildings in the neighbourhoods were examined according to their structural systems, 597 buildings were reinforced concrete and 1096 were masonry (Figure 7).

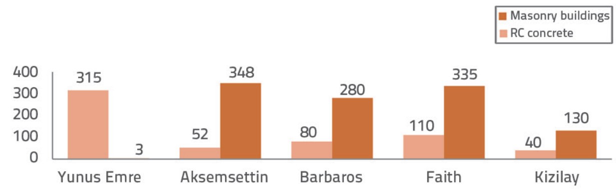

Figure 7. Distribution of buildings according to the structural system

Furthermore, 35 % of the residential buildings in the study area are made of reinforced concrete, and 65 % are masonry systems. Most of the RC residential buildings were in the Yunus Emre neighbourhood.

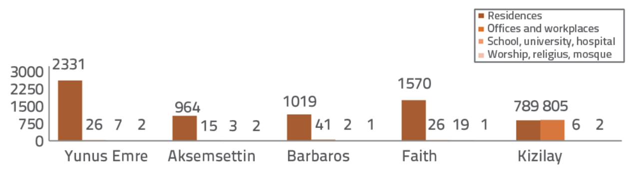

Figure 8. Distribution of buildings according to type of use

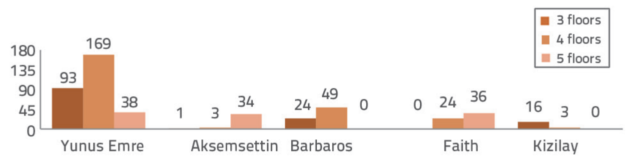

Figure 9. Distribution of buildings according to the number of floors

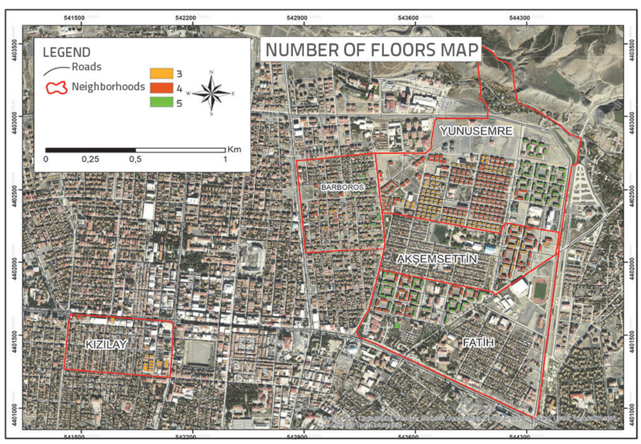

Figure 10. Regional distribution map of buildings according to the number of stories

Figure 8 shows the general distribution of buildings according to their occupancy rates. The statistical distribution of the building stock shows that most of the buildings evaluated are residential buildings

(88 %), while small office and commercial buildings (12 %) are less common. The neighbourhood with the highest number of residences is Yunus Emre, and the least is Kızılay. When the neighbourhoods are examined in terms of the number of stories, most buildings have four floors (51 %) and three floors (32 %), while 22 % have five floors. Yunus Emre is the region with the highest concentration of 5-story buildings. Figure 10 shows the distribution of buildings by the number of stories. Furthermore, there are more medium- and low-rise buildings than high-rise buildings in the examined areas.

Regional distribution of buildings according to vulnerability parameters

In the study, the buildings were analysed considering the vulnerability parameters of heavy overhangs, short columns, soft floors, pounding effects, peak or slope effects, and apparent building quality. Furthermore, their regional distribution was determined and shown on the maps. While 226 (58 %) of the 490 buildings examined according to these parameters had heavy overhangs, this effect was not observed in 224 (42 %) (Figure 11). As seen on the map in Figure 12, most buildings with heavy overhangs are in the Yunus Emre neighbourhood.

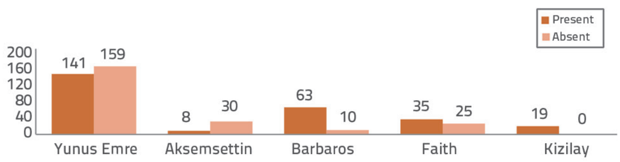

Figure 11. Distribution of buildings according to heavy overhangs

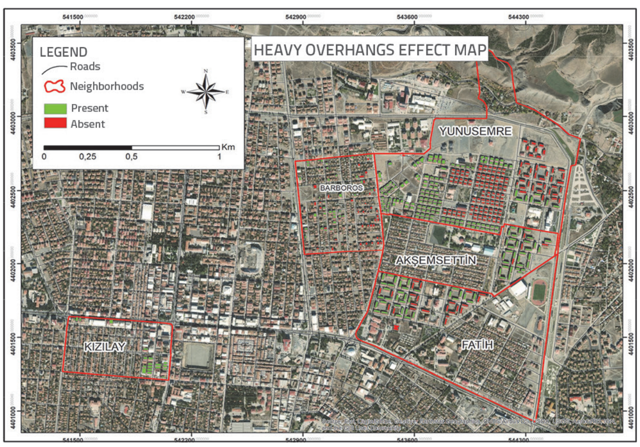

Figure 12. Regional distribution map of buildings according to the heavy overhang effect

When the buildings were analysed according to the short column parameter, 286 (58 %) of the 490 (RC) buildings had the short column effect, while 204 (42 %) did not have this effect (Figure 13).

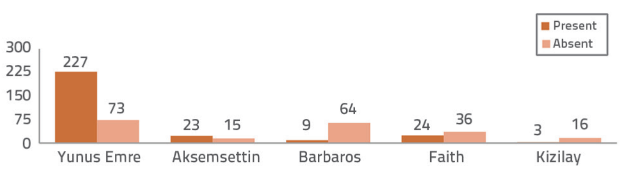

Figure 13. Distribution of buildings according to the short column effect

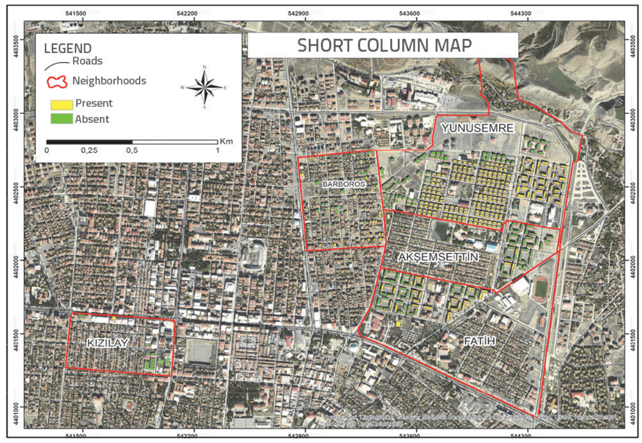

Figure 14. Regional distribution map of buildings according to the short column effect

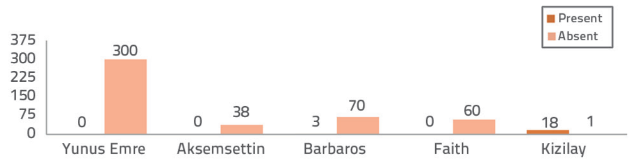

Figure 15. Distribution of buildings according to soft floor effect

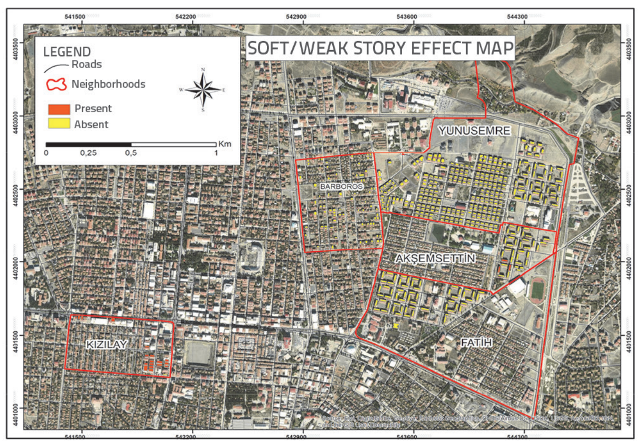

Figure 16. Regional distribution map of buildings according to the soft floor effect

According to the map in Figure 14, the place where the short column effect was most intense was the Yunus Emre neighbourhood. In the context of the *soft floor effect*, statistical results show that only 21 buildings have this vulnerability parameter in the entire building stock, 18 (4 %) of which were in Kızılay and 3 in the Barbaros neighbourhood. This effect was not observed in other districts (Figures 15 and 16).

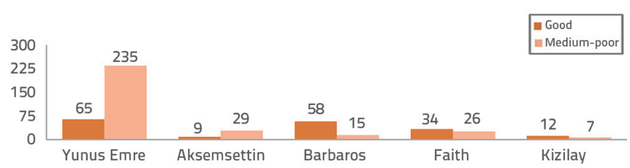

Figure 17. Distribution of buildings according to the apparent building quality

Table 8. Number of buildings in the neighbourhoods according to their construction date

Neighbourhoods	Yunus Emre	Akșemsettin	Barbaros	Fatih	Kızılay
Number of building	300	38	73	60	19
Before the earthquake	229	22	14	24	6
After the earthquake	71	16	59	36	13

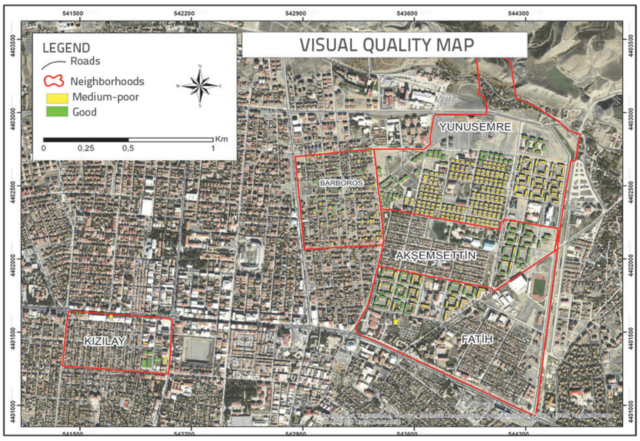

Figure 18. Regional distribution map of buildings according to apparent building quality

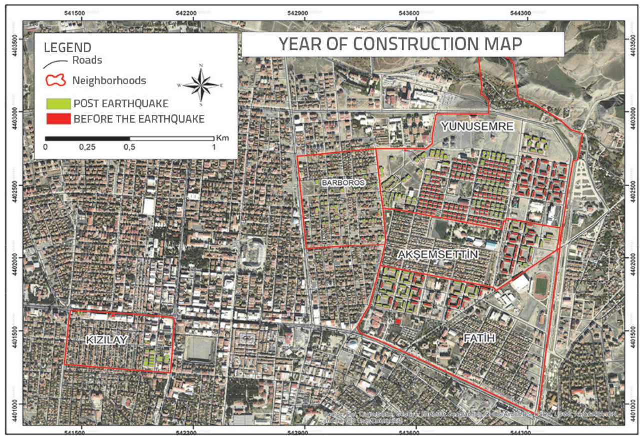

Figure 19. Regional distribution map of buildings according to construction dates

Table 9. Construction dates of buildings according to Seismic Design Code (SDC)

Neighbourhoods	SDC 2018	SDC 2007	SDC 1997	SDC 1975
	> 2018	2017 - 2007	2006 - 1997	1996 - 1992
Yunus Emre	3	40	28	229
Akșemsettin	-	8	2	28
Barbaros	6	46	7	14
Fatih	-	20	16	24
Kızılay	2	8	-	6

Conversely, when the buildings are screened in terms of apparent building quality, 178 RC buildings (36 %) were in good condition and 312 (64 %) were in medium-poor condition (Figure 17). Yunus Emre is the neighbourhood with the most visible quality vulnerability. On the contrary, Kızılay is the region with the lowest vulnerability rate (Figure 18).

The most critical parameter that determines the apparent quality of the building is its age, thus represented by the year of construction. The 1992 earthquake and earthquake regulations were considered the main parameters. According to the analysis results, 295 out of 490 houses were built before and 195 after the earthquake. 78 % of the structures built before the earthquake are in Yunus Emre, 8 % in Fatih, 7 % in Akșemsettin, 5 % in Barbaros, and 2 % in Kızılay (Table 8). 36 % of the buildings constructed after the earthquake were in Yunus Emre, 30 % in Barbaros, 19 % in Fatih, 8 % in Akșemsettin, and 7 % in Kızılay. The map created according to the construction dates of the buildings is presented in Figure 19.

Furthermore, the year of construction of the buildings has an indirectly effect on their quality because it indicates which earthquake code they were built to. While Turkey has had a Seismic Design Code (SDC) since 1940, it was renewed in 1975, 1997, 2007, and 2018, respectively. Statistical results show that 60 % of the building stock was built according to the 1975 regulation (Table 9). Approximately 78 % of the structures that suffer from this vulnerability parameter are located in the Yunus Emre district. Furthermore, the age of the building also affects its quality. These buildings in Yunus Emre District are at least 30 years old.

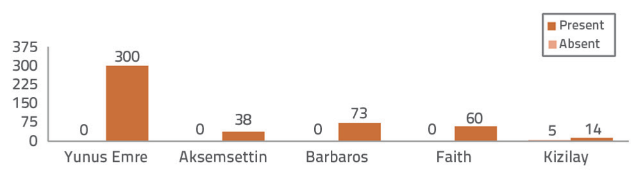

Figure 20. Number and distribution of buildings according to the pounding effect

The pounding effect was observed in only five (1 %) buildings out of the 490 buildings inspected by street screening (Figure 20). These RC buildings are located in the Kızılay district. The difference in floor heights and floor levels in the buildings in this area created this effect. The prevalence of separate and block construction in other

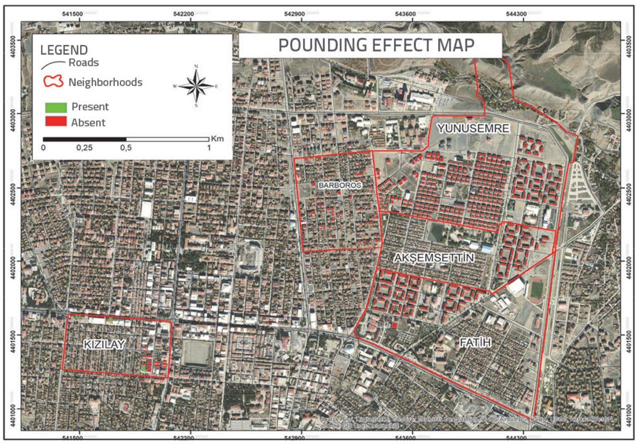

Figure 21. Regional distribution map of buildings according to the pounding effect

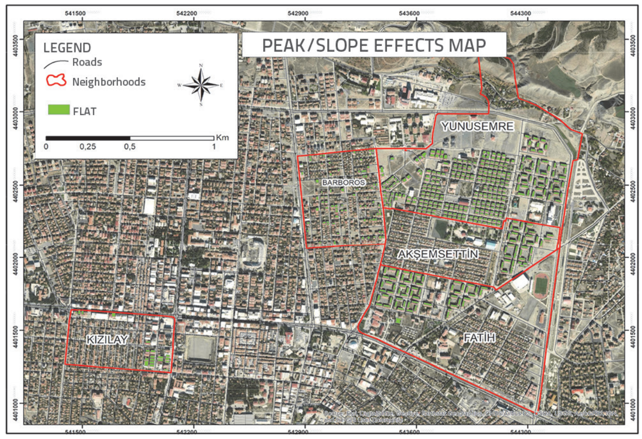

Figure 23. Regional distribution map of buildings according to peak/ slope effects

Table 10. Distribution of vulnerability parameter data by neighbourhoods

Parameters / Neighbourhoods	Heavy overhang		Short column		Soft floor		Pounding effect		Apparent quality		Peak/Slope effect	
	Yes	No	Yes	No	Yes	No	Yes	No	Loše	Dobro	Yes	No
Yunus Emre	141	159	227	73	-	300	-	300	235	65	-	-
Akşemsettin	8	30	23	15	-	38	-	38	29	9	-	-
Barbaros	63	10	9	64	3	70	-	73	15	58	-	-
Fatih	35	25	24	36	-	60	-	60	26	34	-	-
Kızılay	19	0	3	16	18	1	5	14	7	12	-	-

neighbourhoods eliminated the impact on the buildings (Figure 21). When the positioning of the reinforced concrete residential buildings concerning each other was examined, 70 % of the 490 buildings were separate and 27 % were in a block layout. As shown in Figure 22, the adjacent settlement is negligible, and this arrangement is noticeable only in the Kızılay neighbourhood. The peak or slope effect, another fragility parameter, was not observed in any building since the slope was between 0 and 10 in the scanned area (Figure 23).

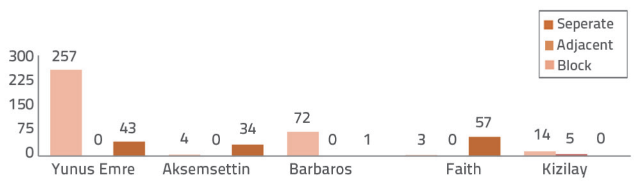

Figure 22. Number of buildings in the neighborhoods according to their order

According to the study (Table 10), almost 64 % of the RC buildings have moderate or poor apparent quality. Short column effects appear at 58 % within the selected building stock, where nearly 54 % have heavy overhangs effect. Conversely, most buildings have no soft floor (4 %) and a pounding effect (0.8 %). All of the buildings do not suffer from the peak or slope effect. Therefore, when we look at the distribution of negativeness parameters observed in RC buildings by street scanning, the most intense parameter are the apparent quality of the building. The minor negative parameters is the pounding effect and soft floor, and there is no peak or slope effect. The data in Table 10 show that the Yunus Emre neighbourhood is the region that suffers the most from all vulnerability parameters, except for the soft floor and pounding effect. Unlike the others, the buildings in the Kızılay neighbourhood suffer from soft floors and pounding effects.

Regional distribution of buildings according to risk priorities

This section calculated the building earthquake score of 490 RC residential buildings in five neighbourhoods. Buildings were ranked as 1st priority, 2nd priority, and 3rd priority according to their building earthquake score and presented on the map. Figure 24 shows the distribution of the building dataset regarding the building earthquake score and the risk priority accordingly. This distribution indicates that 233 of the surveyed buildings have a building earthquake score lower than 85 (0 < BES < 85). Therefore, these buildings have the 1st priority for detailed assessment. The number of buildings within the 86 < BES < 105 is 239, indicating the 2nd priority buildings. Priority buildings are those whose building earthquake score is within the range of 106<BES<135. Their number is 18. Accordingly, 47 % of 490 RC residential buildings were determined as 1st priority, 49 % as 2nd priority, and 4 % as 3rd priority (Figure 24).

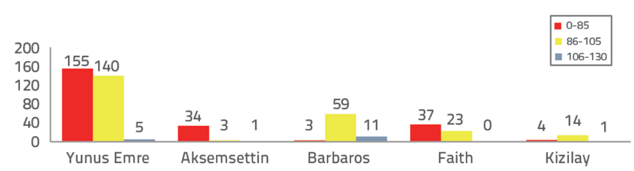

Figure 24. Distribution of buildings according to earthquake score

The distribution of buildings to neighbourhoods in order of priority is also shown in Figure 25. 66 % of the 1st priority reinforced concrete residential buildings are located in Yunus Emre, 16 % in Fatih, 15 % in Akşemsettin, 2 % in Kızılay, and 1 % in Barbaros district. These data show that Barbaros and Kızılay have at least 1st priority buildings, while Yunus Emre has the highest density. Based on the distribution of the 2nd priority buildings, 58 % of the 239 buildings are in Yunus Emre, 25 % in Barbaros, 10 % in Fatih, 6 % in Kızılay, and 1 % in Akşemsettin. The neighbourhood with the highest density of 3rd priority buildings is Barbaros, with 61 %.

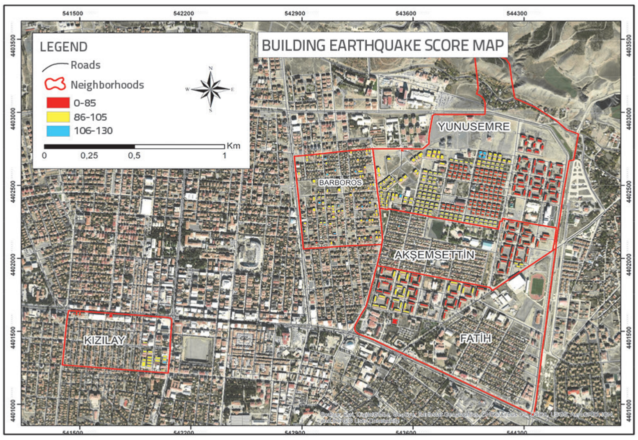

Figure 25. Regional distribution map of buildings according to risk priorities

34 of the 38 buildings in Akşemsettin are in the 1st priority risk group when the neighbourhoods are evaluated within themselves. Furthermore, 89 % of the existing RC building stock in Akşemsettin is at risk. Fatih is the second neighbourhood with the highest level of vulnerability, after Akşemsettin. Specifically, 62 % of 60 RC residences in this district are in the 1st priority group, and 52 % of the 300 RC residential buildings in the Yunus Emre neighbourhood are in the 1st priority group. Furthermore, the rate of 2nd priority buildings is higher in Barbaros and Kızılay districts (Table 11).

Distribution of vulnerability parameters in Risk Priorities

The study also examined the distribution of vulnerability parameters in building index. Accordingly, 90 % of 1st priority RC residential buildings suffer from poor construction quality, 84 % from short columns, and 14 % from heavy overhangs. Soft floor and pounding effects are negligible (Figure 26).

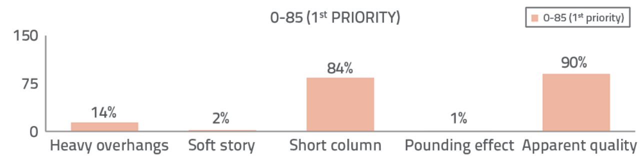

Figure 26. Distribution of vulnerability parameters in 1st priority buildings

93 % of the buildings have heavy overhangs, considering the distribution of vulnerability parameters in 2nd priority buildings. The short column and apparent building quality are reduced compared to the 1st priority buildings. While the apparent building quality is at a rate of 44 % in the 2nd priority buildings, it falls to 11 % in the 3rd priority buildings. Similarly, 38 % of 2nd priority buildings suffer from the soft floor parameter, while this ratio has decreased to 6 % in 3rd priority buildings (Figure 27).

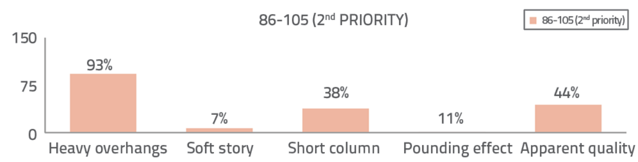

Figure 27. Distribution of vulnerability parameters in 2nd priority buildings

As shown in Figure 28, most buildings of the 3rd priority are suffered the heavy overhang effect. While 67 % of the buildings have this negative parameter, soft stories, short columns, and apparent quality are negligible. As a result, most buildings at 2nd and 3rd priority suffered from heavy overhang (Figure 28).

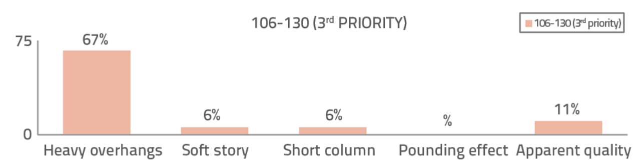

Figure 28. Distribution of vulnerability parameters in 3rd priority buildings

Table 11. Risk priority groups in neighbourhood according to BES

	Risk priority			
Neighbourhoods	**1st priority buildings**	**2nd priority buildings**	**3rd priority buildings**	**Total buildings**
Yunus Emre	155	140	5	**300**
Akşemsettin	34	3	1	**38**
Barbaros	3	59	11	**73**
Fatih	37	23	0	**60**
Kızılay	4	14	1	**19**
Total	**233**	**239**	**18**	**490**

4. Conclusion

Erzincan is one of the cities in Turkey that has been most affected by severe earthquakes throughout history. Therefore, identifying seismically vulnerable buildings and neighbourhoods is a crucial step for developing effective disaster mitigation and recovery strategies for this area. The objective of this study was to determine the seismic risk of existing buildings in Erzincan using a street screening method and to create a regional-scale inventory based on a geographic information system. Furthermore, 490 RC residential buildings in five neighbourhoods, namely, Fatih, Yunus Emre, Akşemsettin, Barbaros, and Kızılay in Erzincan, were assessed using the street screening method developed by METU and prioritised according to the building earthquake scores. The results obtained by this method were digitised in the ArcGIS program, and maps were created.

Based on the findings in this study, all the areas are flat and suitable for settlement and have a medium-solid soil structure that has no liquefaction risk.

According to the street screening assessments, 47 % of the case buildings had a high priority and 49 % medium priority, for the detailed evaluation. However, only 4 % of the building stock was at the lowest priority level. These results indicate the need for effective seismic mitigation planning because many buildings in the surveyed neighbourhoods required a second-stage assessment. In this scope, most of the RC residential stock in Yunus Emre had the 1st priority for detailed evaluation. Additionally, it is necessary to prioritise this area and the buildings defined in the geographic information system. After Yunus Emre, the other areas with high vulnerability levels are Akşemsettin and Fatih. Conversely, the neighbourhoods with the highest number of Second Priority buildings are Yunus Emre, Barbaros, Fatih, and Kızılay.

In the study, RC buildings were also evaluated for vulnerability parameters, such as soft story, short column, heavy overhang, impact effect, apparent quality, and peak/slope effect. According to the results, vulnerability characteristics were influential in the risk priorities of buildings. Furthermore, the negative parameters affecting the buildings in the first two priority levels differ. The primary determinant of the level of 1st priority risk is apparent quality and the soft floor effect, while the other is heavy overhangs. Furthermore, first-priority (0-85) buildings were mostly built before the 1992 Erzincan Earthquake when the relationship between the apparent quality of the building and the year of construction is considered. These data are critical. It is impossible to reach these buildings' projects because the Erzincan Municipality building collapsed during the earthquake. Therefore, these buildings, whose locations are defined in the geographic information system, must be prioritised and evaluated using analytical methods.

The 2nd priority (86-105) and 3rd priority (106-130) buildings were constructed after the 1992 earthquake and received engineering services within the 1997 and 2007 Earthquake Codes, considering the parameters affecting the risk priority score. However, this result does not indicate that all buildings identified as low-risk are constructed in accordance with the current earthquake code (2018). Therefore, the buildings with 2nd and 3rd risk priorities must be evaluated using the detailed analysis method. Moreover, some buildings with the same risk priority were affected by the apparent quality. It may be necessary to give detailed evaluation priority to these structures within the neighbourhood where they are located.

Furthermore, most buildings in the surveyed regions have heavy overhangs. The desire to obtain more usable space on the ground floor or the first floor causes heavy overhangs, especially in new buildings. However, it is crucial to design buildings that will eliminate the impact of this negative parameter, considering the damages caused by the 1992 earthquake. Another frequent negative parameter is the short column effect. The decrease in the impact of the short column parameter in the 2nd and 3rd priorities shows that design precautions have been taken to reduce this effect in new buildings. The soft floor parameter was observed only in the Kızılay district. However, this does not mean that there are no structures outside the study area. This effect occurs in residential buildings whose ground floor is used commercially. Thus, the decisions to be taken by the local government in urban planning studies will reduce this vulnerability. Unlike, most of the buildings, the stock does not suffer from the pounding effect. The main reason is that the RC residential buildings in the neighbourhoods are arranged as independent units or blocks according to the Erzincan city settlement plan. The decision taken in this direction is correct, and decision-makers must continue this when planning. In addition, Erzincan is a plain settlement that eliminates the topographical effect on the buildings.

Conversely, the regional information obtained by the street scanning method applied in the study will help local decision-makers and stakeholders decide on the number of regions and buildings requiring improvement work. The incorporation of GIS into the street scanning method has enabled easy identification of risk priority buildings and visualisation of the spatial distribution. Storing and mapping these data in the geographic information system will be an essential database for second-level evaluation decisions, spatial planning, and urban transformation studies. In addition, disseminating this building stock analysis made in five neighbourhoods and applying it to the whole province, thus creating a more comprehensive inventory, is important to reduce the city's structural risk within the scope of disaster preparedness.

The street scanning method used in the study is only the first-stage evaluation method. Therefore, final results can only be obtained after a detailed evaluation. Moreover, this method is based on observations from outside the building. Therefore, a team of architects and civil engineers with sufficient experience and knowledge must be selected or trained before the team goes into the field to obtain accurate data for future studies.

It is recommended to establish cooperation between academia and local government and work together on pre-earthquake mitigation plans to ensure that the results obtained in this and similar studies are not only at the academic level but can also be practically implemented.

REFERENCES

[1] Bayraktar, H.: Determination of Settlement Status in terms of Disaster Risk and Local Disaster Risk Management of Düzce Kaynaşlı District Using GIS and Street Scanning Methods, 2014, PhD Thesis, Gazi University Institute of Science and Technology, Ankara

[2] Reilinger, R., McClusky, S., Vernant, P., Lawrence, S., Ergintav, S., Çakmak, R., Nadariya, M.: GPS constraints on continental deformation in the Africa-Arabia-Eurasia continental collision zone and implications for the dynamics of plate interactions. Journal of Geophysical Research: Solid Earth, 111 (2006) B5, pp. 91-108.

[3] Işık, E., Karaşin, İ.B., Demirci, A., Büyüksaraç, A.: Seismic risk priorities of site and mid-rise RC buildings in Turkey. Challenge Journal of Structural Mechanics, 6 (2020) 4, pp. 191-203.

[4] Haçin, I.: 1939 Erzincan Great Earthquake. Journal of Atatürk Research Center, 30 (2014) 88, pp. 37-70.

[5] Çatal, H.H.: Damages to buildings due to earthquake. In 3rd International Symposium on İnnovative Approaches in Scientific Studies, section: Engineering nd natural sciences, 19 (2019) 21, pp. 310-315.

[6] Ali, S.M., Akkoyunlu, M.F.: Statistical analysis of earthquake catalogs for seismic hazard studies around the Karliova Triple Junction (eastern Turkey). Journal of African Earth Sciences, 186 (2022), pp. 104436

[7] Taymaz, T., Jackson, J.A., ve McKenzie, D.P.: Active tectonics of the North and Central Aegean Sea, Geophysical Journal International, 106 (1991), pp. 433-490.

[8] Cakir, F., Uckan, E., Shen, J., Seker, B. S., Akbas, B.: Seismic damage evaluation of historical structures during Van earthquake, October 23, 2011. Engineering Failure Analysis, 58 (2015), pp. 249-266.

[9] Dogan, G., Ecemis, A.S., Korkmaz, S.Z., Arslan, M.H., Korkmaz, H.H.: Buildings damages after Elazığ, Turkey Earthquake on January 24, 2020. Natural Hazards, 109 (2021) 1, pp. 161-200.

[10] Demir, A., Altıok, T.Y.: Numerical assessment of a slender structure damaged during October 30, 2020, İzmir earthquake in Turkey. Bulletin of Earthquake Engineering, 19 (2021) 14, pp. 5871-5896.

[11] Tezcan, S.S., Bal, I.E., Gulay, F.G.: P25 scoring method for the collapse vulnerability assessment of R/C buildings. Journal of the Chinese Institute of Engineers, 34 (2011) 6, pp. 769-781.

[12] Ates, A., Bilim, F., Buyuksarac, A., Aydemir, A., Bektas, O., Aslan, Y.: Crustal structure of Turkey from aeromagnetic, gravity and deep seismic reflection data. Surveys in Geophysics, 33 (2012) 5, pp. 869-885.

[13] Demirel, M., Tatar, O., Koçbulut, F.: Kinematics of the faults around the Koyulhisar (Sivas) region on the North Anatolian Fault Zone, Geological Bulletin of Turkey, 59 (2016) 3, pp. 357-370.

[14] Tankut, T.: Disaster preparedness in Turkey – an overview. Advances in civil engineering, 1–3 November 2000, 1 (2000).

[15] Arslan, M.H., Korkmaz, H.H.: What is to be learned from damage and failure of reinforced concrete structures during recent earthquakes in Turkey? Engineering Failure Analysis, 14 (2020), pp. 1–22.

[16] Siembieda, W., Bruce, B., Ken, T.: Disaster recovery, a global planning perspective in interplan, Chicago. Illinois: International Division of the American Planning Association, 69 (2002).

[17] Neves, F., Costa, A., Vicente, R., Oliveira, C.S., Varum, H.: Seismic vulnerability assessment and characterisation of the buildings on Faial Island, Azores. Bulletin of Earthquake Engineering, 10 (2012) 1, pp. 27-44.

[18] Okuyucu, D., Savaş, G.K., Gedik, B., Şuşarlıoğlu, M.F., Kara, T.: Determination of regional earthquake risk distribution of buildings by street scanning method: Erzurum – Yenişehir Example, Fırat University Engineering Journal of Science, (2018), pp. 219-231.

[19] Kassem, M.M., Nazri, F.M., Farsangi, E.N.: The seismic vulnerability assessment methodologies: A state-of-the-art review. Ain Shams Engineering Journal, 11 (2020) 4, pp. 849-864.

[20] Özçelik, Ö., Baran, T., Saatçi, A., Mısır, S., Kahraman, S., Girgin, S.C.: The Results of the Building Stock Inventory and Earthquake Safety Preliminary Evaluation Project in Balçova and Seferihisar Districts, İzmir, TMMOB 2nd İzmir City Symposium, (2013), pp. 157-167.

[21] Işık, E., Özlük, M.H.: Evaluation of Tatvan urban building stock, LAAOJ, Scientific Science, (2013), pp. 8-21.

[22] Fragiadakis, M., Vamvatsikos, D., Aschheim, A.: Application of nonlinear static procedures for seismic assessment of regular RC moment frame buildings, Earthquake Spectra, 30 (2014) 2, pp. 767-794.

[23] Polese, M., Verderame, G.M., Mariniello, C., Iervolinoe, I., Manfredi, G.: Vulnerability analysis for gravity load designed RC buildings in Naples–Italy, Journal of Earthquake Engineering, 12 (2008), pp. 234-245

[24] Sattar, S., Liel, A.B.: Seismic performance of nonductile reinforced concrete frames with masonry infill walls: II. Collapse assessment, Earthquake Spectra, 32 (2016) 2, pp. 819-842.

[25] Kassem, M.M., Nazri, F.M., Farsangi, E.N.: Development of seismic vulnerability index methodology for reinforced concrete buildings based on nonlinear parametric analyses, MethodsX, 6 (2019), pp. 199-211

[26] Kaplan, O., Guney, Y., Topcu, A., Ozcelikors, Y.: A rapid seismic safety assessment method for mid-rise reinforced concrete buildings. Bulletin of Earthquake Engineering, 16 (2018) 2, pp. 889-915.

[27] FEMA 154: Rapid Visual Screening of Buildings for Potential Seismic Hazards, Federal Emergency Management Agency, Washington, D.C., 2015.

[28] NZSEE: Assessment and Improvement of the Structural Performance of Buildings in Earthquake, Recommendations of a NZSEE Study Group on Earthquake Risk Buildings, New Zealand, 2006.

[29] Sangiorgio, V., Uva, G., Aiello, M.A.A.: A multi-criteriangeletti, Comparison between vulnerability assessment and damage index, some results, in: Proceedings of the 9th World Conference on Earthquake Engineering: Tokyo, Kyoto, Japan, (1998), pp. 181–18.

[30] NRCC: Manual for Screening of Buildings for Seismic Investigation, Institute for Research in Construction, National Research Council Canada, Ottawa, 1993.

[31] JPDPA (2001) Seismic Evaluation and Retrofit, The Japan Building Disaster Prevention Association, Japan.

[32] BU, YTU, ITU, METU: İstanbul Deprem Master Planı, İstanbul Büyükşehir Belediyesi Planlama Ve İmar Dairesi Zemin Ve Deprem İnceleme Müdürlüğü, İstanbul, 2003.

[33] Sucuoğlu, H.: Determination of Earthquake Risks in Urban Building Stocks by Street Scanning Method, Sixth National Earthquake Engineering Conference, Istanbul. (2007), pp. 267-284.

[34] Ministry for Environment and Urban Planning: Principles for Identifying Risky Buildings; Ministry for Environment and URBAN planning; Ankara, Turkey, 2019.

[35] Tunçağ, M.: İzmir Metropolitan Municipality Radius Project, İzmir and Earthquake Conference, İzmir, (2017), pp. 41-46.

[36] Kepenek, E.: A Model Proposal for Structural Risk Classification for Urban Transformation Purposes, PhD Thesis, Süleyman Demirel University, Institute of Science and Technology, Isparta, 2016.

[37] Işık, E.: The Evaluation of the Building Stock in Bitlis Province at the First Level (by Street Scanning Method), Süleyman Demirel University Journal of the Institute of Science, (2013), pp. 173-178.

[38] Özkaynak, H., Özbay, A.E.Ö.: Seismic vulnarability assessment of reinforced concrete buildings located in Esenler District of İstanbul. Afyon Kocatepe Üniversitesi Fen Ve Mühendislik Bilimleri Dergisi, 18 (2018) 1, pp. 285-294.

[39] Ateş, A., Poyraz, S., Çoban, Ö.: Determination of regional soil structure earthquake risk distribution of buildings by street survey method: The sample of Bilecik Province, Düzce University Journal of Science Technology, 9 (2021) 4, pp. 1310-1328.

[40] Özşahin, E.: Flood risk analysis in Albania, International Journal of Eurasian Social Sciences, (2013), pp. 91-109.

[41] Sönmez, M.E., Çelik, M.A., Seven, M.: Determination of erosion risk areas of kilis central district with the help of geographical ınformation systems and remote sensing. KSU Journal of Social Sciences, (2013), pp. 1-21.

[42] Ocak, F.: Examination of Ünye City Floods by Vulnerability Method, M.Sc., Ondokuz Mayıs University, Institute of Social Sciences, Samsun, 2018.

[43] Kassem, M.M., Beddu, S., Ooi, J.H., Tan, C.G., Mohamad El-Maissi, A., Mohamed Nazri, F.: Assessment of seismic building vulnerability using rapid visual screening method through web-based application for Malaysia. Buildings, 11 (2021) 10, pp. 485.

[44] Mohamad, I.I., Yunus, M.M., Harith, N.S.H.: Assessment of building vulnerability by integrating rapid visual screening and geographic information system: A case study of Ranau township. In IOP Conference Series: Materials Science and Engineering ,527 (2019) 1, pp. 012042

[45] Catulo, R., Falcão, A. P., Bento, R., Ildefonso, S.: Simplified evaluation of seismic vulnerability of Lisbon Heritage City Centre based on a 3DGIS-based methodology. Journal of Cultural Heritage, 32 (2018), pp. 108-116.

[46] Rajarathnam, S., Santhakumar, A.R.: Assessment of seismic building vulnerability based on rapid visual screening technique aided by aerial photographs on a GIS platform. Natural Hazards, 78 (2015) 2, pp. 779-802.

[47] Ilic, J.M., Bento, R., Cattari, S.: 3DGIS representation for supporting seismic mitigation policies at urban scale: The case study of Lisbon. Journal of Cultural Heritage, 45 (2020), pp. 265-278.

[48] Tokgöz, H., Bayraktar, H.: GIS risk analysis of a first-degree seismic zone: Kaynaşlı (Turkey), Periodicals of Engineering and Natural Sciences, 6 (2018) 2, pp.10-23.

[49] Columbro, C., Eudave, R.R., Ferreira, T.M., Lourenco, P.B.: On the use of web mapping platforms to support the seismic vulnerability assessment of old urban areas.Remute Sensing, 14 (2022) 6, pp. 1424-2-25.

[50] Orhan, F.A.: Geographical overview of the effects of earthquakes on urban and residential architecture: The example of the 1939 Erzincan Earthquake. Atatürk University Journal of Social Sciences Institute, (2019), pp. 339-364.

[51] Sucuoğlu, H., Gülkan, P.: General Evaluation of Structural Damages, 13 March 1992 Erzincan Earthquake Engineering Report, Ankara, 1992.

[52] Barka, A., Gülen, L.: Complex evolution of the Erzincan Basin (Eastern Turkey) and its pull-apart and continental escape origin. Journal of Structural Geology, (1989), pp. 275-283.

[53] Aydın, Ö.L. Bektaş, Ö., Büyüksaraç, A., Yılmaz, H.: 3D modeling and tectonic ınterpretation of the Erzincan Basin (Turkey) using potential field data. Earth Sciences Research Journal. Earth Sci. Res. J., 23 (2019) 1, pp. 57-66.

[54] Barka, A., Kadinsky-Cade, K.: Strike-slip fault geometry in Turkey and its influence on earthquake activity. Tectonics, 7 (1988) 3, pp. 663-684.

[55] Barka, A.: Slip distribution along the North Anatolian fault associated with the large earthquakes of the period 1939 to 1967. Bulletin of the Seismological Society of America, 86 (1996) 5, pp. 1238-1254.

[56] Barka, A., Eyidogan, H.: The March 13, 1992 Erzincan earthquake. Terra Nova, 5 (1993) 2, pp. 190-194.

[57] Şengezer, S.: Examination of Damages in the City of Erzincan on March 13, 1992 by Neighborhoods, 2nd National Earthquake Engineering Conference, Istanbul, (1993), pp. 404-415.

[58] Kaypak, B.: Three-dimensional VP and VP/VS structure of the upper crust in the Erzincan basin (eastern Turkey). Journal of Geophysical Research: Solid Earth, 113 (2008) B7.

[59] Bayrak, Y., Yilmaztürk, A., Öztürk, S.: Relationships between fundamental seismic hazard parameters for the different source regions in Turkey. Natural Hazards, 36 (2005) 3, pp. 445-462.

[60] Aslan, O.: The Effect of Local Ground Conditions on the Structural Damages of the 13 March 1992 Erzincan Earthquake, Master Thesis, ITU Institute of Science and Technology, Istanbul, 2015.

[61] Arıoğlu, E., Girgin, C.: The Seismotectonic Structure of Turkey and the Evaluation of the Spiritual/Economic Dimensions of Earthquakes, Research Report, Publication No: YM / AR-GE / 2002-5, 2002.

[62] Perrone, D., Ailello, M. A., Pecce, M., Rossi, F.: Rapid visual screening for seismic evaluation of RC hospital buildings. Structures, 3 (2015), pp. 57-70

[63] Bektaş, N., Kegyes-Brassai, O.: Conventional RVS methods for seismic risk assessment for estimating the current situation of existing buildings: A state-of-the-art review. Sustainability, 14 (2022) 5, pp. 2583.

[64] Tezcan, S., Yazıcı, A., Özdemir, Z., Erkal, A.: Irregularity of weak storey-soft storey. In Sixth National Earthquake Engineeing Conference, 2007.

[65] Harirchian, E., Lahmer, T., Buddhiraju, S., Mohammad, K., Mosavi, A.: Earthquake safety assessment of buildings through rapid visual screening. Buildings, 10 (2020) 3, pp. 51

[66] Bal, İ.E., Tezcan, S., Gülay G.F.: P25 Rapid Evaluation Method for Determining the Failure Risk of Reinforced Concrete Buildings. Sixth National Earthquake Engineering Conference, 16-20 October 2007, Istanbul, pp. 661-667.

[67] TSDC: Turkish Seismic Design Code, Ankara, Official Gazette dated 18 March 2018 and reiterated number 30364, 2018.

[68] Disaster and Emergency Management Presidency, "Turkey Earthquake Hazard Map", https://deprem.afad.gov.tr/deprem-tehlike-haritasi, Last accessed: 15.05.2021