# ASSESSMENT OF STRUCTURAL DAMAGE IN ADIYAMAN AND CALIBRATION OF RAPID VISUAL SCREENING METHODS AFTER KAHRAMANMARAŞ EARTHQUAKE SEQUENCE

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**Yusuf EKİNCİ**

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We approve the thesis of **Yusuf EKİNCİ**

**Examining Committee Members:**


**Assist. Prof. Dr. Uğur DEMİR**
Department of Architecture
Izmir Institute of Technology

**Prof. Dr. Koray KORKMAZ**
Department of Architecture
Izmir Institute of Technology

**Assist. Prof. Mauricio Gabriel Morales BELTRAN**
Department of Architecture
Yaşar University


**9 December 2024**


**Assist. Prof. Dr. Uğur DEMİR**
Supervisor
Department of Architecture
Izmir Institute of Technology

**Prof. Dr. Koray KORKMAZ**
Head of the Department of Architecture
Izmir Institute of Technology

**Prof. Dr. Mehtap EANES**
Head of the Graduate School
of Engineering and Sciences
Izmir Institute of Technology

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# ABSTRACT


## ASSESSMENT OF STRUCTURAL DAMAGE IN ADIYAMAN AND CALIBRATION OF RAPID VISUAL SCREENING METHODS AFTER KAHRAMANMARAŞ EARTHQUAKE SEQUENCE

Earthquakes are an inevitable reality for Türkiye due to its geographical location. Mitigating potential loss of life and property during future earthquakes necessitates implementing precautions and developing sustainable strategies. However, limited time and financial resources for comprehensive evaluations have led to the emergence of rapid seismic performance assessment methods to categorize buildings by risk and identify the most vulnerable structures.

The buildings damaged in the Kahramanmaraş earthquakes in Adıyaman were evaluated according to the results of the damage assessment studies carried out after the earthquake, and the causes of the damage were discussed. Damage distributions, construction years, number of storeys and construction techniques were examined separately for 45337 buildings in the city center and 477 buildings were examined in detail within the scope of the thesis. This study uses various rapid assessment methods to evaluate 477 buildings in Adıyaman. Data were collected from the Ministry of Environment and Urbanization, field surveys, and Google Earth Street views. Buildings were assessed using FEMA P-154 (FEMA, 2015), the Canadian Seismic Screening Method (Rainer et al., 1992), and the Rapid Visual Screening Method (Sucuoğlu et al., 2007), considering parameters like number of storeys, structural system types, construction year, and structural irregularities.

Comparative analysis revealed the methods' limited accuracy in identifying seismic performance. To improve reliability, penalty scores were calibrated using real earthquake data, enhancing predictive accuracy. The study also highlights the critical impact of design decisions made during planning, offering guidance to architects on avoiding structural irregularities to improve building resilience.



**Keywords:** 2023 Kahramanmaraş Earthquakes, Structural Damage, Structural Irregularities, Rapid Assessment Methods, Adıyaman

# ÖZET


## KAHRAMANMARAŞ DEPREMİ SONRASINDA ADIYAMAN'DAKİ YAPISAL HASARIN DEĞERLENDİRİLMESİ VE HIZLI GÖRSEL TARAMA YÖNTEMLERİNİN KALİBRASYONU

Depremler, Türkiye'nin coğrafi konumu nedeniyle kaçınılmaz bir gerçekliktir. Gelecekte yaşanabilecek depremlerde can ve mal kaybını önlemek ve hasarı en aza indirmek için gerekli önlemlerin alınması ve sürdürülebilir stratejilerin geliştirilmesi gereklidir. Ancak, kapsamlı değerlendirmeler için yeterli zaman ve mali kaynak olmaması, yapıların risk durumlarına göre sınıflandırılmasını ve en riskli yapıların tespit edilmesini sağlayan hızlı deprem performansı değerlendirme yöntemlerinin geliştirilmesini zorunlu kılmıştır.

Adıyaman'da Kahramanmaraş depremlerinde hasar gören yapılar, deprem sonrası yapılan hasar tespit çalışmaları sonuçlarına göre değerlendirilmiş ve hasar nedenleri tartışılmıştır. Kent merkezinde yer alan 45.337 yapı, hasar dağılımları, yapım yılları, kat sayıları ve yapım teknikleri açısından incelenmiş; 477 yapı ise tez kapsamında detaylı olarak ele alınmıştır. Bu çalışmada Adıyaman'daki 477 yapı, çeşitli hızlı değerlendirme yöntemleriyle analiz edilmiştir. Gerekli veriler Çevre, Şehircilik ve İklim Değişikliği Bakanlığı veri tabanı, saha çalışmaları ve Google Earth Sokak Görüntüleri aracılığıyla toplanmıştır. Yapılar, FEMA P-154 (FEMA, 2015), Kanada Sismik Tarama Yöntemi (Rainer et al., 1992) ve Türkiye'ye özgü Hızlı Görsel Tarama Yöntemi (Sucuoğlu et al., 2007) kullanılarak kat sayısı, taşıyıcı sistem tipleri, yapım yılı ve yapısal düzensizlikler gibi parametreler açısından değerlendirilmiştir.

Karşılaştırmalı analiz, bu yöntemlerin sismik performansı belirlemede sınırlı doğruluğa sahip olduğunu göstermiştir. Güvenilirliği artırmak amacıyla, her bir yönteme ait ceza puanları gerçek deprem verileri kullanılarak kalibre edilmiş ve tahmin performansı iyileştirilmiştir. Çalışma ayrıca, tasarım aşamasındaki kararların sonuçlarını vurgulamakta ve mimarların yapısal düzensizliklerden kaçınmaları için rehberlik sunmaktadır.



**Anahtar Kelimeler:** 2023 Kahramanmaraş Depremleri, Yapısal Hasar, Yapısal Düzensizlikler, Hızlı Değerlendirme Metotları, Adıyaman

*to my precious family...*

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# CHAPTER 1

# INTRODUCTION

Türkiye, located in a seismically active region, owes its susceptibility to earthquakes to its geographical positioning. The Anatolian Peninsula, positioned at the convergence of the Eurasian, Arabian, and African tectonic plates, experiences frequent seismic activity due to the movements of these plates. The seismic reality has become inherent to Türkiye's social and economic fabric. Consequently, fostering earthquake awareness and fortifying infrastructure against seismic hazards should rank among the nation's foremost priorities. These imperative underscores the need for Türkiye to consistently undertake preparatory measures and precautions, both at the governmental and individual levels.

## 1.1 Framing the Problem

An analysis of major earthquakes in Türkiye reveals that numerous significant seismic events have occurred across different regions and at various times. These earthquakes have led to considerable loss of life and extensive damage to buildings. The following are some notable earthquakes in Türkiye along with their associated statistics. The Mw=7.9 magnitude earthquake that struck Erzincan on December 27, 1939, is one of the deadliest earthquakes in Türkiye's history. This catastrophic event claimed the lives of 32,968 individuals and resulted in the destruction or damage of 116,720 buildings. On March 28, 1970, a Mw=7.2 magnitude earthquake struck the Gediz district of Kütahya, resulting in the loss of 1,086 lives and causing damage to 19,291 buildings. Another significant seismic event occurred on November 24, 1976, when a magnitude Mw=7.5 earthquake hit the Çaldıran district of Van, claiming the lives of 3,840 people and damaging 9,232 buildings. This earthquake led to the destruction of numerous villages in the region and triggered a significant humanitarian crisis. On August 17, 1999, a Mw=7.4 magnitude earthquake struck the Gölcük district of Kocaeli, shaking the Marmara Region and resulting in the deaths of 17,480 people. The quake also caused damage to 73,342 buildings. Just a few months later, on November 12, 1999, a magnitude Mw=7.2 earthquake struck Düzce, resulting in the loss of 894 lives. On October 23, 2011, a Mw=7.2 magnitude earthquake struck the Tabanlı district of Van, claiming the lives of 644 people and destroying 2,262 buildings . On May 19, 2011, 2 people lost their lives and 122 people were injured as a result of an earthquake with a magnitude of Mw=5.9 in Simav district of Kütahya province (Kandilli Rasathanesi 2017). On October 30, 2020, an earthquake with a magnitude of Mw=5.9, whose epicenter was the Greek island of Samos, severely affected Izmir. A total of 119 people died and 1053 people were injured in Türkiye and Greece (Erener et al. 2021).

A country with a history of numerous devastating earthquakes must implement all precautions to mitigate future risks. In Türkiye, two types of measures are recommended for buildings with insufficient earthquake resistance: i) demolishing and rebuilding high-risk structures as part of urban transformation projects, and ii) retrofitting of buildings to meet the required conditions according to regulations. To conduct these studies effectively, it is crucial to first identify the buildings at risk that require retrofitting or demolition and reconstruction. According to data obtained from TÜİK, there were 11.5 million buildings in Türkiye in 2020, reflecting the state of the building stock (TÜİK 2020). Over the four-year period leading up to 2024, the number of buildings in Türkiye increased. In 2023 alone, 138,270 new buildings were constructed across the country, according to data from TÜİK (TÜİK 2024). Given this trend, it is estimated that the total number of buildings in Türkiye will reach 14,171,703 by 2050 (TÜİK 2023). The outputs of the LESSLOSS project, funded by the European Union (EU), serve as a critical benchmark for understanding the scale of work required to address the building stock (Spence 2007). Based on data from the LESSLOSS study, it is infeasible, both in terms of time and cost, to collect and analyze the data required for detailed structural assessments. The study estimates that at least 25 billion dollars and a period of 25 years are necessary to identify and analyze risky buildings within the Istanbul building stock and to complete the retrofitting of those that meet the required standards (Spence 2007). Given the extensive time periods and extremely high financial costs indicated by the study of Istanbul's building stock, it is evident that conducting a similar study for the entire building stock of Türkiye would be highly impossible.

The high costs and limited time have clearly underscored the need for methods that can quickly and reliably identify high-risk structures. Rapid earthquake performance assessment methods aim to prevent potential loss of life and property by categorizing structures based on their earthquake risk. These methods identify the buildings at the highest risk and in need of urgent measures, ensuring that available labor and material resources are directed toward the most vulnerable structures.

Rapid earthquake performance assessment methods provide a quick and reliable way to evaluate the earthquake performance of structures (Özkaynak and Özsoy Özbay 2018). These methods utilize structural data to predict the earthquake performance of buildings. For instance, FEMA p-154 method (Federal Emergency Management Agency, 2015)assesses factors such as regional seismicity, soil conditions, year of construction, applicable earthquake codes, type of structural system, structural irregularities, and the appearance of the building. The Sucuoğlu method (Sucuoğlu, Yazgan, and Yakut 2007) considers regional seismicity, structural irregularities, year of construction, and exterior appearance. Similarly, the Canadian Seismic Method (Rainer, Allen, and Jablonski 1992) evaluates seismicity, year of construction, intended use, structural irregularities, and the overall appearance of the building. These three methods are discussed in detail in Chapter 4 as part of the research.

The parameters affecting the structure's seismic performance play a vital role in earthquake performance evaluation methods to efficiently collect data about the structure and produce highly accurate results. Considering these parameters, it is seen that structural irregularities that have a direct effect on the earthquake performance of the building can be prevented at the design stage. This situation reveals that although it is under the responsibility of civil engineers and the calculations made to ensure that the structural systems can fulfil their duties completely with sufficient strength, architects responsibility on design of the building and the planning of the spaces should also play a very active role in this process.

In building design, factors such as building forms that emerge according to needs or for design reasons, wide openings created to obtain expansive spaces, showcases designed for commercial spaces, floor height differences between neighboring floors that arise in line with different needs, heavy overhangs made to obtain more space on the upper floors of the building, all stem from architectural decisions made in the design phase. With the decisions to be taken at the architectural design stage, the earthquake performance of the buildings can be kept safely in the field, and the loss of life and property in earthquakes in Türkiye can be prevented.

## 1.2. Research Methodology

With an aim to evaluate the capabilities of the current rapid visual screening methods on prediction of building seismic performances prior to devastating earthquakes, three different methodologies have been discussed within the scope of the thesis. Within the scope of the thesis study, the correct result rates of the rapid earthquake performance evaluation methods applied to the buildings that were severely damaged, demolished or urgently required to be demolished due to the impact of the Kahramanmaraş earthquakes on February 6 2023 and the contribution of the penalty points applied to the results were discussed. In addition, this thesis study has discussed which ratios the decisions taken during the design phase affect the earthquake performance of the buildings and what should be considered to avoid these errors by the architects responsible for building design.

All of buildings analyzed in this thesis were selected from the central district of Adıyaman province, one of the cities most impacted by the earthquake. This choice can be demonstrated by the fact that the author has survived in Adıyaman during the earthquake, has extensive knowledge about the building stock of the city since he lives in Adıyaman, and that he has the chance to re-examine the buildings that were heavily damaged in the earthquakes and have not yet been destroyed.

After determining Adıyaman as the study location, 477 buildings were chosen based on detailed pre-earthquake condition data availability. These structures, representing a subset of the 115,332 buildings affected by the earthquake (TÜİK 2023), included heavily damaged, partially demolished, or entirely collapsed cases. The selection criteria prioritized structures for which substantial pre-earthquake data could be gathered, complemented by observations from damage assessments and verifications via building coordinates on Google Earth. For the 477 buildings identified, data that can create an identity of the building, such as the number of floors, construction years, building visuals, location data, structural system types, and structural irregularities of the building, were collected.

For the chosen buildings, data collection commenced by applying three rapid earthquake performance evaluation methods. The issues considered when selecting these three rapid earthquake performance evaluation methods are as follows: The data that can be obtained from the analyzed structures, the amount of time allocated for each structure and finally, how compatible the methods can work with the Turkish building stock. These parameters are vital for a reliable and efficient evaluation of structures. As part of this study, the structures were analyzed using the three Rapid Visual Screening (RVS) methods mentioned above. While the buildings were undergoing these inspections, the accuracy of the data collected during the damage assessment was checked. Corrections were made to data such as years of construction and number of storeys. While making these checks, Google Earth Street View visuals of the buildings whose locations were determined with the help of coordinates, photographs taken during the damage assessment study and collected data from building visits, if not demolished, were used.

After examining the structures separately with the specified rapid earthquake performance evaluation methods, each method's prediction about the structure's condition was evaluated. The results of the method were compared proportionally with the damage received by the structures during the earthquake. In order to increase the accuracy of the predictions made, it was suggested in which direction the penalty points applied by the methods should be updated if necessary.

On February 6, the statistics of the presence of structural irregularities in 477 buildings, which reflect the destructive effects of the Kahramanmaraş earthquakes on the structures, were obtained. Obtained data show how many irregularities may arise due to the decisions made during the design phase of the structure, which can affect its earthquake performance. With these statistics, the architect's roles in increasing the building's earthquake performance and what should be avoided are discussed.

The research questions were determined by considering the earthquake risk and the need for rapid assessment methods:

1- If the buildings that were severely damaged or collapsed in the Kahramanmaraş earthquakes were evaluated by rapid earthquake performance evaluation methods, what kind of results would be obtained?

2- How compatible are the results obtained with real earthquake data?

3- How can methods that perform poorly with respect to real earthquake data be calibrated and how does their performance change after calibration?

4- What are the effects of structural irregularities, which is one of the most important parameters that RVS methods evaluate structures? What are the duties of architects in this regard?

# CHAPTER 2

# LITERATURE REVIEW

Türkiye is an earthquake-prone country, as the devastating earthquake in Kahramanmaras in 2023 has once again painfully demonstrated. With the effect of the lessons learned from the earthquakes experienced, it is desired to determine the earthquake performance of buildings both in Türkiye and around the world and to take precautions according to the assessment results. Fast and cost-effective ways were sought to determine the risk classifications of buildings. The main reason for this is the excess of the existing building stock. Demolishing and reconstructing all the buildings deemed risky through urban transformation works will cause an insurmountable financial burden. Moreover, retrofitting all buildings classified as high-risk is not feasible due to limited time and financial resources. Consequently, methods have been developed to rapidly assess the earthquake performance of structures, enabling a swift risk classification for analyzed buildings. These methods ensure that the riskiest structures in the building stock are identified, and the available resources are utilized in the most accurate way. While evaluating the earthquake performance of structures, different methods have been developed that enable comment on the structure's condition by using various parameters and grouping the structures according to their risk status. Within the scope of this thesis, performance evaluation methods developed in Türkiye and abroad are briefly described in this section.

Street survey is one of the leading methods of quickly determining the earthquake risks of buildings. Developed by Sucuoğlu et al. (2007), the street survey method can evaluate buildings by examining them at the observation level. During this evaluation, a performance score (PS), which expresses a final score, is obtained by applying the basic score obtained with the number of storeys of the building, the PGV value of the region where it is located and the penalty scores determined for structural irregularities. It prioritizes building risk according to the obtained score (Sucuoğlu et al. 2007). Özkaynak and Özbay (2018) applied the evaluation method developed by Sucuoğlu et al. (2007) to 160 buildings in the Esenler region of Istanbul and evaluated the earthquake performance of these buildings. As a result of this study, it was found that 10% of the structures examined were categorized as structures at the highest priority level, and the reason for this result was mainly attributed to the poor construction details. In addition, it was observed that 76% of the structures were subjected to the hammering effect due to their attached construction scheme to the adjacent buildings, while 30% of the structures were subjected to the short column effect.

In 1997, Hassan and Sözen aimed to survey the earthquake performance of structures in large-scale building inventories with as little time and computation as possible (Hassan and Sözen 1997). While developing this method, they calibrated it using 46 structures damaged in the 1992 Erzincan earthquake. The method obtains a building priority index (PI) by utilizing scores based on column cross-sectional ratio (CI) and wall cross-sectional ratio (WI). Risk ranking is obtained for the structures thanks to the PI value obtained. In this method, a low score refers to a risky building.

Bal, Tezcan, and Gülay (2007) developed a rapid earthquake assessment method which is known as P25 method. The P25 method is an earthquake assessment method developed to assess the seismic vulnerability of different types of structures rapidly. The approach categorizes structures according to factors such as structural irregularities, construction materials and year of construction, each of which plays a critical role in earthquake resilience. The P25 method serves the purpose of maintaining accuracy while optimizing the speed of assessment. It is integrated into seismic risk management programs worldwide, enabling large-scale vulnerability mapping studies in high-risk areas. The method's simplified scoring systems and visual inspection criteria make P25 method a supportive tool for preventive safety measures and post-earthquake damage assessments (Bal, Tezcan, and Gülay 2007). Unlike street scanning methods, the dimensions of the structural elements are also evaluated when applying the P25 method. In addition, it also uses parameters such as moments of inertia, structural irregularities, number of storeys and ground conditions to assign a score to the structure. Thanks to this P score, whether the building is high, medium or low risk is understood.

The discriminant analysis method developed by Yucemen and Askan (2002) evaluates structures based on statistical results by evaluating the number of storeys, soft storey irregularity, moment of inertia, the proportion of overhangs in the structure, the density of vertical elements and the hyperstaticity of the structure (Yucemen and Askan 2002).

Based on findings from the study, the Seismic Safety Screening Method (SSSM) (Ozdemir, Boduroglu, and Ilki 2005), modified from the Japanese Seismic Index Method (JSIM) (Ministry of Construction of Japan 1990), proves reliable for assessing seismic safety in mid and low-rise reinforced concrete buildings, aligning well with results obtained from structural analysis. The seismic capacity index improves understanding of the resilience of structures by providing a quantitative measure of their level of safety. However, the calibrated coefficients remain provisional, and further work is required to apply this method across a wide range of RC buildings in different seismic zones and to validate the results through structural analysis (Özdemir and Taşkın 2006).

The PERA method (Ilki et al. 2014), which was developed in Türkiye and is currently used in building analysis studies conducted by the Istanbul Metropolitan Municipality, is one of the rapid earthquake performance evaluation methods that emerged as a result of the cooperation of ITU, Boğaziçi University and Van Yüzüncü Yıl University researchers. This method, developed on the basis of the Turkish earthquake regulations, eliminates the contradictions that may arise against the regulations. This method evaluates the structure in many ways by performing performance-based assessments and structural analyses under certain assumptions. During the earthquake performance evaluation, attention is paid to the details related to the reinforcement of the structural elements of the building, and the concrete quality, axial bending, and shear capacities of the vertical structural elements are considered. In addition, structural irregularities are essential evaluation parameters when applying the method. The assessment provides a risk-based prioritization of the structures examined and ensures that the available time and financial resources are correctly directed to high-risk structures (Ilki et al. 2014).

The Canadian seismic screening method (Rainer, Allen, and Jablonski 1992) analyzes structures under two separate headings: structural index and non-structural index. By summing these values, the performance score of the structure is calculated, and a risk priority ranking is made for the structure. When applying this method, each parameter is represented by a letter, which identifies high-risk structures and enables measures to be taken for these structures. The seismicity of the region, soil conditions, structural system type, structural irregularities, structural importance coefficient, and non-structural components are used to obtain a structural performance index (SPI). The higher the SPI score, the higher the risk level of the structure. Işık et al. (2017) conducted a study on the building stock of Muş province using the Canadian seismic screening method. As a result of the study, 48% of the analyzed buildings were classified as medium priority, 47% as high priority, and 5% as very hazardous. With the help of this method, it can be concluded that the earthquake performance of the building stock of Muş province is relatively low.

Demirbaş et al. (2021) assessed 130 heavily damaged reinforced concrete buildings from the 2020 Elazığ earthquake using rapid earthquake performance evaluation methods. The methods applied included the street scanning merhod developed by Sucuoğlu et al. (2007) and the Canadian Seismic Screening Method (Rainer, Allen, and Jablonski, 1992). Their findings showed a high degree of alignment between the risk levels identified by these methods and the actual damage classes recorded post-earthquake, though some inconsistencies remained.

Applied Technology Council (ATC) developed the FEMA p-154 rapid visual screening method (2002) to evaluate the earthquake performance of structures constructed with different construction techniques by visual screening. After it was updated in 2002, the second edition was published, followed by the third edition in 2015 (FEMA 2015). This method, which interprets the structure as safe or unsafe according to the final score obtained after determining the basic scores for each construction technique separately and applying penalty scores according to the condition of the structure and the structural irregularities it contains, recommends detailed structural analysis for structures with inadequate earthquake performance.

Tischer, Mitchell, and Mcclure (2011) used FEMA p-154 and the Canadian seismic screening method to evaluate the earthquake performance of 100 educational buildings on 16 campuses in Quebec and compared the results. According to FEMA p-154, 65% of the structures needed detailed analysis, while 34% of the structures evaluated according to the Canadian seismic screening method were classified as high priority, and 16% were potentially hazardous.

Adam et al. (2015) evaluated the earthquake performance of brick-masonry structures built in Vienna between 1848 and 1918 using the FEMA p-154 (2002) method. During the evaluation, researchers applied various modifications to determine the structures' performance more precisely. After creating vulnerability classes for 375 structures, they wanted to minimize the loss of life and property in the event of a possible disaster by sharing the data obtained with the relevant units to ensure life safety.

Kızılkaya (2018) examined an educational building consisting of three blocks built at various times and with different construction techniques in Istanbul with the help of using the first stage of FEMA p-154 (FEMA 2015), the Canadian Seismic Screening Method and the Japanese Seismic Index method. At the end of this study, the author evaluated the pros and cons of the methods and discussed their suitability for the Turkish building stock. As a result of the study, he concluded that the Canadian seismic screening method can be used reliably in Türkiye to determine the rapid earthquake performance and to classify buildings into risk groups.

Harirchian et al. (2020) applied FEMA p-154, Indian Method (IITK-GSDMA) (NDMA 2013) and Sucuoğlu RVS procedure to 28 reinforced concrete structures from Bingöl building stock. Within the scope of the study, the accuracy, validation, and comparisons of these three methods were examined. According to the results, they concluded that the FEMA p-154 RVS method exaggerates the results, while the other two methods give more accurate results and are easier to apply.

Kassem et al. (2021) conducted a preliminary earthquake assessment of 500 structures in Northern and Eastern George Town, Malaysia, using the FEMA p-154 rapid earthquake performance assessment method. As a result of the studies, it was revealed that 90% of the structures should be analyzed in detail. Then, they modified the rapid earthquake performance evaluation method, making it suitable for the Malaysian building stock. The results obtained were processed through ArcGIS and published for future studies.

Metin and Öztürk (2021) conducted a study on a 2-storey building in Bursa province using the FEMA p-154 method, Canadian Seismic Screening Method and P25 Scoring Method (Bal et al. 2007). According to this study, FEMA p-154 gave the structure a score of 3 and considered the structure safe; the Canadian seismic screening method found the structural performance index (SPI) to be 4.5 and considered the structure safe, and in the P25 method, the P-score was calculated as 31.5. According to this score, the structure was recommended to undergo a detailed structural analysis.

The Japanese Seismic Method (Ministry of Construction of Japan 1990) is a detailed seismic pre-assessment method that evaluates at three levels. The structures that do not get sufficient result points in the first stage go through more detailed analysis in the second and third stages. In the Japanese Seismic Index Method, material strengths of structural elements, section dimensions, deformation in structural elements over time depending on the age of the building, and irregularities due to the shape of the building are essential parameters to evaluate the structure's performance. Separate calculations are made for each floor. In addition, in this earthquake performance method, technical drawings related to the building are needed since it is necessary to reach the cross-sections of the vertical load bearing elements. Since this method uses the structural system data of the building instead of using only visual data, it gives more accurate results than street scanning methods. However, its application requires more time and incurs higher costs.

Maeda et al. (2012) investigated the reinforced concrete educational buildings affected by the Tohoku earthquake in 2011 in Eastern Japan using the Japanese seismic index method. After examining the structures, the team evaluated them in 5 different damage groups and observed that the method outputs and the damage data of the structures after the earthquake coincided.

Mehani et al. (2013) applied the Japanese Seismic Index Method (Ministry of Construction of Japan 1990) to assess low- and medium-rise reinforced concrete buildings in the region affected by the 2003 Mw=6.8 Boumerdès earthquake in Algeria. They categorized the structures into four evaluation classes based on regulatory and seismic code compliance: pre-code, low seismic code, medium seismic code, and high seismic code levels. As a result of this study, it was concluded that the most damaged structures were the structures evaluated in the pre-code class.

The buildings affected by the Kahramanmaraş earthquakes, detailed under subheading 3.3, *Building Inventory Database*, were assessed using rapid earthquake performance evaluation methods. Among the various approaches discussed above, three methods were selected based on the quality of available data concerning the buildings. Given that many structures were either severely damaged, collapsed or urgently needed to be demolished to be unsafe for entry, the evaluation needed to rely on methods that could be applied through street-level scanning. These selected methods are as follows respectively. FEMA p-154 (FEMA, 2002), the Sucuoğlu Rapid Visual Screening Procedure (Sucuoğlu et al., 2007), and the Canadian Seismic Screening Method (Rainer, Allen, and Jablonski, 1992). A comparative analysis of earthquake-damaged buildings was conducted by employing these methods with their unique frameworks. This analysis highlighted critical structural deficiencies and evaluated the efficacy and weaknesses of rapid screening tools in post-disaster contexts. Finally, examined methods were calibrated within the scope of the thesis using real earthquake damage.

# CHAPTER 3

# KAHRAMANMARAŞ EARTHQUAKES AND ASSESSMENT OF STRUCTURAL DAMAGE

In this section presents a comprehensive analysis of the Kahramanmaraş earthquakes that struck on February 6, 2023, along with their extensive impact. Furthermore, it examines the building stock of Adıyaman, one of the cities most severely impacted by the earthquake, focusing on various parameters such as the number of storeys, construction years, and structural system types.

## 3.1. Earthquake

Türkiye is situated along the Alpine-Himalayan seismic belt, a highly active tectonic region, and has historically been subjected to numerous significant and destructive earthquakes. Türkiye is located in the Anatolian Plate region and is significantly influenced by tectonic interactions between the Eurasian and the Arabian Plates (Figure 3.1). The northward movement of the Arabian Plate creates compressional forces that lead to considerable stress accumulation along the East Anatolian Fault. This dynamic tectonic setting has been the source of numerous devastating earthquakes throughout history, as depicted in (Özden, Gündoğdu, and Bekler 2015).

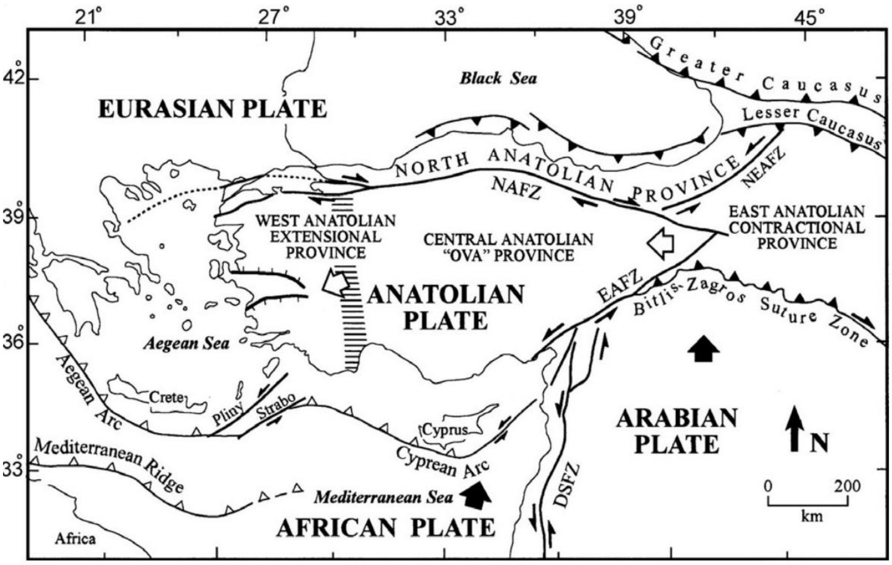



Figure 3.1. Simplified tectonic map of Türkiye (adopted from Şengör et al. 1979; Barka 1992)

The East Anatolian Fault has been the source of numerous destructive earthquakes throughout history. Notable events include the 29 November 1114 earthquake, estimated to exceed Mw =7.8, the 28 March 1513 Kahramanmaraş earthquake with a magnitude of Mw=7.4, the 1822 Antakya earthquake with a magnitude of Mw=7.8, the 1971 Bingöl earthquake with a magnitude of Mw=7.2, and the 1893 Malatya earthquake with a magnitude of Mw=7.1 (Ambraseys and Jackson 1998). The devastating earthquakes have caused serious loss of life and property in the region.

On 6 February 2023, 2 destructive earthquakes occurred on 6 February 2023 at 04.17 (Mw=7.8) with the epicenter in Pazarcık (Kahramanmaraş) and at 13.24 (Mw =7.5) with the epicenter in Elbistan (Kahramanmaraş) (AFAD 2023) (Figure 3.2). As stated in the report prepared by AFAD (2023), these two devastating earthquakes, which occurred 9 hours apart, caused 4,323 aftershocks in the 10 days between February 6 to 16. A total of 11 provinces in Southeastern Anatolia, Mediterranean and Eastern Anatolia regions were affected by these earthquakes. These cities are Adana, Adıyaman, Diyarbakır, Elazığ, Gaziantep, Hatay, Kahramanmaraş, Kilis, Malatya, Osmaniye and Şanlıurfa. Based on the 2022 Address Based Population Registration System data, a total of 14,013,196 people were affected by the earthquake in these 11 provinces (TÜİK 2023). These population values correspond to 16.4% of the total population of the country

(85,279,553). The disaster report prepared by AFAD on June 2, 2023, stated that 50,783 people lost their lives and 115,353 people were injured (AFAD 2023). Two major earthquakes on the Eastern Anatolian Fault line affected many structures in the area covering 11 provinces with different damage levels.

Due to the Kahramanmaraş earthquakes and aftershocks, 39,361 buildings were partially or completely collapsed, while 202,571 buildings were severely damaged in 11 provinces in Türkiye (Republic of Türkiye Presidency of Strategy and Budget 2024). Based on the data retrieved from the Ministry of Environment and Urbanization's database, the distribution graph of cities affected by the February 6 earthquakes, categorized by damage classes, is presented in Figure 3.3. The graph clearly highlights the provinces most severely impacted by the earthquake, as well as those where the destruction was most pronounced. In particular, the proportion of destroyed buildings in Adıyaman and Hatay stands out, with these provinces exhibiting the highest ratios of demolished structures relative to their overall building stock. Adana holds the distinction of having the highest proportion of undamaged buildings in relation to its total building stock, with 77.28% remaining intact after the earthquake.

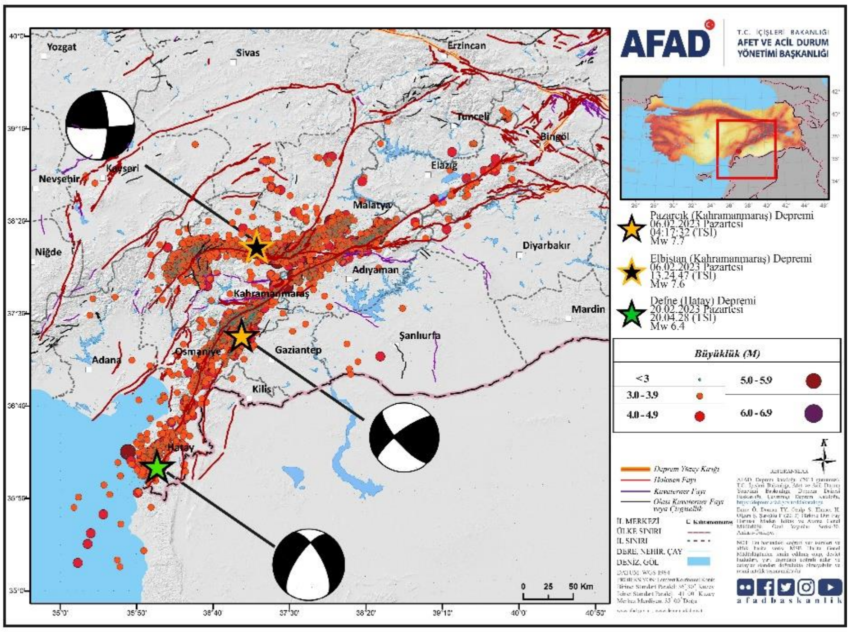



Figure 3.2. Pazarcık Mw 7.8, Elbistan Mw 7.6, Defne (Hatay) Mw 6.4 earthquakes and aftershocks in the region. (AFAD 2023)

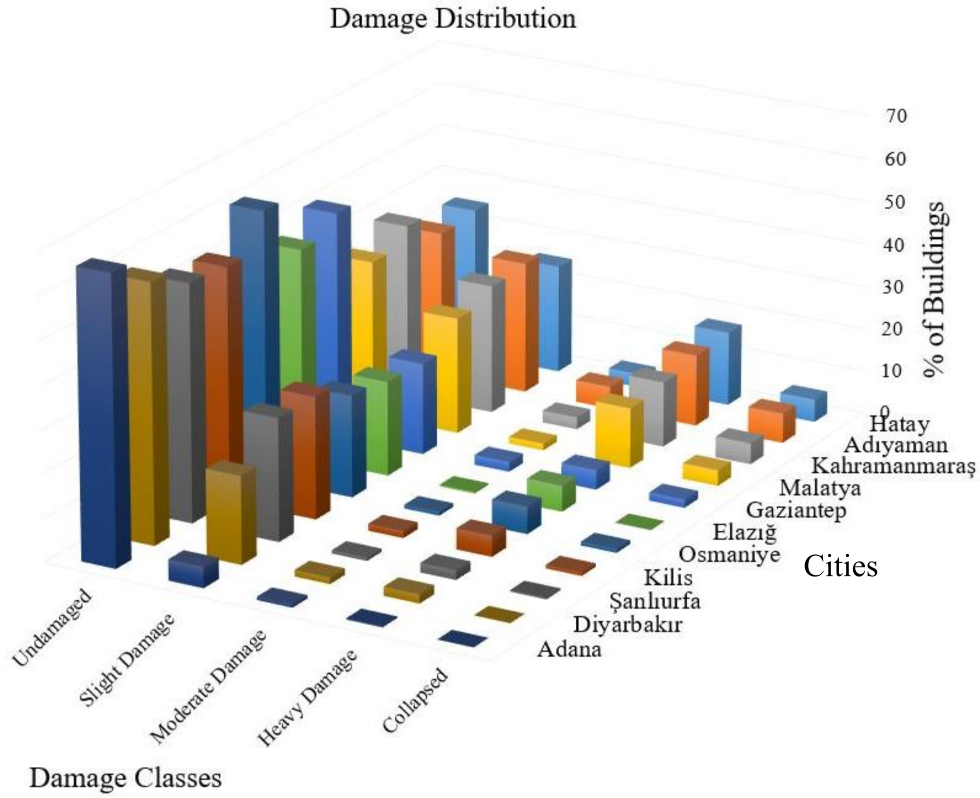



Figure 3.3. Graphic of damage distribution percentages by province (Ministry of Environment and Urbanization, 2023).

The buildings in Adıyaman, which were heavily damaged or collapsed during the Kahramanmaraş earthquake, were analyzed using post-earthquake images and direct building observations conducted during visits to the earthquake zone. To obtain information about completely collapsed buildings, location-based investigations were conducted with Google Earth Street images.

When examining the impact of an earthquake on structures, we encounter anomalies that can be categorized into three primary classifications. One of the first reasons buildings fail to withstand earthquakes safely is that they were not constructed in accordance with earthquake regulations at the time of their construction. Substandard building practices, which do not meet even the minimum required standards, are the leading cause of the destruction observed during earthquakes. Construction defects such as insufficient concrete class required for the designed structure, insufficient amount of steel reinforcement, incorrect connection of steel reinforcements have caused the structures to be severely damaged or collapsed in earthquakes. Until Turkish Seismic Design Code (1998) (ABYYHY 1998) has been released, steel reinforcements used in structural systems lacked ribs, which reduced the bond between the concrete and steel, leading to diminished earthquake performance. Following the Turkish Seismic Design Code (1998) (ABYYHY 1998), the use of ribbed steel reinforcement became mandatory. Another key factor contributing to the extensive damage that buildings endure during earthquakes is the decisions made during the design phase. Despite efforts to control design-phase decisions through earthquake regulations, defects such as weak or soft story irregularities, short columns, improper positioning of the center of stiffness, and the absence of infill walls for storefronts are commonly found in buildings that suffer severe damage or collapse during earthquakes. An analysis of the building stock in Adıyaman, one of the cities most affected by the Kahramanmaraş earthquake, revealed that structural defects, which could have been prevented during the design stage, led to heavy or moderate damage in many buildings. Additionally, thousands of buildings were destroyed, resulting in significant loss of life and property. The final, yet equally important, factor is the modifications made to buildings post-construction. Alterations such as cutting columns and beams or removing partition walls directly compromise the structural integrity, thereby weakening the overall strength of the building.

The Isias Hotel in Adıyaman tragically exemplifies the severe consequences of unauthorized modifications (Figure 3.4). According to the expert report prepared on the causes of the collapse of the Isias Hotel in the earthquake, the concrete strengths were insufficient according to the concrete samples taken, the stirrups were missing, and 135-degree connections were not made according to the earthquake regulations of the time it was built. The report also found that the structure had a severe level of soft floor irregularity in the direction of the collapse (Cyprus Union of Chambers of Turkish Engineers and Architects (KTMMOB) Chamber of Civil Engineers (İMO) 2023). Consequently, the hotel collapsed during the first earthquake at 4:17 AM on February 6. Additionally, the building was created by combining two neighboring structures originally designed as dwellings, in violation of the original building permits.


Figure 3.4. a) Isias Hotel, Adıyaman before Earthquake. (Courtesy of Google Street view) b) Isias Hotel, Adıyaman after Earthquake.

## 3.2. Building Stock of Adıyaman

Adıyaman, one of the cities most affected by the Kahramanmaraş earthquake, has a population of 604,978, according to 2023 data from TÜİK (TÜİK 2023). Following the earthquakes on February 6, a total of 115,332 buildings were impacted. According to data from the damage assessment studies conducted after the earthquake (Republic of Türkiye, Presidency of Strategy and Budget 2024), Adıyaman city center and all other districts has 217,368 independent units classified as residential, 6,056 as barns, and 28,347 as commercial buildings (Table 3.1). The damage distribution of the buildings in the city is illustrated in Figure 3.5.

Based on the results of damage assessment studies conducted in Adıyaman, 7.27% of residential buildings required immediate demolition or completely collapsed, 16.01% were classified as severely damaged, 5.68% were moderately damaged, 41.38% sustained slight damage, and 26.53% survived the earthquake without any damage. Given these rates, 73.47% of the residential buildings were affected by the earthquake, experiencing varying degrees of damage or complete collapse, resulting in significant loss of life and property.

Table 3.1. Building inventory data of Adıyaman city, including districts, grouped according to damage classes of buildings (ÇŞB 2023).

| Adıyaman All Districts | | | | |
|---|---|---|---|---|
| | Structure | Housing | Barn | Commercial |
| Urgent Demolition-Collapsed | 8254 | 15811 | 1012 | 2701 |
| Heavy Damaged | 20060 | 34811 | 1963 | 3284 |
| Moderate Damaged | 4588 | 12349 | 186 | 2382 |
| Slight Damage | 38456 | 89968 | 1340 | 11131 |
| Undamaged | 38370 | 57672 | 1415 | 8293 |
| Total | 115332 | 217368 | 6056 | 28347 |

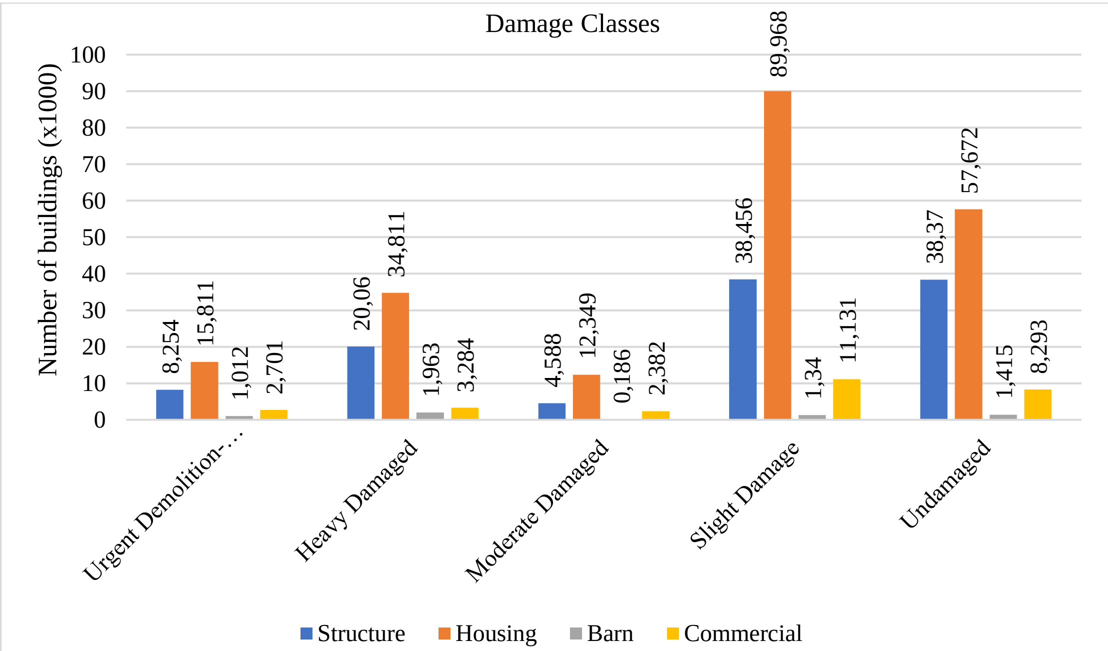



Figure 3.5. Graphical representation of data of Adıyaman, including districts, grouped according to damage classes of buildings (ÇŞB 2023).

An analysis of the data from damage assessment studies conducted by the Ministry of Environment and Urbanization reveals that the earthquake impacted a total of 45,337 buildings in Adıyaman's central district. Adıyaman's building stock suffered significant damage after the 6 February earthquake. The city had a total of 104,455 housing units, 1,564 barns, and 14,334 commercial buildings, most of which were impacted by the earthquake to varying extents. In terms of housing, approximately 9.5% either collapsed completely or required urgent demolition, creating an immediate shelter crisis for a large portion of the city. Additionally, 18.52% were categorized as heavily damaged, while 7.85% sustained moderate damage, highlighting the need for extensive repair and reconstruction. However, 48.98% of the housing units experienced only slight damage, suggesting that some could remain usable or require minor repairs. Only 13.02% of the structures survived the earthquake completely intact. These figures demonstrate that the majority of Adıyaman's building stock was affected in some way, necessitating significant reconstruction and retrofitting efforts throughout the city (Figure 3.6).

Considering the buildings affected by the Kahramanmaras earthquake, it is seen that there are 45,337 buildings in the center of Adıyaman built at different times, with different floor numbers and different construction techniques.

Table 3.2. Building inventory data of Adıyaman city center, grouped according to damage classes of buildings (ÇŞB 2023).

| Adıyaman City Center | | | | |
|---|---|---|---|---|
| | Structure | Housing | Barn | Commercial |
| Urgent Demolition-Collapsed | 3538 | 9942 | 411 | 2036 |
| Heavy Damaged | 8131 | 19349 | 528 | 2068 |
| Moderate Damaged | 2397 | 8205 | 60 | 1699 |
| Slight Damage | 19645 | 51169 | 318 | 6121 |
| Undamaged | 9883 | 13609 | 230 | 2178 |
| Total | 45337 | 104455 | 1564 | 14334 |

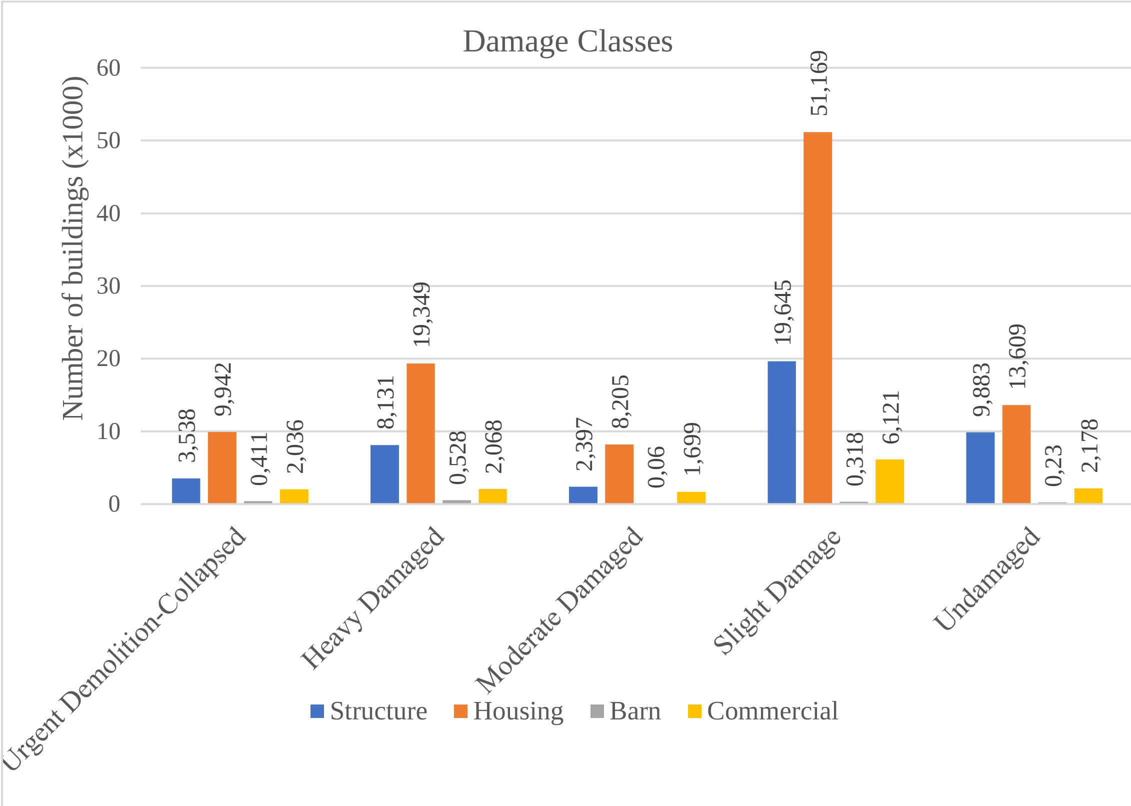



Figure 3.6 Graphical representation of data of Adıyaman city center, grouped according to damage classes of buildings (ÇŞB 2023).

### 3.2.1. Year of Construction

The results obtained from the comparisons made according to the years of construction are shown in Figure 3.7 under 5 main year groups. It should be noted that the construction dates in the database rely on the entries by the reconnaissance teams, which many times based on their best prediction. Therefore, even though the author did his best on verifying the construction dates of the examined buildings using Google Street View, the likelihood of errors on the dates should be noted.

While deciding on these construction year groups, the dates when the earthquake regulations were changed were taken into consideration. The 5 different construction year groups obtained by this grouping are as follows: 1980 and before, between 1980 and 2000, between 2000 and 2008, between 2008 and 2018, and finally from 2018 and after.

When the data is analyzed, the area where the building stock shows the highest agglomeration with 40.38% consists of the buildings built between 1980 and 2000. It can be assumed that 53.01% of the 45,329 buildings in question were likely constructed in accordance with the earthquake regulations introduced after Turkish Seismic Design Code (1998) (Figure 3.7).

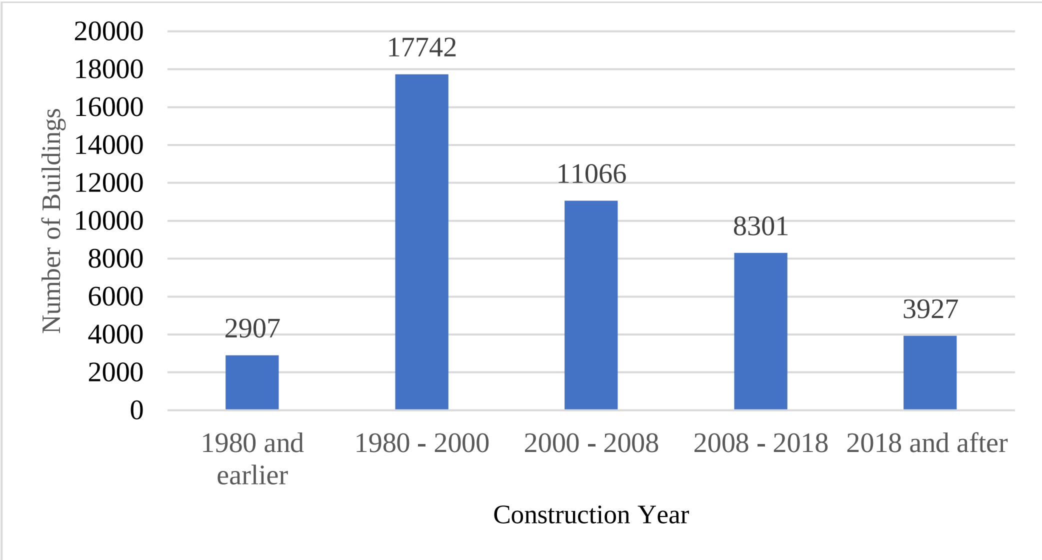



Figure 3.7 Distribution graph of the buildings Adıyaman according to construction years (ÇŞB 2023).

Among the buildings that were completely or partially destroyed in the earthquake, those constructed in 2000 or earlier comprise the largest proportion, making up 47.19% of the total. This highlights the vulnerability of older buildings, many of which were built before the introduction of stricter seismic regulations after 1998 as mentioned earlier (Figure 3.8).

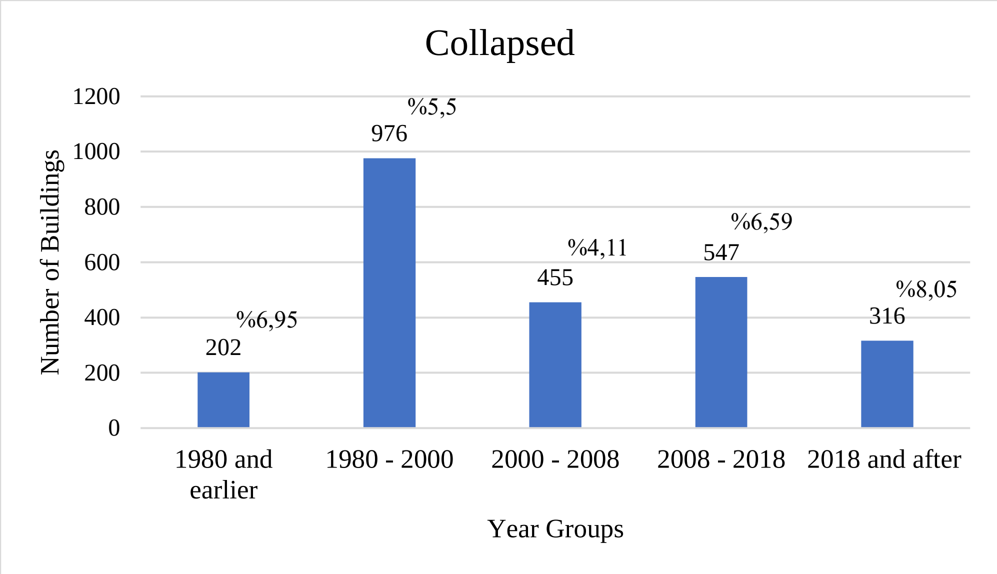



Figure 3.8 Collapsed buildings in the city center of Adıyaman according to construction year groups (ÇŞB 2023).

When analyzing the buildings identified as being at risk of collapse due to earthquake damage and marked for urgent demolition to prevent potential loss of life and property, it is observed that the numbers of buildings from the periods 1980-2000, 2000-2008, and 2008-2018 are relatively similar. In contrast, the group of buildings constructed in 1980 or earlier, which would be expected to exhibit the most significant damage, represents the lowest percentage, at just 4% (Figure 3.9).

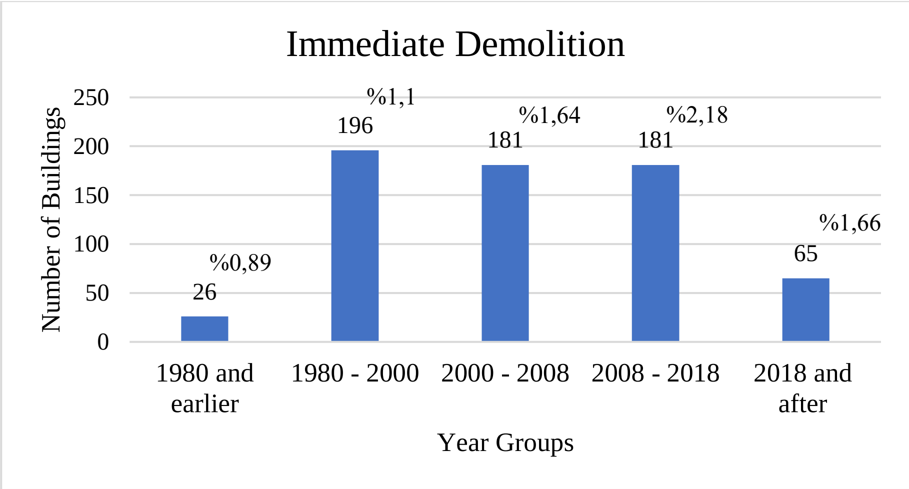



Figure 3.9. Distribution of the buildings as to be demolished immediately during damage assessment according to construction year groups (ÇŞB 2023).

In the damage assessment studies conducted after the earthquake in Adıyaman, 3,261 buildings constructed between 1980 and 2000 were identified as heavily damaged, representing the highest rate at 38.39%. Conversely, buildings constructed in 2018 or later had a low rate of heavy damage, with only 463 buildings affected, accounting for 5.45%. Contrary to expectations, buildings constructed before 1980 had the lowest rate of heavy damage, with only 413 buildings affected (Figure 3.10).

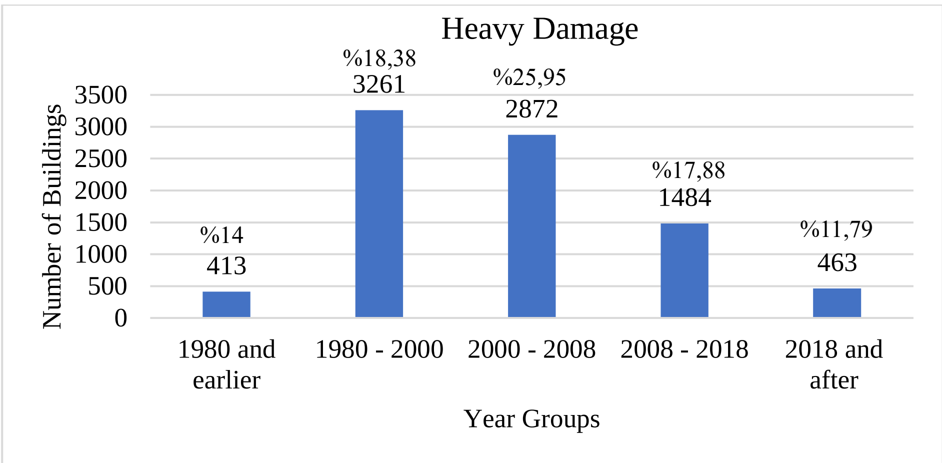



Figure 3.10. Distribution of heavily damaged buildings according to construction year groups (ÇŞB 2023).

The distribution graph for the moderate damage category reveals a distinct pattern compared to other damage categories. Generally, the graph exhibits a decreasing trend from buildings constructed between 1980 and 2000 to those built in 2018 and later. However, in the medium damage category, buildings constructed between 2000 and 2018 experienced medium damage at a rate of 15.33%, which is lower than expected. In contrast, the highest proportion of moderate damage was observed in buildings constructed between 1980 and 2000, accounting for 45.51% (Figure 3.11).

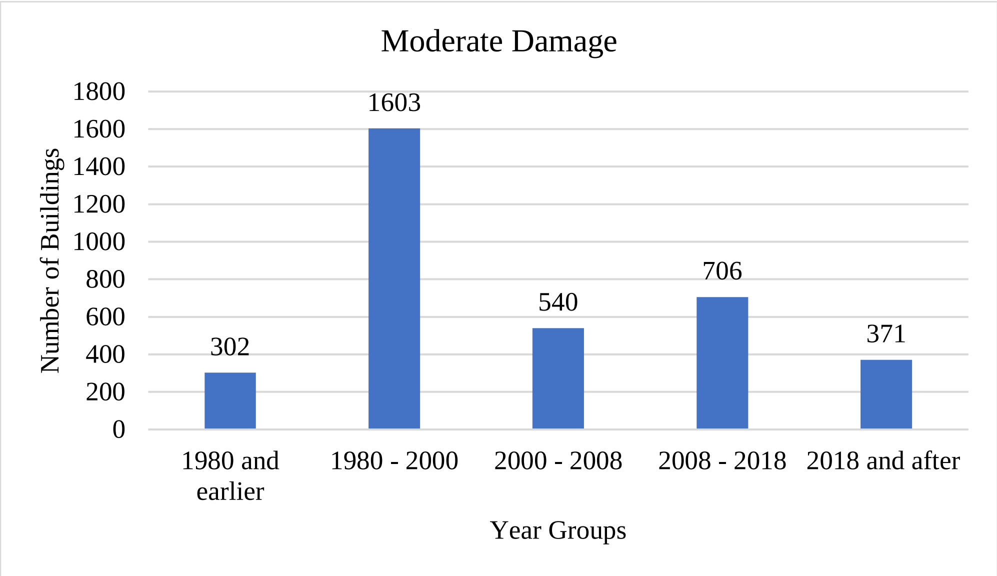



Figure 3.11. Distribution of moderately damaged buildings according to construction year groups (ÇŞB 2023).

When analyzing the buildings that survived the February earthquakes with slight damage, the distribution pattern closely resembles that of the heavily damaged buildings. Notably, 6,385 buildings constructed between 1980 and 2000 make up the largest portion of this category, representing 37.97% of the total. Buildings constructed in 1980 and earlier had the smallest share in the low damage group, accounting for just 5.14% with 865 buildings (Figure 3.12).

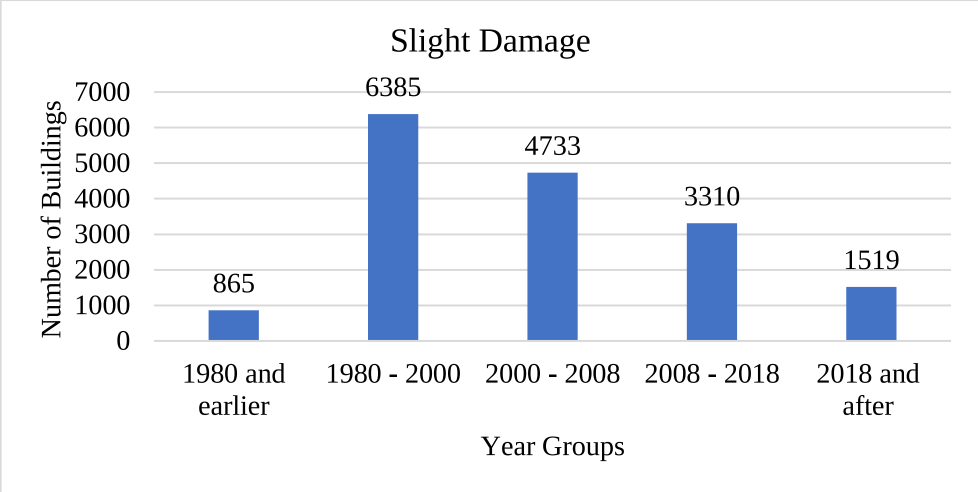



Figure 3.12. Distribution of slightly damaged buildings according to construction year groups (ÇŞB 2023).

According to the damage assessment studies conducted in Adıyaman city center following the February 6 earthquakes, the graph depicting buildings that survived without damage closely mirrors the general trend. Buildings constructed between 1980 and 2000, totaling 4,362, represent the largest share at 44.38%. In contrast, buildings constructed in 1980 or earlier, with the fewest numbers, account for the smallest share of undamaged buildings, at 10.36% (Figure 3.13).

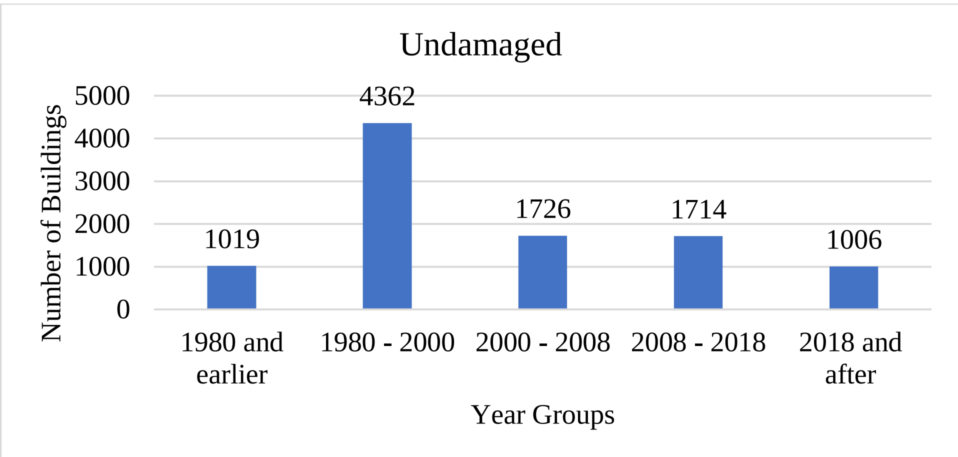



Figure 3.13. Distribution of undamaged buildings according to construction year groups (ÇŞB 2023).

### 3.2.2. Number of Floors

The number of storeys in a building is one of the most crucial factors influencing its earthquake performance (Sucuoğlu, Yazgan, and Yakut 2007). When comparing the performance of buildings with varying storey numbers but identical structural systems and floor plans in a study, it was found that multi-storey buildings exhibited lower resistance to base shear forces compared to low-rise buildings. This highlights the heightened vulnerability of taller structures in earthquake scenarios (Özdemir, Işik, and Ülker 2016). On the other hand, an analysis of the damage assessment studies conducted after the February 6 Kahramanmaraş earthquakes reveals that low-rise buildings constitute a significant proportion of the heavily damaged structures. This observation suggests that, despite their generally higher resistance to base shear forces, certain low-rise buildings were more vulnerable to damage due to additional contributing factors, such as poor construction practices, design flaws, or inadequate material quality. Under these circumstances, factors such as the earthquake regulations in force at the time of construction, the orientation of the structural system, the placement, direction, and quantity of shear columns (if present), ground conditions, and the building's proximity to the earthquake's epicenter have clearly shown that the earthquake resistance of buildings can vary significantly, even when they have the same number of storeys. These variables underscore the complexity of determining structural resilience and highlight the need for comprehensive assessment beyond just building height.

An analysis of the data from buildings impacted by the February 6 earthquakes in the central district of Adıyaman reveals that among the 43,943 affected structures, 1-storey buildings make up the largest proportion, totaling 19,635 buildings. These 1-storey structures constitute 44.06% of the total building stock, a notably high percentage compared to other buildings with storeys ranging from one to fifteen. This substantial representation highlights the prevalence of low-rise buildings within the district. Based on the data derived from the analyzed building stock, the lowest representation was found in 13- and 15-storey buildings, with each category comprising only one structure. Significantly, the 15-storey building suffered extensive damage and was subsequently demolished following the earthquake, whereas the 13-storey building experienced minimal damage and remained intact (Figure 3.14). This disparity illustrates the variability in earthquake resilience among high-rise structures, even within a small sample size.

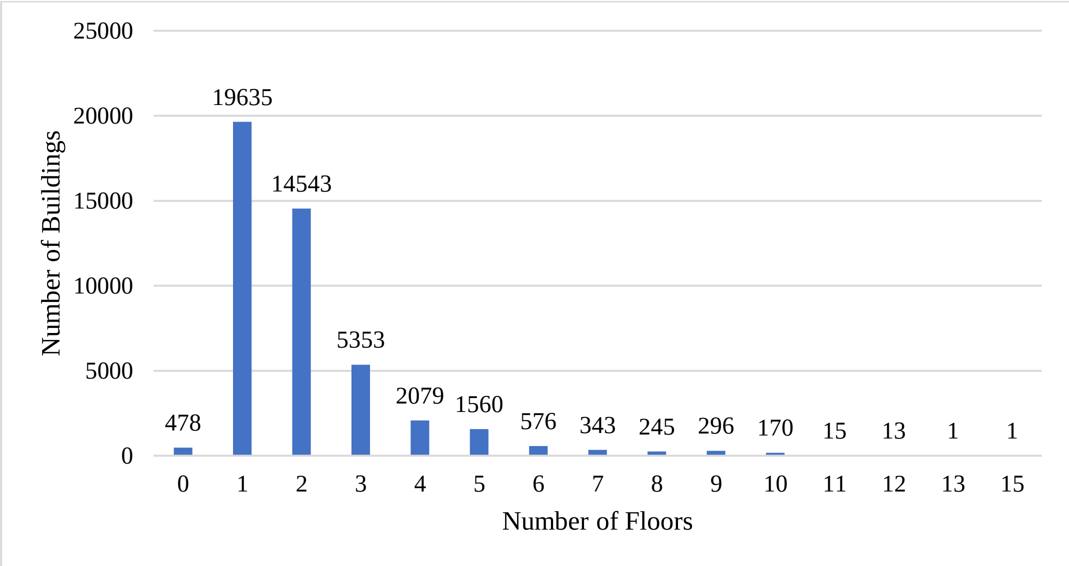



Figure 3.14. Distribution graph of the number of floors of buildings in Adıyaman city center (ÇŞB 2023).

An examination of the buildings that failed to demonstrate sufficient earthquake performance and collapsed following the devastating earthquakes reveals that single-storey buildings accounted for the highest number of collapses, with 1,277 structures affected. After single-storey buildings, which represent 50.99% of the demolished structures, two-storey buildings account for 34.3% of the demolitions, with 859 buildings affected (Figure 3.15).

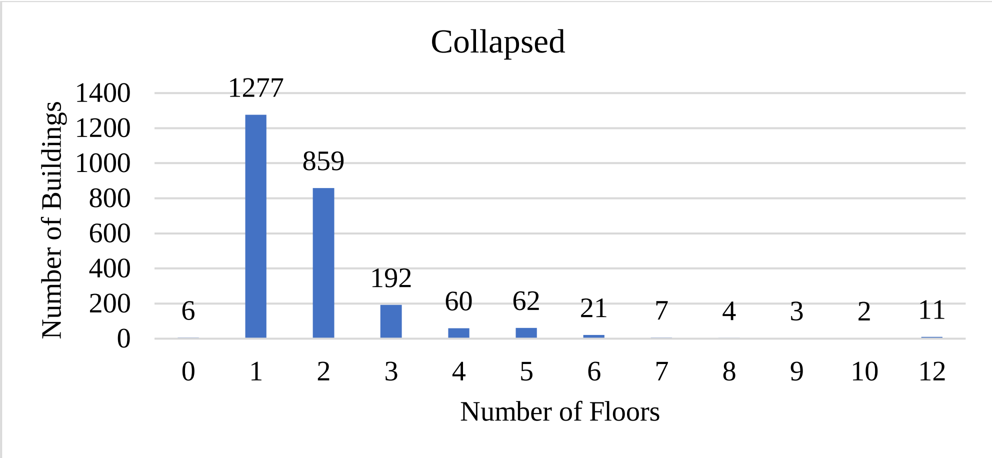



Figure 3.15. Distribution graph of the number of storeys of collapsed buildings in Adıyaman (ÇŞB 2023).

A total of 978 buildings falls into the category of structures that sustained significant damage during the earthquake but did not completely collapse or are at risk of imminent collapse, requiring urgent demolition. The highest concentration within this damage group was observed in single-storey buildings, which make up 38.75% of the total, accounting for 379 buildings. Single-storey buildings are followed by two-storey buildings, which represent 22.7% of the 978 buildings, with 222 structures (Figure 3.16).

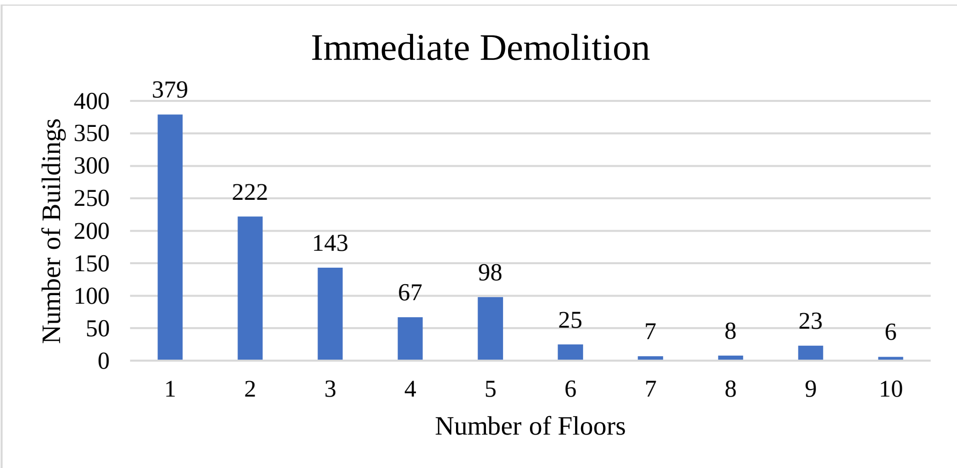



Figure 3.16. Distribution graph of the number of storeys of the buildings to be demolished immediately in Adıyaman city center (ÇŞB 2023).

In the analysis of buildings identified as heavily damaged in the damage assessment studies following the Kahramanmaraş earthquakes, single-storey buildings accounted for the largest number, with 2,766 structures, followed closely by two-storey buildings, with 2,564 structures. These two categories represented the highest accumulation of heavily damaged buildings, underscoring the vulnerability of low-rise structures in this seismic event. An analysis of the damage assessment studies indicates that among the heavily damaged buildings, single-storey structures constitute 38.75%, while two-storey structures account for 22.69%. Notably, buildings with six or more storeys experienced the least damage. A significant factor contributing to this trend is the relative age of the buildings; high-rise structures in Adıyaman city center are generally newer than low-rise ones. Consequently, these multi-storey buildings, constructed in accordance with more recent and stringent earthquake regulations, exhibited better earthquake performance compared to older, low-rise buildings (Figure 3.17).

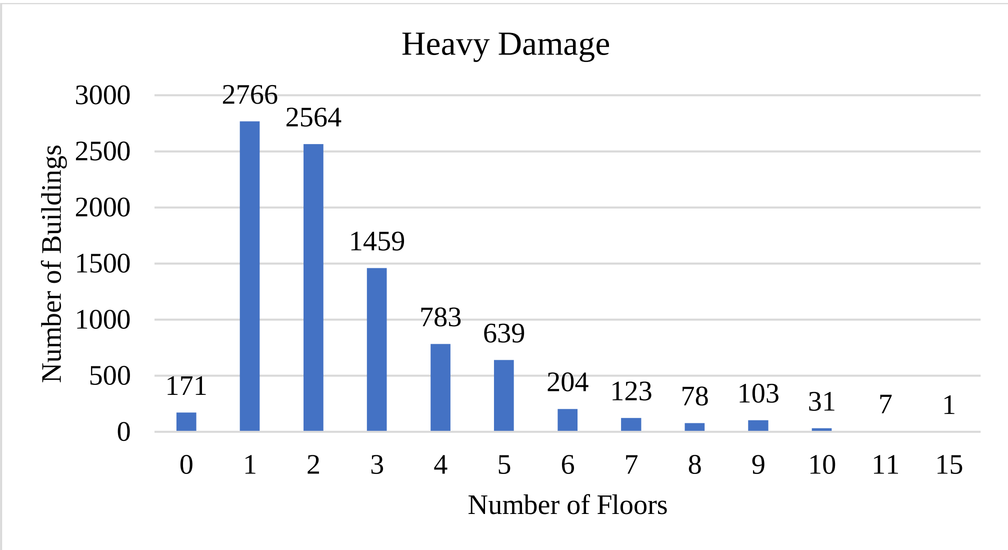



Figure 3.17. Distribution graph of the number of storeys of the heavily damaged buildings in Adıyaman city center (ÇŞB 2023).

When examining the buildings that sustained moderate damage during the earthquake, single-storey structures comprise 53.39% of this category, totaling 1,910 buildings. This notable percentage underscores the vulnerability of single-storey buildings, despite their relatively lower height, in terms of earthquake resilience. Single-storey buildings are followed by two-storey and higher structures. Notably, one of the 12-storey buildings, among the tallest in Adıyaman, survived the earthquake with only moderate damage (Figure 3.18).

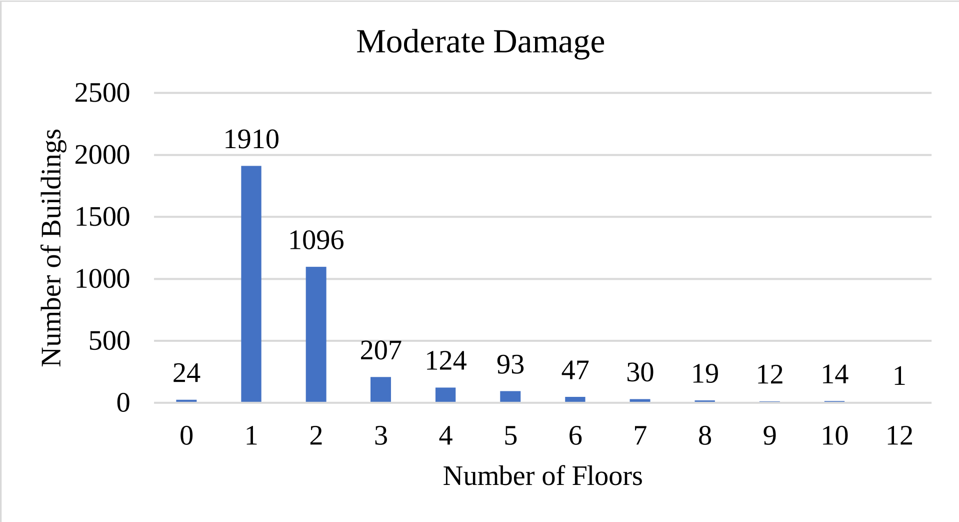



Figure 3.18. Distribution graph of the number of storeys of the moderate damaged buildings in Adıyaman city center (ÇŞB 2023).

The damage assessment studies revealed that the concentration of buildings classified as slightly damaged predominantly consisted of one-storey and two-storey structures. Of the 17,167 buildings assessed, 37.43% were single-storey, accounting for 6,427 buildings, while 33.89% were two-storey, with 5,819 buildings. Notably, a 13-storey building in the same damage group was observed to have sustained only minor damage (Figure 3.19).

Of the 43,943 buildings analyzed, 10,071 survived the Kahramanmaraş earthquakes without sustaining any damage, thus preventing loss of life and property. When examining these undamaged buildings, single-storey and two-storey structures are particularly notable. Single-storey buildings, comprising 57.15% of this category with 5,756 structures, represent the largest concentration, as observed in other damage classes. Two-storey buildings, with 3,314 structures follow these. Among the undamaged high-rise buildings that emerged from the earthquake, 8-, 9-, and 10-storey buildings stand out.

While it is generally expected that an increase in storeys would reduce a building's earthquake performance, the survival of these taller buildings without damage suggests that comprehensive measures were likely implemented during both the design and construction phases and that these buildings may have been constructed in areas with appropriate ground conditions (Figure 3.20).

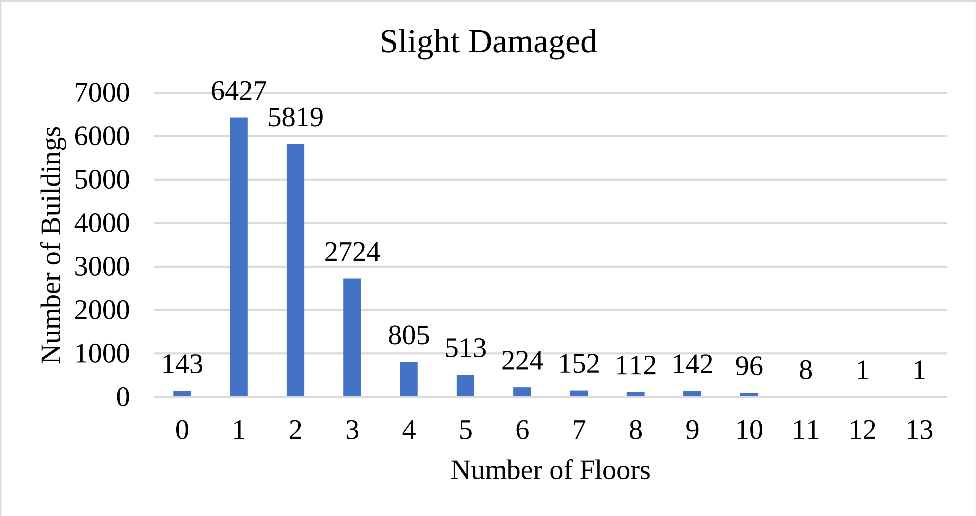



Figure 3.19. Distribution graph of the number of storeys of the Slight Damaged buildings in Adıyaman city center (ÇŞB 2023).

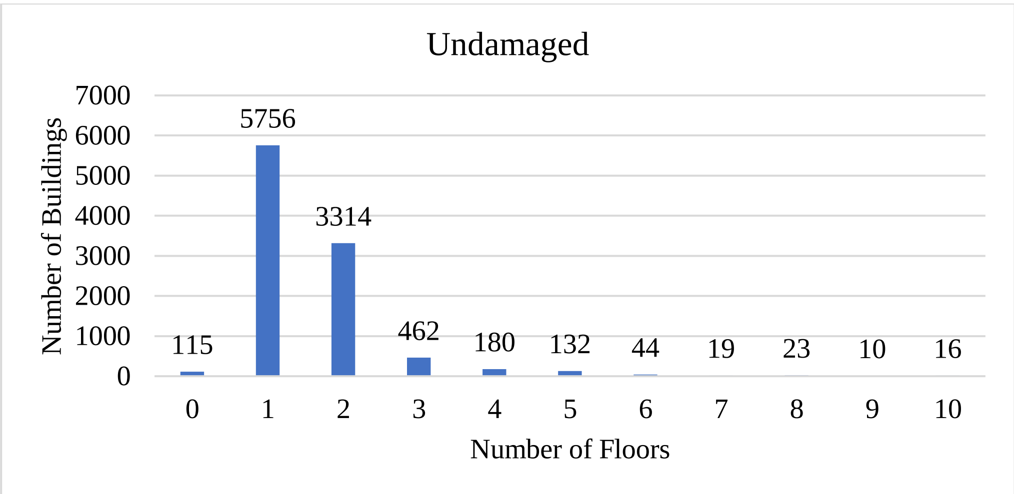



Figure 3.20. Distribution graph of the number of storeys of the undamaged buildings in Adıyaman city center (ÇŞB 2023).

### 3.2.3. Construction Techniques

In Adıyaman's city center, the following construction techniques were observed: 363 steel structures, 29,346 reinforced concrete structures, 12,053 various types of masonry structures, 6,879 masonry-briquette structures, 3,032 hybrid structures, 478 prefabricated structures, 39 structures constructed using the Bağdadi technique, and finally, 18 structures built with the Hımış technique (Figure 3.19). The damage assessment studies conducted on Adıyaman's building stock revealed that 66.78% of the 43,943 analyzed buildings were reinforced concrete structures. This construction technique is widely used in Türkiye due to its relatively low cost, durability, and minimal maintenance requirements. When designed and constructed with accurate static calculations, reinforced concrete structures demonstrate excellent earthquake performance and offer high resistance to fire.

An analysis of the reinforced concrete structures affected by the Kahramanmaraş-centered earthquakes reveals significant damage patterns. Of the 29,346 reinforced concrete buildings in Adıyaman, 4.52% completely collapsed, leading to loss of life and property. A substantial 24.76% (7,267 buildings) were classified as severely damaged, while 3.02% (896 buildings) were marked for immediate demolition due to the high risk they posed. Additionally, 6.16% of the buildings sustained moderate damage. However, 40.89% (12,001 buildings) experienced only minor damage, and 4,943 buildings remained undamaged, successfully safeguarding their occupants from any loss of life or property. Masonry-brick buildings were the second most common construction type in Adıyaman, representing 15.35% of the 43,943 structures analyzed. Of the 6,879 masonry-brick buildings, 2,018 were impacted by the earthquakes, experiencing damage across various categories or complete collapse. Despite this, these buildings largely fulfilled their intended purpose, helping to prevent loss of life and property. Their performance underscores the resilience of this traditional construction technique in certain contexts, though the extent of damage still highlights the need for improved structural standards (Figure 3.21).

In addition to the commonly observed buildings in Adıyaman's building stock, traditional construction techniques like Bağdadi and Hımış were also identified.

Of the 39 buildings constructed using the Baghdadi technique, although 2 collapsed, the remaining 37 withstood the earthquake without any loss of life. Similarly, among the 18 buildings built using the Hımış construction technique, only 1 collapsed, while the other 17 survived the earthquake undamaged.

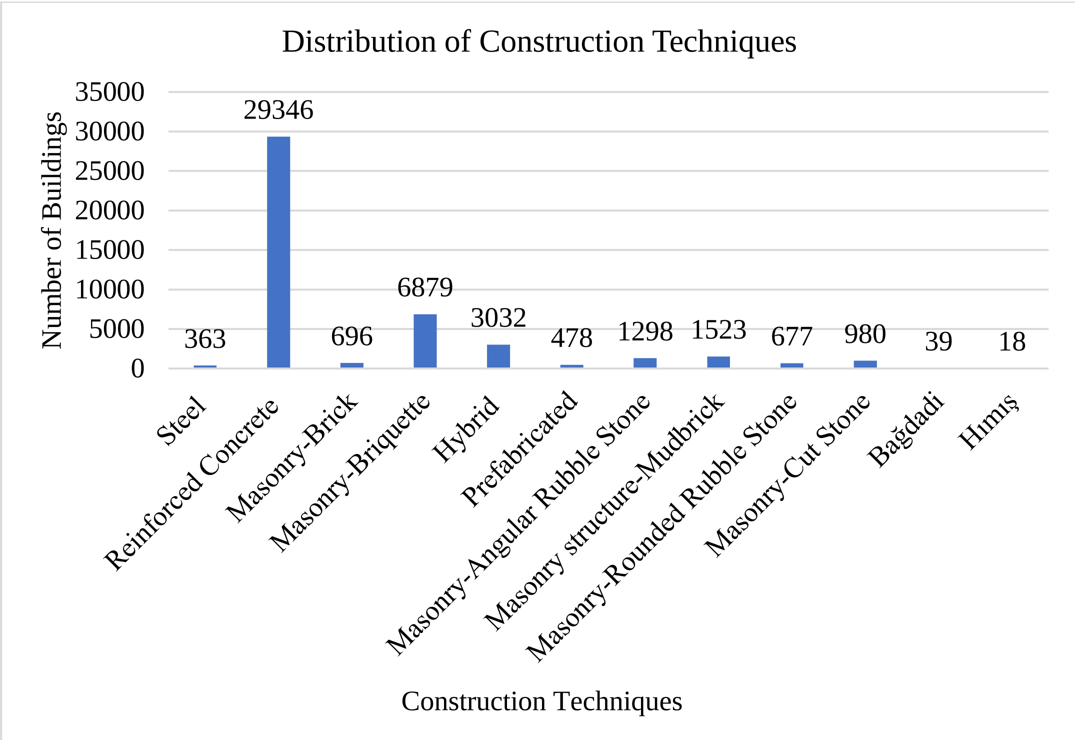



Figure 3.21. Distribution graph of buildings in Adıyaman city center according to construction techniques (ÇŞB 2023).

Reinforced concrete structures represent the most affected category with 1,328 buildings, accounting for 53.03% of the total collapsed structures., followed by masonry-briquette structures, which accounted for 458 collapsed buildings (Figure 3.22.a). Reinforced concrete buildings in the urgent demolition category were the group with 896 units in this damage class (Figure 3.22.b). When the structures severely damaged in the earthquake are analyzed, reinforced concrete buildings are the most affected group, with 7,267 structures constituting 81.39% of the severely damaged structures. This highlights the significant vulnerability of this construction type, despite its widespread use and reputation for strength, particularly when proper design and construction practices are not strictly followed (Figure 3.22.c). In the analysis of the moderately damaged buildings obtained from the damage assessment studies, reinforced concrete buildings were the most represented structures, with 1,809 units constituting 51.43% of this group (Figure 3.22.d). While some of these buildings were retrofitted, the rest were demolished after the earthquake because they were deemed risky. Looking at the graph of undamaged structures, 4,164 masonry buildings withstood the earthquake, following reinforced concrete structures. In addition, 100 steel and 728 hybrid structures survived the earthquake without damage, again demonstrating the durability of these construction techniques against seismic events when applied correctly (3.22.f).

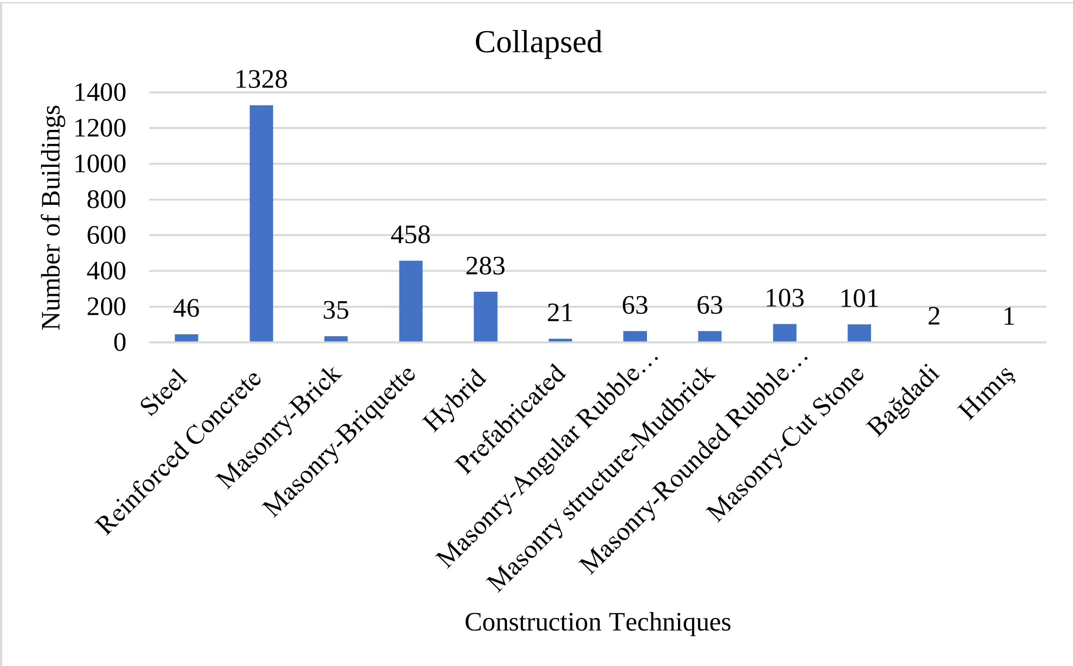



Figure 3.22.a. Distribution graph of collapsed buildings in Adıyaman city center according to construction techniques (ÇŞB 2023).

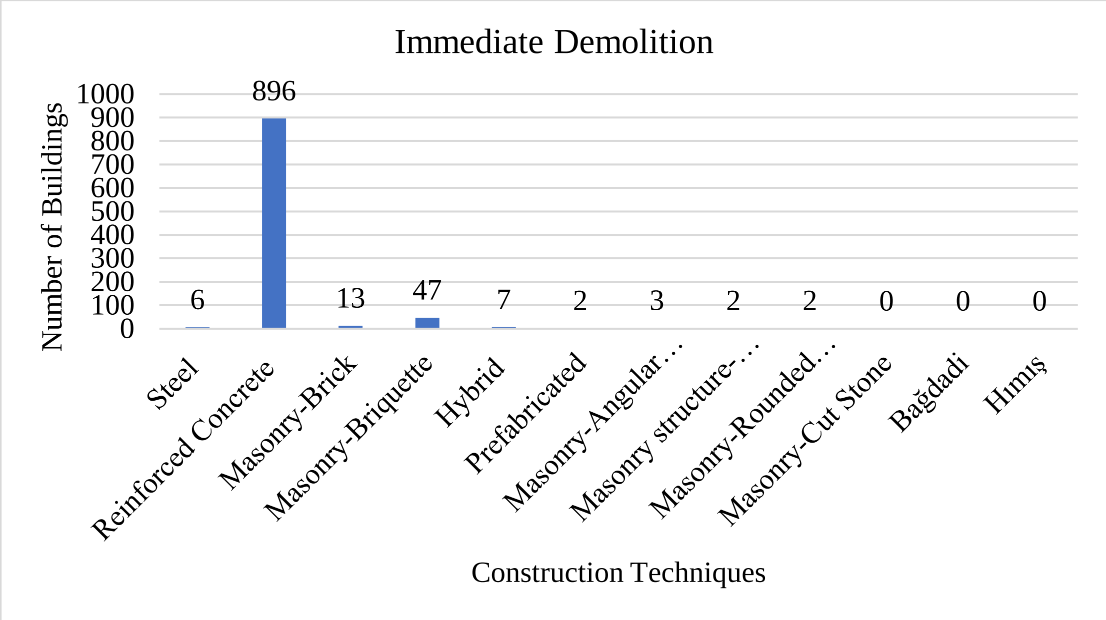



Figure 3.22.b. Distribution graph of construction techniques of the buildings to be demolished immediately in Adıyaman city center (ÇŞB 2023).

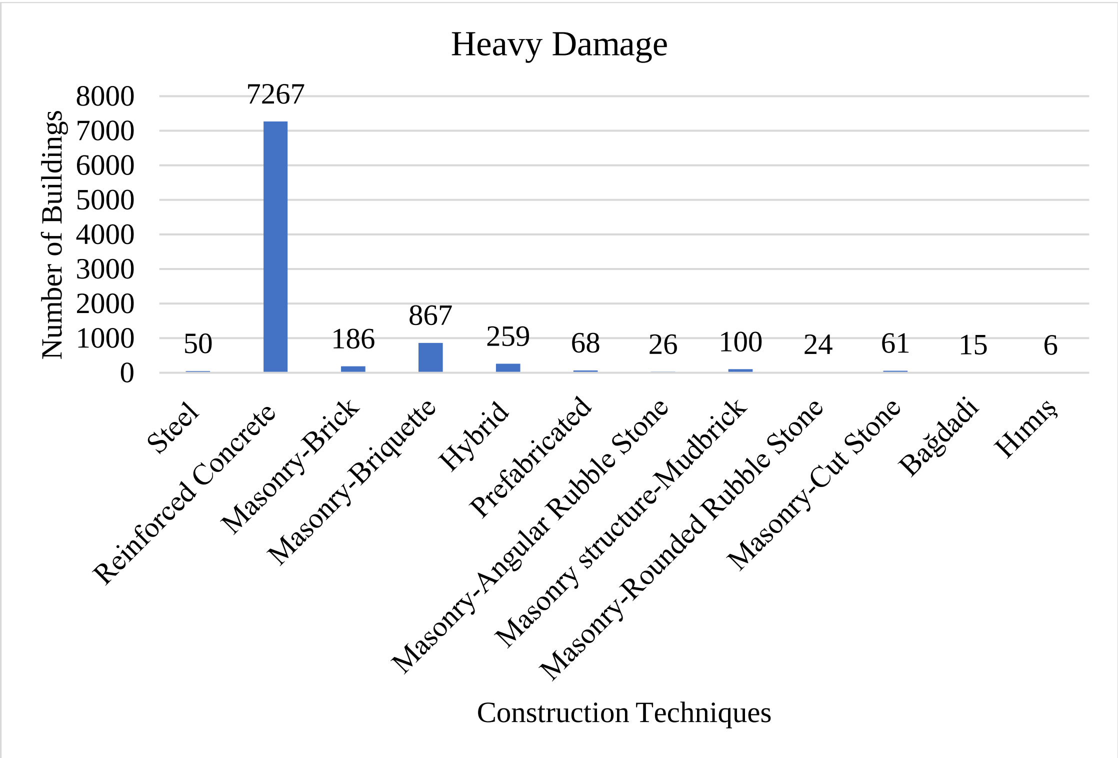



Figure 3.22.c. Distribution graph of construction techniques of heavily damaged buildings in Adıyaman city center (ÇŞB 2023).

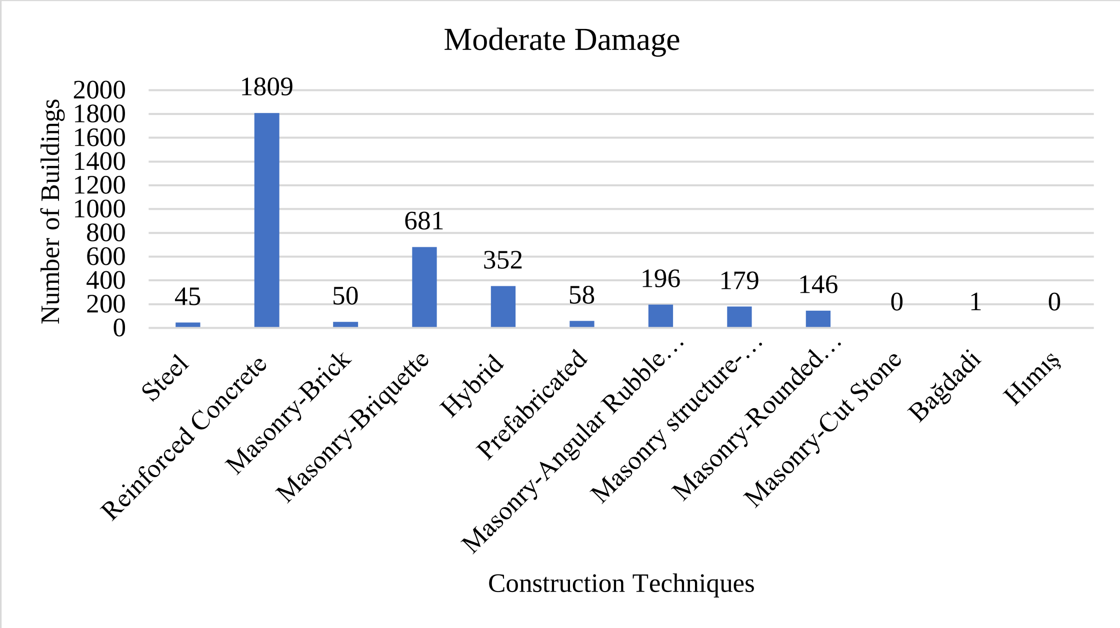



Figure 3.22.d. Distribution graph of construction techniques of moderate damaged buildings in Adıyaman city center (ÇŞB 2023).

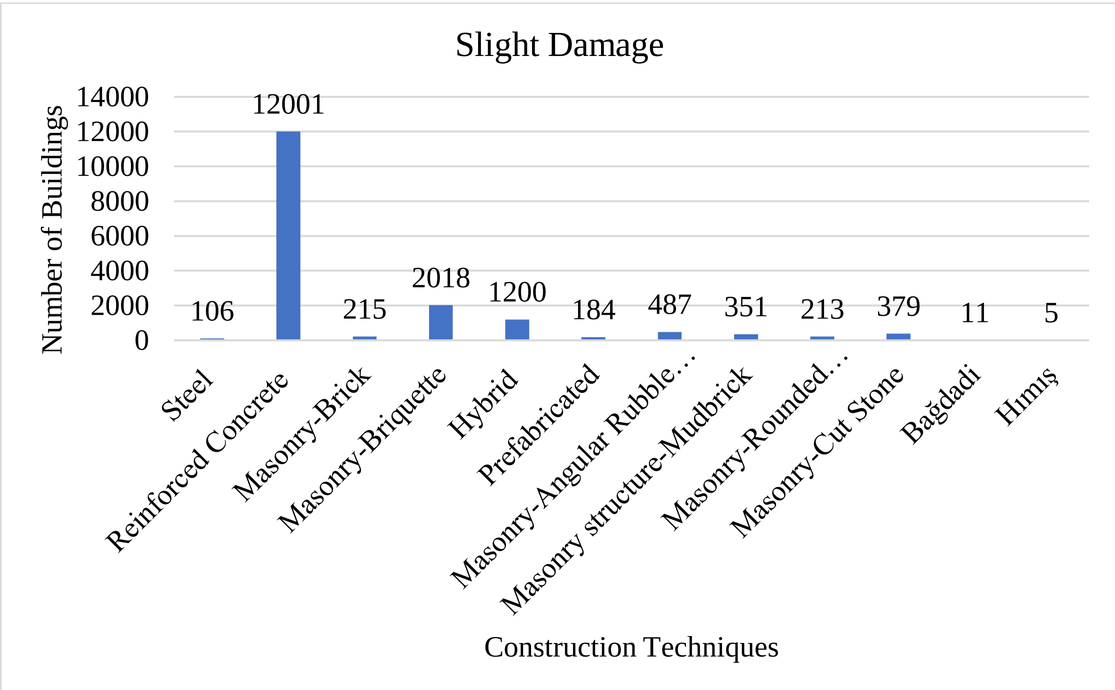



Figure 3.22.e. Distribution graph of construction techniques of Slight Damaged buildings in Adıyaman city center (ÇŞB 2023).

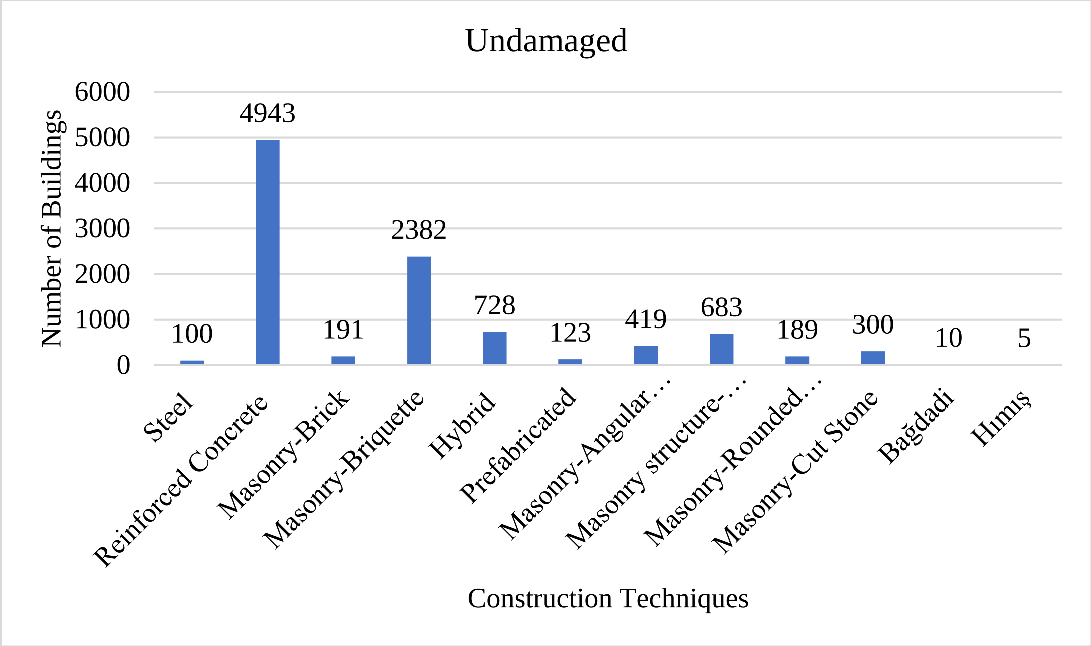



Figure 3.22.f. Distribution graph of construction techniques of undamaged buildings in Adıyaman city center (ÇŞB 2023).

## 3.3. Building Inventory Database

The 6 February Kahramanmaraş earthquakes impacted 11 provinces, with Kahramanmaraş, Adıyaman, and Hatay being the hardest hit. In response, the Ministry of Environment and Urbanization conducted a comprehensive damage assessment study across the affected provinces. This study gathered crucial information from the buildings in the earthquake zone, including details on the condition of the structures, year of construction, type of structural system, number of storeys, and building locations. Based on the data collected, a specific building tag was created for each structure, categorizing them according to their damage level and other key factors.

The buildings affected by the earthquakes, whose damage conditions were determined through damage assessment studies, had their structural data collected in the Ministry of Environment and Urbanization’s database. This data was subsequently evaluated for comprehensive research, utilizing the database's detailed information to analyze the earthquake's impact on these structures.

Initial studies on the database concentrated on the building stock in the central district of Adıyaman. This focus was chosen largely due to the researcher's familiarity with the pre-earthquake condition of Adıyaman's building stock. As a result of this narrowed scope, the number of buildings analyzed was reduced to 43,943. These buildings were categorized and examined under three primary headings: year of construction, number of storeys, and type of structural system. The detailed data are discussed in Chapter 3.2, with accompanying explanations presented through graphs.

Following the examination of 43,943 buildings in the center of Adıyaman, 477 structures were selected from among those heavily damaged, urgently demolished, or collapsed buildings to be examined with rapid earthquake performance evaluation methods and to make an inference according to the pre-earthquake condition of these structures. The most important factor considered while selecting the 477 buildings was the availability of sufficient information about the building. The evaluation results of the buildings for which sufficient data cannot be collected are incomplete. An analysis of the damage conditions of the 477 buildings selected for detailed investigation reveals that 7 buildings were fully collapsed (Figure 3.23), 170 were classified as high-risk and marked for urgent demolition (Figure 3.24), and 300 buildings exhibited heavy damage (Figure 3.25), yet remained structurally intact following the earthquake. The distribution of damage classes of the selected structures is illustrated in Figure 3.26.

The selection process prioritized reinforced concrete structures, the dominant construction method in Adıyaman’s building stock, as well as masonry buildings, which are the second most prevalent. Among the selected buildings, 63 were masonry, and 414 were reinforced concrete. This selection is expected to provide valuable insights into the performance of rapid earthquake evaluation methods across different construction techniques.

Figure 3.23. Collapsed building from Adıyaman city center
(Courtesy of Google Street view).

Figure 3.24. Buildings requiring immediate demolition from Adıyaman city center
(Courtesy of Google Street view).

Figure 3.25. Heavily damaged building from Adıyaman city center (Courtesy of Google Street view).

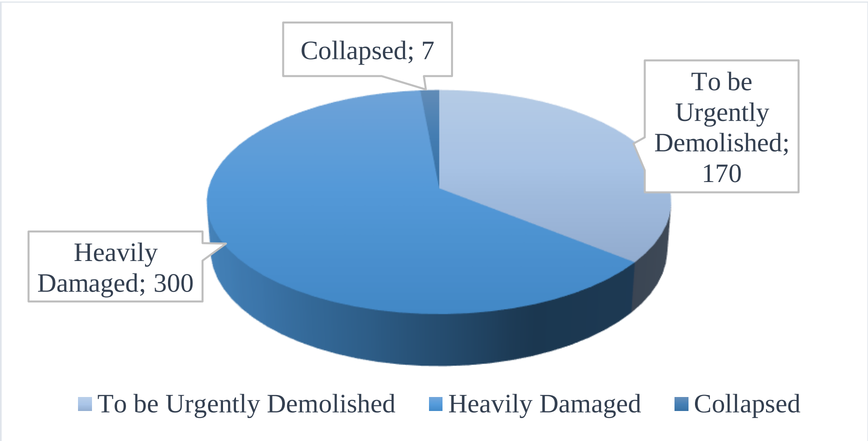



Figure 3.26. Distribution of damage classes of the selected structures (ÇŞB 2023).

The 477 buildings examined in this study were analyzed using data provided by the Ministry of Environment and Urbanization, gathered through damage assessment studies (ÇŞB 2023). This data includes photographs, address information, building coordinates, number of storeys, year of construction, damage status, intended use, building area, and type of structural system. Furthermore, additional detailed information about the buildings was collected through on-site photographs and their geographical coordinates to enhance the scope of the analysis.

When examining the construction years of the selected buildings from Adıyaman's building stock, the release dates of Turkish earthquake regulations were considered. Specifically, the seismic design regulations from 1975, 1998, 2007, and 2018 were used as reference points. Of the 477 buildings, 22 were built in 1980 or earlier and were constructed without being subject to any of these earthquake regulations. The 191 buildings constructed between 1980 and 2000 were designed according to the 1975 regulations. Additionally, 155 buildings built between 2000 and 2008 were designed under the Turkish Seismic Design Code (1998) regulations. A total of 91 buildings were constructed between 2008 and 2018 in accordance with the 2007 regulations, while 18 buildings constructed from 2018 onwards reflect compliance with the 2018 seismic design regulations (Figure 3.27).

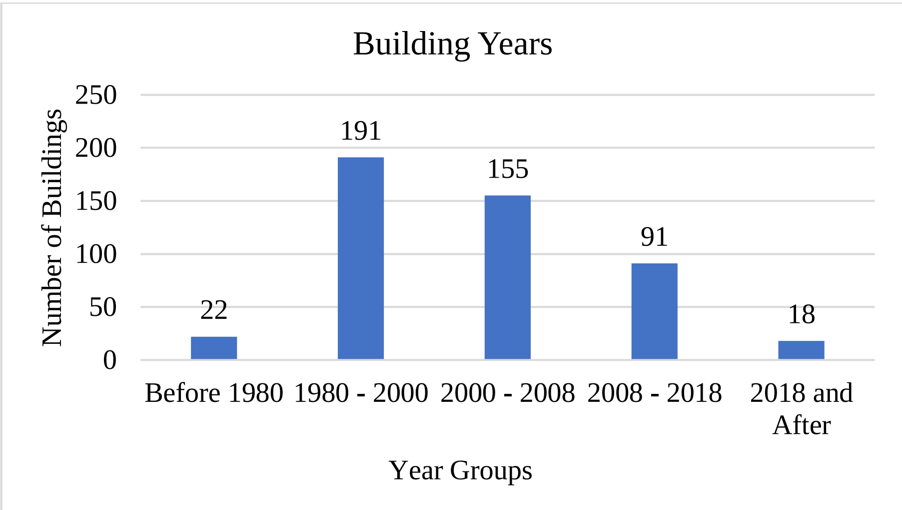



Figure 3.27. Distribution of 477 structures by year of construction (ÇŞB 2023).

Among the 477 buildings selected from Adıyaman's central building stock, one of the most critical data points gathered concerns the number of storeys. A broader analysis of Adıyaman reveals that low-rise buildings constitute a substantial portion of the overall building stock. Notably, single-storey buildings comprise 44.06% of the 43,943 structures, while two-storey buildings account for 33.09% of the total (Figure 3.13).

When examining the distribution of storeys among the 477 buildings selected for this comprehensive study, single-storey buildings, makeup 14.76% of the dataset, with 70 units, two-storey buildings, representing most of detached houses in Adıyaman, account for 16.66% of the dataset, with 79 units. In the case of three-storey buildings, 77 were analyzed, comprising 13.24% of the sample.

Buildings with four and five storeys are primarily located in newer areas of Adıyaman compared to neighborhoods dominated by lower-rise structures. Four-storey buildings account for 17.93%, with 85 buildings, while five-storey buildings represent 13.24%, with 77 buildings.

Buildings with six storeys and above have been constructed more frequently in Adıyaman in recent years due to economic growth, the rising demand for housing, and the evolution of earthquake regulations. In this category, the data reveals 16 buildings with six storeys, comprising 3.37% of the dataset, 17 buildings with seven storeys (3.58%), 13 buildings with eight storeys (2.74%), 31 buildings with nine storeys (6.54%), 11 buildings with ten storeys (2.32%), and finally, five buildings with 11 storeys accounting for 1.05% of the analyzed sample (Figure 3.28).

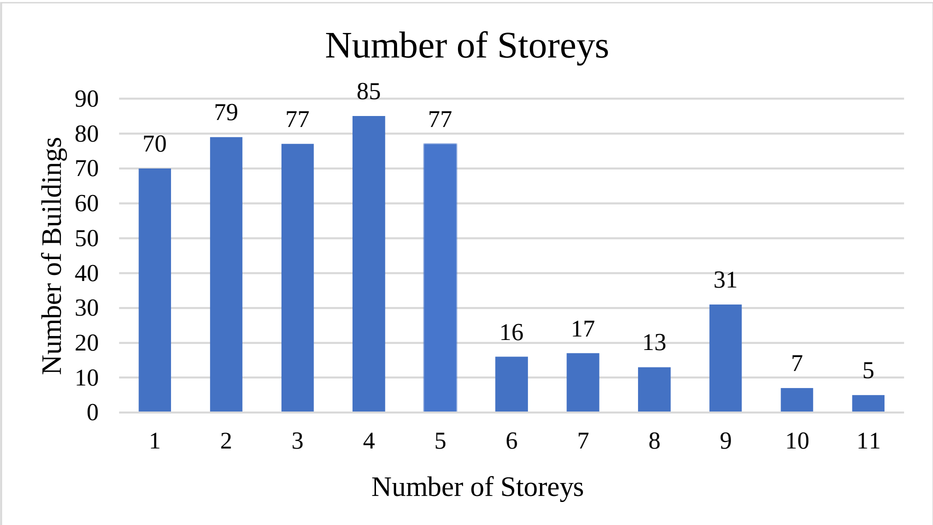



Figure 3.28. Distribution of the number of storeys of the buildings in the selected database (ÇŞB 2023).

One of the 11-storey complex from database, consisting of 4 blocks and constructed in 2015 in the center of Adıyaman, sustained heavy damage during the earthquake. For safety reasons, all four buildings were subsequently demolished following the earthquake (Figure 3.29). These buildings had one of the most expensive house prices at Adıyaman

Figure 3.29. 11-storey complex from database. (Courtesy of Google Street view).

The 477 buildings, intended for detailed analysis with the help of rapid earthquake performance assessment methods, were evaluated using the coordinate data collected during the damage assessment studies. The coordinates and images of these buildings were verified through Google Earth Pro. Using ArcGIS software, the coordinates were subsequently mapped onto the Adıyaman city map, providing a visual representation of the spatial distribution of these structures, as illustrated in Figure 3.30. One of the key advantages of having the coordinate data for the buildings is that it enables access to images of the pre-earthquake conditions via Google Earth Street view. This not only allows the visual verification of the building data but also facilitates a detailed evaluation of each building through street-scanning techniques, helping to identify potential structural irregularities. The selected buildings are primarily concentrated around Atatürk Boulevard in the city center. This area experienced the most significant impact from the earthquake, with many of the buildings located along this street sustaining the highest levels of damage.

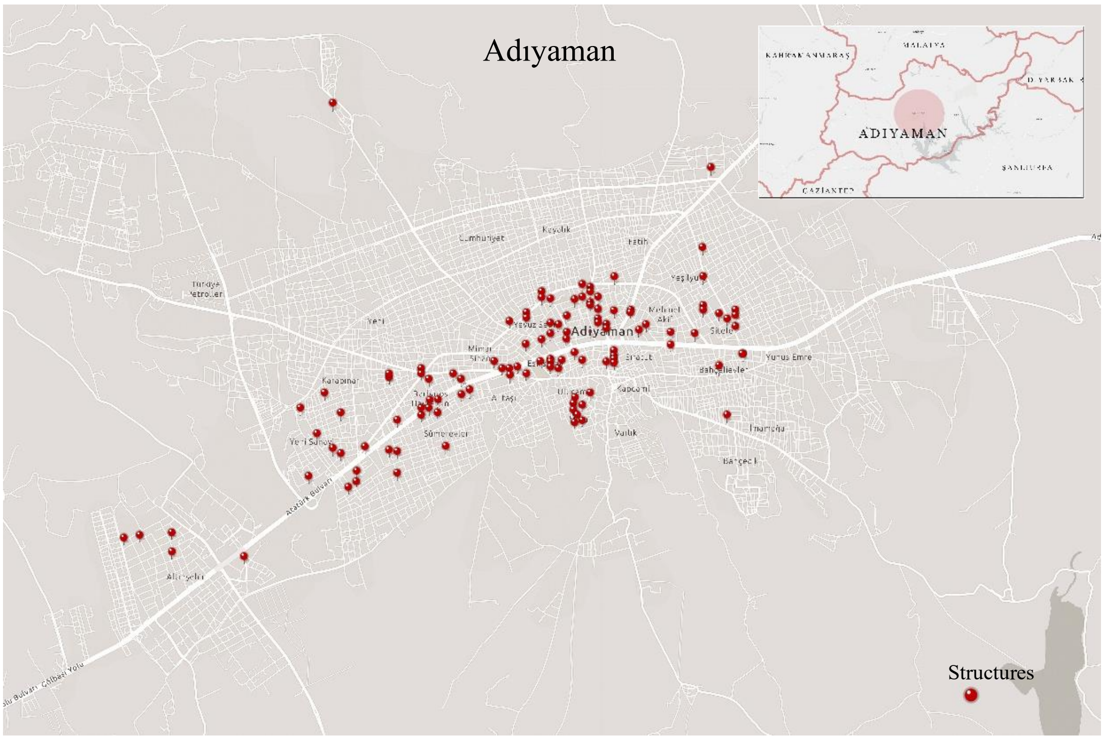



Figure 3.30. The coordinates of the 477 buildings analyzed in this study are plotted on the map of Adıyaman city, providing a spatial overview of the building distribution and their respective locations within the city's map.

The selected structures for detailed analysis with rapid earhtquake assessment methods were examined for structural irregularities, which are thoroughly discussed in Chapter 3.4. Each building was individually assessed for compliance with the Turkish Earthquake Code (TBDY 2018), and the identified irregularities include the following: A1 - Torsional Irregularity, A2 - Floor Discontinuity, A3 - Projection Discontinuity in Plan, B1 - Weak Storey, B2 - Soft Storey, B3 - Discontinuity of Vertical Members. Additionally, other issues such as Short Columns, Hammering Effect, Heavy Overhang, Existing Non-Parallel Axes, and Strong Beam Weak Column configurations were also detected.

In addition to the structural irregularities mentioned above, the data collected on 477 buildings selected from the Adıyaman building stock, such as the number of storeys, year of construction, construction techniques, and earthquake damage to the building, are shown in detail in Appendix A. The year of construction data are expressed in two different columns in the table. The first of these columns shows the construction years determined by the damage assessment officers. In contrast, the second column shows the construction year data confirmed using Google Earth aerial photographs and coordinates.

## 3.4. Structural Deficiencies

Türkiye is located on the Alpine-Himalayan earthquake belt and has experienced significant earthquakes throughout its history, resulting in considerable loss of life and property. It is situated in a region where high seismic activity is frequently observed. The earthquake reality of Türkiye is clearly illustrated by several significant seismic events which are discussed in detail in Chapter 1. The major earthquakes and the loss of life and property have been a lesson for Türkiye. Regulations shaped according to the lessons learnt have aimed to take building safety one step further with each update. The 1999 Gölcük and Düzce earthquakes revealed that the existing regulations and earthquake regulations could not provide sufficient life and property safety.

According to the research conducted, it is thought that nearly 60% of the buildings in Türkiye's building stock were built before 2000, and the earthquake performance of these buildings is not sufficient due to factors such as insufficient concrete and reinforcement qualities, lack of static calculations, and lack of technical drawings (Cansız 2022). Upon reviewing the damage assessment studies conducted in the center of Adıyaman, it was found that 20,649 buildings, accounting for 45.55% of the 45,329 buildings evaluated, were constructed in 2000 or earlier. These findings are elaborated in Chapter 3.2.1, *Year of Construction*. Figure 3.6 illustrates the distribution of 45,329 buildings in the city, categorized by construction years. The buildings built before 2000, which had such a high distribution in the building stock, had the lowest earthquake performance when the Kahramanmaraş earthquake on 6 February was considered.

According to Borcherdt and Holzer (1996) the Mw=6.9 magnitude earthquake in Kobe in 1995 led to the spread of the view that earthquake regulations should be improved worldwide. Türkiye, an earthquake prone country, also took steps to bring about radical changes after the Düzce and Gölcük earthquakes in 1999. The year 2000 is the starting point for the construction of more reliable structures in terms of the measures taken for the building stock of Türkiye and the updated regulations. The 1998 regulation, which obliges the use of ready-mixed concrete and ribbed reinforcements that provide adequate strength, and the building inspection law, which started to be implemented in pilot provinces in 2001 and this building inspection law has become mandatory to be used all over Türkiye in 2011, this situation shows that the buildings constructed after the year 2000 have evolved into buildings with high earthquake resistance and where the importance of human life is at the forefront since they are designed under regulations containing stricter conditions and their compliance with the regulations is controlled by an official control mechanism. To keep the earthquake performances of the designed structures in a safer area, to provide sufficient strength for the foreseen periods of use and to consider the building needs for appropriate use purposes, to keep them within the legal framework and ultimately to ensure the safety of life and property, TS500 Standard for the design and calculation rules of reinforced concrete structures was put into force in 2000 in addition to the Turkish Earthquake Regulations (TSE 2000).

In Türkiye, where earthquake is an inevitable reality, buildings are tried to be constructed safely with the help of regulations with different scopes, constraints and characteristics. Another issue that is as important as the strengths, sections, and materials of the structural systems of these structures is the structural irregularities that arise as a result of the decisions made during the design phase of the building. Within the scope of the study, the effects of structural irregularities arising as a result of the decisions made during the design phase of the building were investigated, and both cases of buildings with and without heavy overhangs were compared. The heavy overhangs affected the structure's stiffness and caused soft storey irregularity, also mentioned in TBDY-2018 (İnan and Korkmaz 2012).

The first regulation to address structural irregularities was the Regulation on Structures to be Built in Disaster Areas (ABYYHY 1998). The issues to be considered regarding structural irregularities continued to be developed with the "Regulation on Buildings to be Built in Earthquake Zones" (DBYBHY 2007) (Doğan et al. 2022). The latest regulation on these structural irregularities is Turkish Building Earthquake Code (TBDY 2018). In this earthquake regulation published in 2018, this issue is explained in detail.

The TBDY-2018 describes structural irregularities as follows: Plan irregularities are categorized as A1-Torsion Irregularity, A2-Floor Discontinuities, A3- Projection Discontinuities; Vertical irregularities are categorized as B1-Weak Storey, B2-Soft Storey, B3-Discontinuity of Vertical Elements. In addition to these irregularities mentioned in the earthquake code, other structural irregularities that adversely affect the earthquake performance of the structures and were evaluated in the studies conducted on 477 selected structures are as follows: Short Column, Hammering Effect, Heavy Over hangers, non-parallel axes and finally Strong Beam-Weak Column.

When the construction process of a building is explained in a simple way, it proceeds through a decision-making cycle from the beginning to the end. The decisions taken at each step affect many issues, such as the building's design, functionality and safety. The decisions taken at each step of a constructed building, from the idea stage to the state where it will be ready for use and even after it is used, have a positive or negative effect on the earthquake performance of the building. Decisions made at the architectural design stage can easily prevent possible errors that may occur and prevent potential loss of life and property.

Buildings with structural irregularities are defined in TBDY-2018 as "Structures whose design and construction should be avoided due to their negative behavior against earthquakes" (TBDY 2018). Structural irregularities, shaped according to the decisions taken in the architectural design process, are evaluated under two main headings: irregularities in the plan and irregularities in the elevation, as stated in Turkish Building Earthquake Code (TBDY 2018).

### 3.4.1. A-Irregularities in The Plan

Irregularities in the plan appear as deficiencies or overhangs in the horizontal components of the building. These irregularities negatively affect the stiffness of the structure and reduce its earthquake resistance. Plan irregularities can be categorized under 3 subtitles: A1-Torsional irregularity, A2-Floor discontinuities and A3-Projection discontinuities.

#### 3.4.1.1. A1-Torsional Irregularity

In TBDY-2018, torsional irregularity is categorized as type A1 irregularity. This situation occurs when the Torsional Irregularity Coefficient (ηbi), which represents the ratio of average relative displacement in one direction under two orthogonal earthquake actions on the building, exceeds 1.2 (TBDY 2018) shown in equation 3.1 (Figure 3.31).

$$\text{Torsional irregularity coefficient: } \eta_{bi} = (\Delta_i^{(X)})_{max} / (\Delta_i^{(X)})_{ave} \qquad \text{Torsional irregularity condition: } \eta_{bi} > 1.2 \tag{3.1}$$

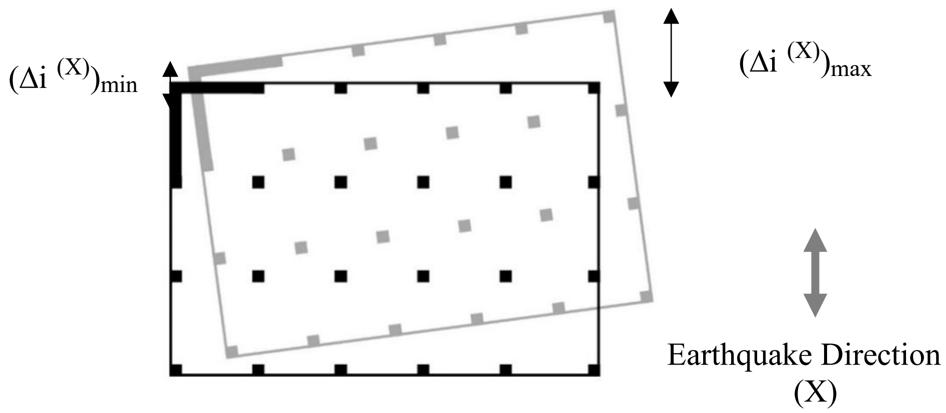



Figure 3.31. Illustration of torsional irregularity.

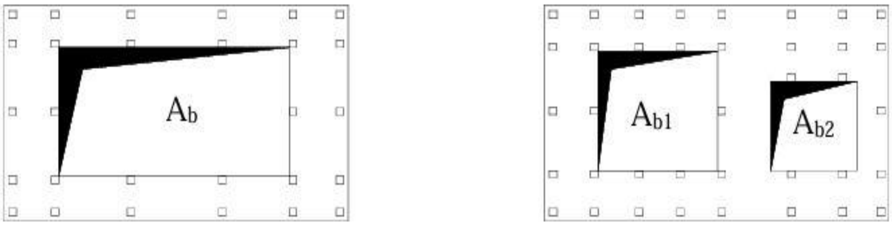
#### 3.4.1.2. A2-Floor Discontinuities

The floors of the building transmit vertical loads to the foundation through columns and beams. While performing this task, the irregularities occurring in the slabs, which are expected to be in a rigid behavior, initially disrupt the rigidity of the slab, and this disruption adversely affects the behavior of the structure during the earthquake. Slab discontinuity, which is one of the irregularities occurring horizontally, occurs in the following three cases, according to the TBDY (2018) (Figure 3.32 and Figure 3.33):

I- The sum of the space areas, including stairs and elevator spaces, is more than 1/3 of the gross floor area (Equation 3.2).

II- Local floor gaps make it challenging to transfer earthquake loads to the vertical structural system elements safely.

III- Sudden decreases in in-plane stiffness and strength of the slab.




Ab = Ab1 + Ab2

Figure 3.32. A2-Floor Discontinuity example for type I. (adopted from TBDY (2018))

$$A_b / A > 1/3 \tag{3.2}$$

$A_b$ : Sum of empty spaces  A  : Total floor area

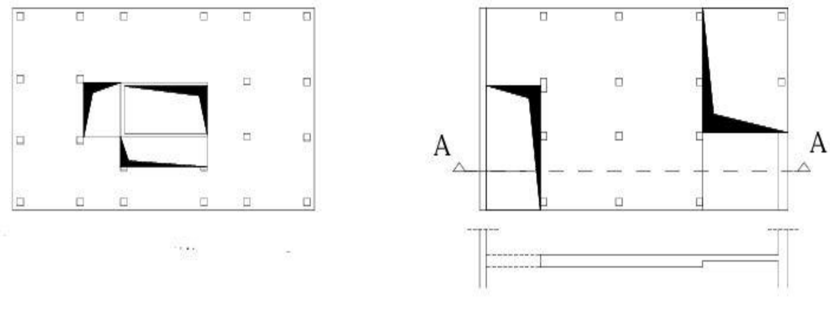
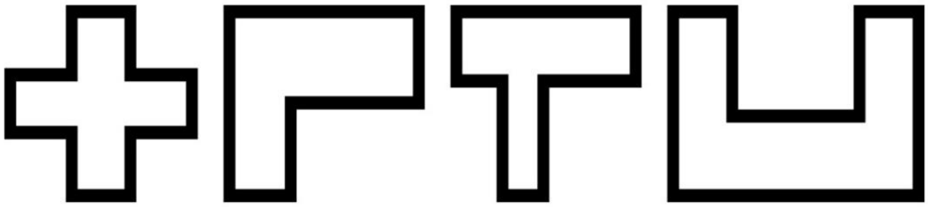



Figure 3.33. A2-Floor Discontinuity example for type II and type III. (adopted from TBDY (2018))

### 3.4.1.3. A3- Presence of Extrusions in The Plan

According to TBDY 2018, the presence of extrusions in the plan is defined as a condition where the dimensions of the protruding parts of the floor plan in two perpendicular directions each exceed 20% of the total plan dimensions of that floor in those same directions. The overhangs in the floor plan negatively affect the earthquake performance of the buildings as they disrupt the rigid diaphragm behavior of the floors shown in figure 3.34.



a) b) c) d)

Figure 3.34. Different plan types which may cause presence of extrusion in the plan irregularity. These shapes stand as a) + plan type, b) L plan type, c) T plan type, d) U plan type.

## 3.4.2. B-Vertical Irregularities

The irregularities in the vertical direction are expressed as B1 weak storey due to strength irregularity between neighboring storeys, B2 soft storey due to stiffness irregularity between neighboring storeys, and B3 discontinuity of the vertical elements of the structural system. These irregularities are explained in detail below.

### 3.4.2.1. B1-Weak Storey

Observations indicate that ground floors tend to have fewer infill walls than upper floors, mainly due to the demands of commercial spaces, display areas, and open layouts typically found on the ground level. This reduction in shear area on the ground floor compared to the upper levels contributes to weak story irregularity. As stated in the 2018 earthquake code, in reinforced concrete structures, in any of the two earthquake directions perpendicular to each other, the ratio of the total effective shear area on any floor to the total effective shear area on the upper floor, that is, the strength irregularity coefficient ($\eta ci$) is less than 0.80 (TBDY 2018) as shown in equation 3.3.

$$\eta_{ci} = (\sum Ae)_i/(\sum Ae)_{i+1} < 0.80 \tag{3.3}$$

### 3.4.2.2. B2-Soft Storey

According to Türkiye building code (2018) soft story irregularity, categorized as type B2 irregularity, occurs when the Stiffness Irregularity Coefficient $\eta_{ki}$, which is the ratio of the average relative story drift at any given story to the average relative story drift at the story directly above or below, exceeds 2.0. This condition excludes basement floors (TBDY 2018)(Figure 3.35).

a) 

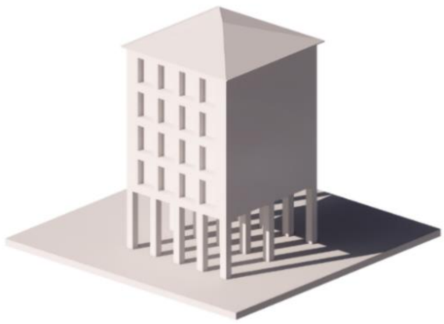
b) 

Figure 3.35. a) Weak Storey, b) Soft Storey irregularities.

### 3.4.2.3. B3-Discontinuity of Vertical Elements

When the vertical load-bearing elements, such as columns or shear walls, that are critical for the structure's resistance to vertical and lateral loads (e.g., earthquakes) are altered—either by omission, removal on certain floors, or placement on the tops or ends of beams or gusset columns—irregularities arise. Specifically, suppose the shear walls on the upper floors are supported by columns on the lower floors. In that case, the structure exhibits B3 irregularity, known as the discontinuity of vertical load-bearing elements in the structural system. The regulation has taken serious warnings and measures to prevent this irregularity. TBDY (2018) states, "Columns are never allowed to be placed on top of cantilever beams or gussets formed on the columns below at any floor of the building." The regulations have issued strict warnings and implemented measures to prevent the occurrence of such irregularities. According to TBDY (2018), columns must not be placed on cantilever beams or gussets formed on the columns below at any building level. Similarly, DBYBHY (2007) and TBDY (2018) explicitly prohibit placing walls on upper floors supported by columns on lower floors. Furthermore, the regulations strictly forbid positioning walls in the middle of openings on beams within their planes at any level of the building (TBDY 2018; DBYBHY 2007).

## 3.4.3 Other Structural Irregularities

Some structural irregularities evaluated by earthquake codes are analysed under other structural irregularities. These irregularities are short column effect, hammering effect, heavy overhangs, non-parallel axes and strong beam-weak column irregularities. These irregularities are analysed in detail below.

### 3.4.3.1. Short Column

The short-column effect occurs when the vertical supports of the structure are subjected to more shear forces than calculated during an earthquake. This structural irregularity occurs when the infill walls are shorter than the column height, i.e. when there are band windows, which we have started to see frequently in buildings with modern architectural trend (Cagatay, Beklen, and Mosalam 2010). The short column effect caused by the band windows may cause significant damage to the structure in the event of an earthquake and may cause the structure to collapse. According to the study on the short column effect related to the dimensions of the band windows, the width of the band windows should be at most 60% of the distance between the two columns. However, the height of the infill walls should be at least 35% of the floor height. These measures can be used to protect the structure from short-column irregularity (Bikce 2011) (Figure 3.36).

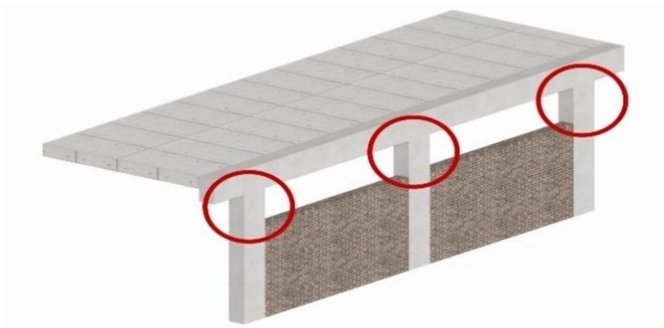


Figure 3.36. Illustration of short column irregularity.

### 3.4.3.2. Hammering Effect

In case of insufficient spacing at the junction facades, neighboring structures will hit each other due to the movements during an earthquake, causing different levels of damage. According to the study by Kamal et al. (2018), it is impossible to accurately evaluate the earthquake performance of structures subjected to the hammering effect. In order to increase the earthquake performance of the structures, it should be decided, and measures should be taken at the design stage to create sufficient gaps between neighboring structures.

### 3.4.3.3. Heavy Overhangs

One of the irregularities that adversely affect the earthquake performance of structures is the heavy overhangs that occur after the decisions taken during the design phase of the structure. Structures with this irregularity increase the total mass of the structure, causing a deviation in the center of stiffness of the structure and causing the structure to perform worse than expected during an earthquake. A building with this irregularity in Adıyaman, which has a soft storey irregularity with heavy overhangs, collapsed in the Kahramanmaraş earthquake and caused loss of life, as shown in Figure 3.37.

Figure 3.37. Building in Adıyaman collapsed. (Adopted from Google earth)

### 3.4.3.4. Non-Parallel Axes

Non-parallel axes may be due to spatial decisions made during the architectural design phase or the shape of the land where the construction will be built. Structures with parallel axes that are built in an orderly provide stability more efficiently. In contrast, in other structures, if no precautions are taken or necessary arrangements are not made, the earthquake performance of the structure is negatively affected (Özmen and Ünay 2007). According to the Turkish Building Earthquake Code, this irregularity is described as follows, “Conditions where the principal axes of the structural elements do not coincide with the earthquake directions taken perpendicular to each other” (TBDY 2018.)

### 3.4.3.5. Strong Beam-Weak Column

While constructing earthquake-safe buildings, the structural system is also expected to be balanced. The column and beam systems that try to sustain the structure under earthquake loads are expected to function effectively, ensuring the structure remains stable and preventing loss of life and property. To achieve this stability, columns should be designed with greater strength than beams (Gökdemir and Günaydın 2018). Figure 3.38 shows a) a structure with strong beam-weak column irregularity and b) a structure without this irregularity.

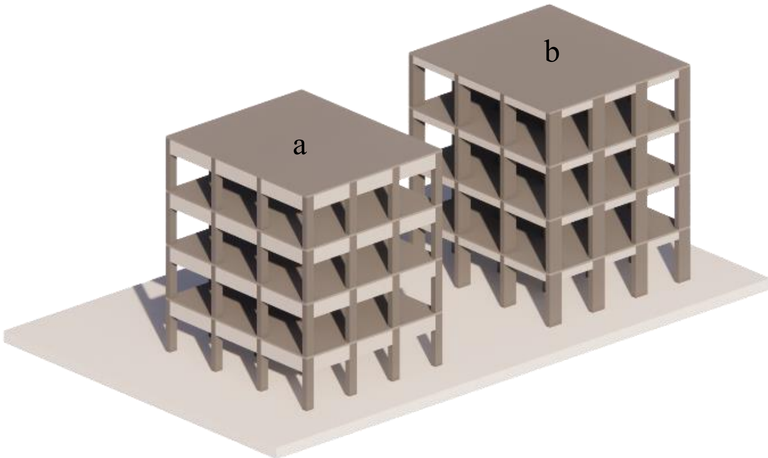



Figure 3.38. Illustration of two building a) strong beam-weak column irregularity b) strong column-weak beam formations.

# CHAPTER 4

# RAPID ASSESSMENT METHODS

Rapid earthquake performance assessment methods have been designed and implemented to facilitate preliminary seismic evaluations of structures. These methods address the impracticality of conducting detailed structural analyses, as specified by the current earthquake code (TBDY 2018), due to the significant financial and time constraints posed by the extensive existing building stock. In assessing the building stock, three methods were selected, which are used to identify the most vulnerable structures against earthquakes by dividing the buildings into priority groups according to their risk status, identifying the riskiest structures and using the available material resources and labour force. FEMA P-154 (FEMA 2002), the Sucuoğlu Rapid Visual Screening Procedure (Sucuoğlu et al. 2007), and the Canadian Seismic Screening Method (Rainer, Allen, and Jablonski, 1992) were selected among the methods that can evaluate the buildings by street scanning due to the limited data available and the fact that it is quite risky to enter most of the buildings. These three methods were selected due to their widespread use as rapid seismic assessment approaches in various countries, each characterized by distinct parameters and methodologies. FEMA P-154 is noted for its broad applicability across different building types, the Canadian Seismic Screening Method provides detailed scoring based on specific structural attributes, and the Sucuoğlu method is uniquely adapted to Türkiye's building stock characteristics. The selection criteria prioritized compatibility with the available building data, alignment with the characteristics of the selected building stock, and the capacity to evaluate seismic performance through visual screening techniques. This strategic selection ensures a comprehensive comparative analysis and enhances the findings' applicability to the study area's building attributes.

## 4.1. FEMA p-154 Rapid Visual Screening Method (FEMA 2002)

The FEMA p-154 method is one of the street survey methods used to identify structures with high vulnerability to earthquake damage. In order to be able to assess the vulnerability of buildings with the rapid visual scanning technique, data related to the building are needed. For the data required to apply the method, it may be necessary to conduct preliminary research on the structure before starting fieldwork (Kızılkaya 2018).

In the implementation of the prescribed approach, the foremost stage entails the careful selection of a data collection form that aligns with the seismicity of region. The evaluation forms of the FEMA p-154 method, which are separated according to different seismic zones, are given in detail in Appendix B. The selected data collection form is filled with data obtained from outside the building and, if possible and safe, from inside the building. While collecting data about the building, parameters such as the building's construction year, number of floors, load-bearing system type and structural irregularities, which will be explained in more detail below, should be carefully evaluated FEMA (FEMA 2002). After examining the positive and negative data, the scores obtained are summed to obtain an S score for each building separately. If the S score obtained is below the limit score, which may vary depending on building structure types, the building performance is considered inadequate, and if it remains above the limit score, the building performance is considered sufficient. Detailed structural analysis is recommended for structures whose earthquake performance is thought to be inadequate. The flowchart of the FEMA p-154 method is as shown in Figure 4.1.

One of the most important parts of the FEMA p-154 method is to determine the material and structural system type of the structure correctly. The reason for this is that each type of building has a different base score, and the scores applied to the positive and negative situations related to the building (Kızılkaya 2018). The error made while determining the type of structure causes the earthquake performance of the structure to be calculated incorrectly after the evaluation. This error means that in the event of a possible disaster, a structure whose earthquake performance is considered adequate may cause loss of life and property.

### 4.1.1. General Information About the Building

In the initial phase of data compilation for the FEMA P-154 rapid assessment method form information about the structure is filled in (Figure 4.2). Data such as the coordinates of the structure, address information, the name of the structure and the name and surname of the person filling out the form are recorded at this stage. The data collected in this phase should be confirmed during the fieldwork. The accuracy of the drawings of the building, if any, should be checked.

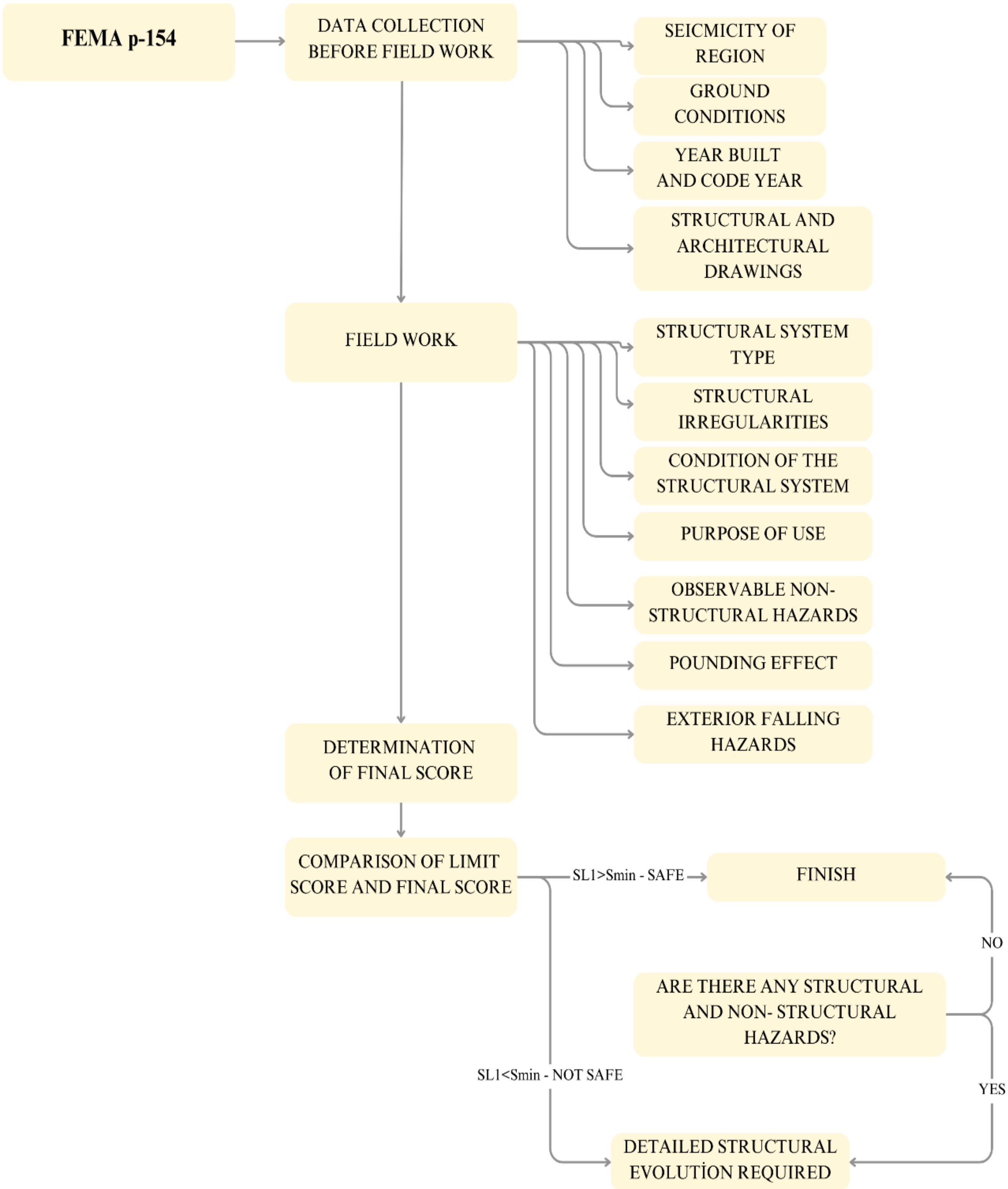
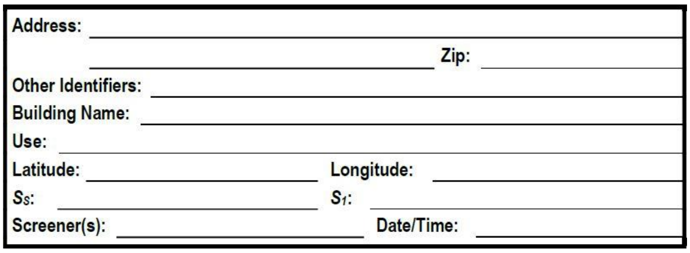



Figure 4.1. FEMA p-154 flowchart.



Address:

Zip:

Other Identifiers:

Building Name:

Use:

Latitude: Longitude:

$S_S$: $S_1$:

Screener(s): Date/Time:

Figure 4.2. FEMA p-154 form, general information about the building.
(Adopted from FEMA p-154 very high seismicity form)

### 4.1.2. Photographs and Drawings of the Building

Photographs and sketches of the building constitute essential data for its identification. In the designated photo section of the form, it's essential to include at least one photograph. Moreover, the section allocated for drawings should provide comprehensive explanations of the building's identifying details (Figure 4.3). It is very important that the data processed at this stage can clearly express the structure so that the accuracy can be checked by the expert engineer after the scanning.

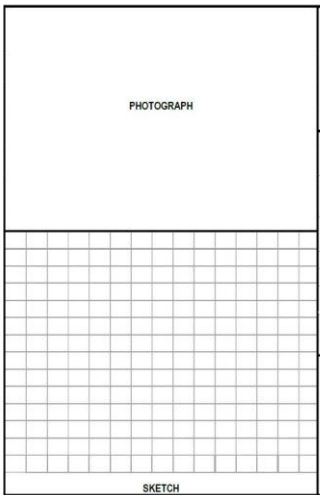



Figure 4.3. FEMA p-154 form, photographs and sketches.(Screenshot from
FEMA p-154 very high seismicity form)

## 4.1.3. Building Characteristics

In this part of the form the collected data about the characteristic features of the structure are collected. The data to be collected for the form are as follows: number of floors, year built and code year, total floor area and additions to the building (Figure 4.4) The data in this section are expected to be filled in before the fieldwork. During the field study, the accuracy of the data should be checked and missing, or incorrect parts should be corrected.

| | | | |
|---|---|---|---|
| **No. Stories:** Above Grade: ______ | Below Grade: ______ | **Year Built:** | ☐ EST |
| **Total Floor Area (sq. ft.):** | ______ | **Code Year:** | ______ |
| **Additions:** ☐ None | ☐ Yes, Year(s) Built: | ______ | |

Figure 4.4. FEMA p-154 form, building characteristics. (Screenshot from FEMA p-154 very high seismicity form)

### 4.1.3.1. Number of Stories

The earthquake resistance of the building and the damage to be received after the earthquake can be related to the height of the building. With the number of storeys data, information about the building height can be obtained if the floor heights are known. When collecting floor number data, the façade with the most floors is taken as reference for buildings located on sloping land. Variations in the number of stories can be indicated effectively through the utilization of both the comment and sketches section.

If verifiable by the screener, it is important to include information on the number of stories below grade. Gathering this data proves especially valuable in case the community opts to delve into potential flooding concerns at a later stage.

### 4.1.3.2. Year Built and Code Year

In instances where the precise construction year of the building is not definitively known, an estimate may be made, and it is important to state on the form that the provided information is based on estimation.

### 4.1.3.3. Total Floor Area

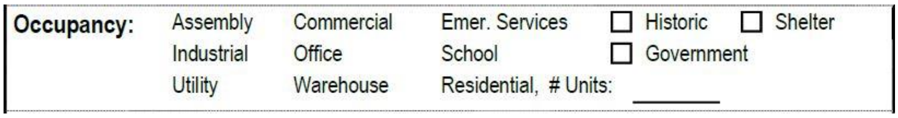
Building floor area can be obtained from architectural drawings of the building. If it is not possible to access the drawings of the building, the building settlement area can be calculated from the aspect measurements.

### 4.1.3.4. Additions

During the assessment of building stock, it is observed that some of structures have additions. These additions may have been made at different times and for different purposes. In the presence of additions, it is necessary to mark the "Yes" box and specify the year in which the respective addition was constructed.

### 4.1.4. Building Occupancy

Occupancy classes are determined so that they can be easily recognized in a street survey and are shown below (Figure 4.5). While these occupancy classes are determined from the street, buildings in the United States are taken as basis.

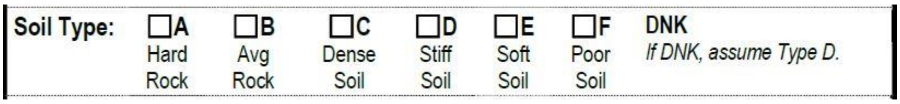


| | | | | | |
|---|---|---|---|---|---|
| **Occupancy:** | Assembly | Commercial | Emer. Services | ☐ Historic | ☐ Shelter |
| | Industrial | Office | School | ☐ Government | |
| | Utility | Warehouse | Residential, # Units: ______ | | |

Figure 4.5. FEMA p-154 form, building occupancy types.(Screenshot from FEMA p-154 very high seismicity form)

### 4.1.5. Soil Type

If the soil class of the building is obtained before the field work, the appropriate soil class should be marked on the form (Figure 4.6). If the determination of soil type is not included in the preliminary process, it becomes the responsibility of the screener to identify it during the on-site visit. In cases where there is insufficient information for classifying the soil type, the selection "DNK" should be made, and Soil Type D should be assumed.



| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Soil Type:** | ☐**A** | ☐**B** | ☐**C** | ☐**D** | ☐**E** | ☐**F** | **DNK** |
| | Hard Rock | Avg Rock | Dense Soil | Stiff Soil | Soft Soil | Poor Soil | *If DNK, assume Type D.* |

Figure 4.6. FEMA p-154 form, soil types. (Screenshot from FEMA p-154 very high seismicity form)

### 4.1.6. Geologic Hazards

When filling out the form, if there are geological hazards such as liquefaction, landslide, surface faulting in the region where the building is located, it should be indicated in the form (Figure 4.7). The presence of these hazards may increase the vulnerability of the structure and cause collapse of the structure.


**Geologic Hazards:** Liquefaction: Yes/No/DNK Landslide: Yes/No/DNK Surf. Rupt.: Yes/No/DNK

Figure 4.7. FEMA p-154 form, geological hazards. (Screenshot from FEMA p-154 very high seismicity form)

### 4.1.7. Adjacency

Structures built in adjacent order may suffer various damages due to the hammering effect they will be exposed to during an earthquake. The collision of adjacent buildings constructed with inadequate clearance distance constitutes an anomaly significantly influencing the seismic behavior of structures. Neglecting to account for this irregularity in the building design phase can lead to unforeseen consequences and result in substantial damage to the structures (Kamal et al. 2018). In the case of an inspected building situated in a contiguous layout, it is important to indicate the status of adjacency in the relevant section of the data form (Figure4.8).


**Adjacency:** ☐ Pounding ☐ Falling Hazards from Taller Adjacent Building

Figure 4.8. FEMA p-154 form, adjacency. (Screenshot from FEMA p-154 very high seismicity form)

According to FEMA p-154 method, the distances between adjacent buildings should be as follows, the minimum expansion joint for adjacent buildings in areas of very high seismic activity should be 2 inches (5.08 cm) for each floor, 1.5 inches (3.81 cm) for each floor in areas of high seismic activity, 1 inch (2.54 cm) for each floor in areas of moderate seismic activity, 1/2 inch (1.27 cm) for each floor in areas of moderate and low seismic activity. Adjacent buildings pose a risk due to elements such as chimneys, parapet walls, water tanks, and slabs that may fall. It is important to note that these elements are at risk of falling.

### 4.1.8. Irregularities in FEMA p-154

During the design and construction phases of a building, various irregularities may occur for functional, design or economic reasons. Irregularities in buildings are generally divided into two categories: vertical irregularities and irregularities in the plan. These irregularities in the structure are evaluated as high or average risk in the evaluation form according to the amount of their presence in the structure. The RVS score takes irregularities into account by including negative score modifiers, the values of which depend on the type and severity of the building's irregularities.

#### 4.1.8.1. Vertical Irregularities

Weak and soft stories, overhangs, setbacks, short columns, and split levels are called vertical irregularities in buildings. They have a negative effect on the behavior of the structural system during an earthquake. These irregularities are also described in detail in the Earthquake Regulations for Buildings in Türkiye (TBDY 2018).

##### 4.1.8.1.1. Sloping Site

The stiffness of the lower part and the upper part of the structure are different in structures built on sloping site. If there is a difference of more than 1 storey between the two facades of the building in the direction of the slope, it is considered as a sloping land irregularity (Figure 4.9). This irregularity also causes the formation of short columns.

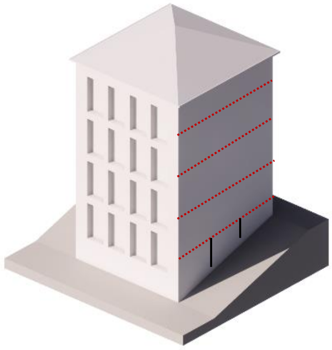


Figure 4.9. Illustration of the structure built on sloping site.
(Black vertical lines represent short columns)

#### 4.1.8.1.2. Weak and/or Soft Story

In cases where the infill walls on one floor of the building are less than the infill walls on the other floors or not at all, the building suffers the greatest damage on this floor during an earthquake (Tezcan et al. 2017). This condition is called weak story irregularity (Figure 4.10).

In cases where the floor height of the ground floor of the building is higher than the other floors, and the infill walls do not continue through all the floors of the building to provide a wider purpose for the commercial spaces on the ground floor, soft floor irregularities occur in the building (Tezcan et al. 2017) (Figure 4.11).

Figure 4.10. Illustration of weak story irregularity.

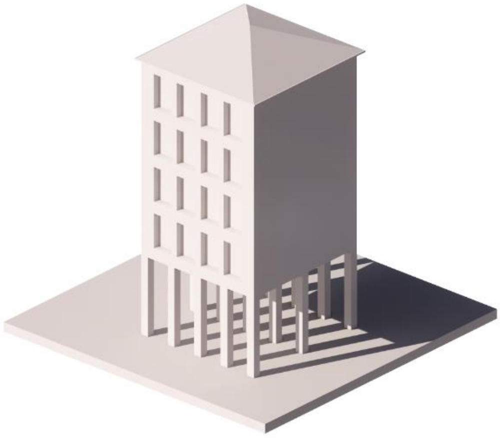


Figure 4.11. Illustration of soft story irregularity.

### 4.1.8.1.3. Setback

Out-of-plane setback occurs when one storey of the building is more inside or outside than the other storey (Figure 4.12). This irregularity can be determined from the position of the outer walls of the building.

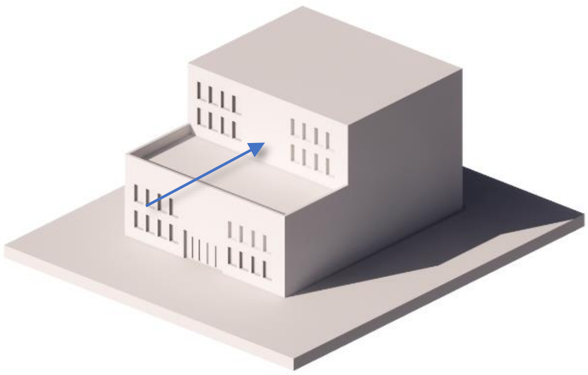


Figure 4.12. Illustration of setback.

## 4.1.8.1.4. Short Column/Pier

The short column effect occurs in buildings mostly as a result of decisions made during the architectural design phase. Band windows, placement of foundations at different levels on sloping sites, basement windows and infill walls up to a certain part of the column cause this irregularity (Figure 4.13). Short column irregularity is considered as an important vertical irregularity.

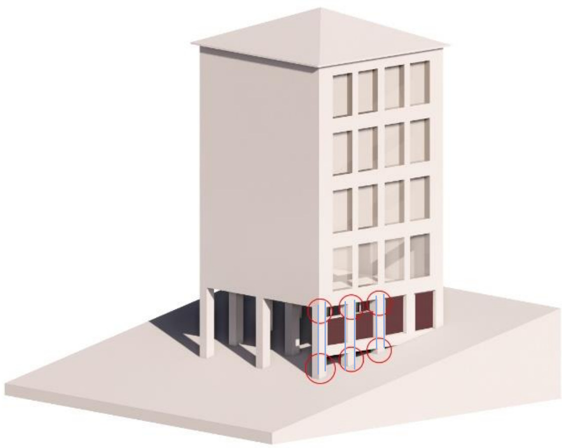


Figure 4.13. Illustration of short column irregularities, shown in a red circle.

## 4.1.8.1.5. Split Level

The situation where the roof or floors are not in the same alignment in a part of the building is called split level (Figure 4.14). In the event of an earthquake, slabs may damage the vertical elements to which they are connected and should be considered as moderate vertical irregularity when filling out the form.

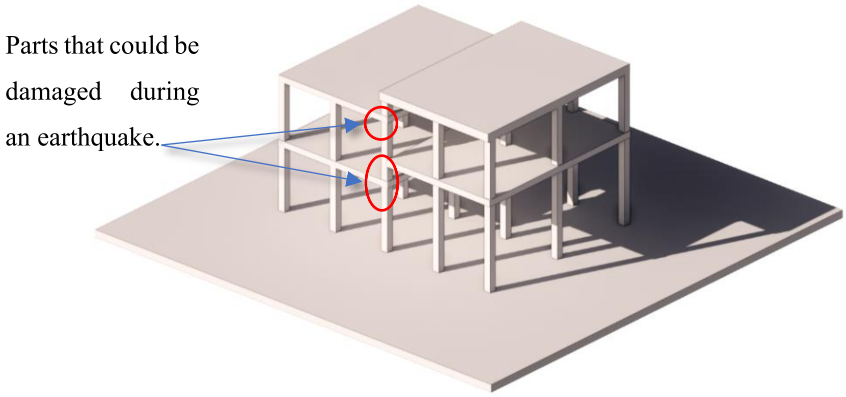



Figure 4.14. Illustration of split level.

### 4.1.8.2. Plan Irregularities

Irregularities in the plan include torsional irregularities, slab discontinuities, non-parallel structural systems, reentrant corners and diaphragm openings.

#### 4.1.8.2.1. Torsional Irregularity

Torsional irregularity is specified as A1 irregularity in the Turkish Building Earthquake Code-2018 (TBDY 2018). This irregularity occurs as a result of the structure being more rigid in one direction and weak in the other direction Figure (4.15).

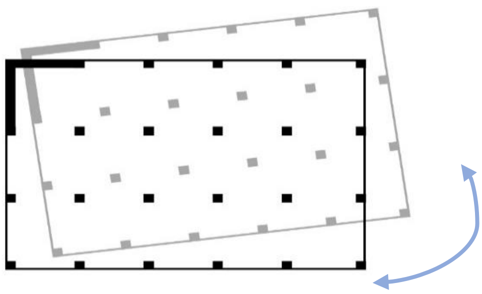


Figure 4.15. Illustration of torsional irregularity

### 4.1.8.2.2. Non-Parallel Systems

Buildings with triangular plans that emerge after decisions at the parcel boundaries or design stage cause torsional irregularities during earthquakes. As a result, the building may collapse (Figure 4.16).

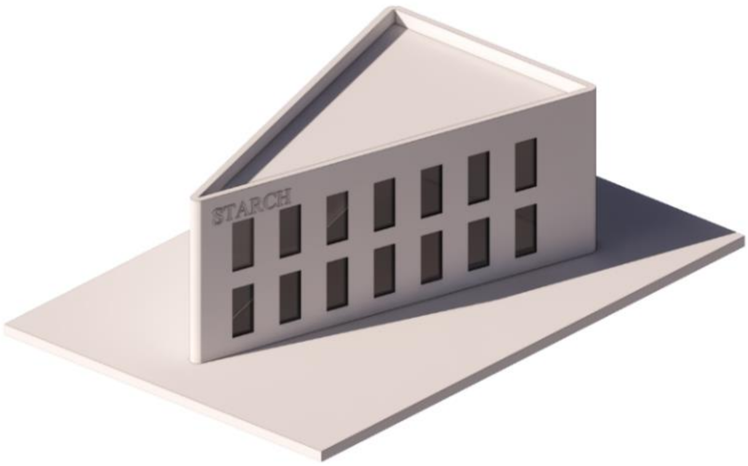



Figure 4.16. Triangular planned building illustration.

### 4.1.8.2.3. Reentrant Corners

In buildings with +, L, T, E and U plan types, it is accepted that there is an irregularity in the plan when the distances of the projections are more than 6.1m (FEMA p-154, 2015). If seismic joints are not used in the building's projections, the building will lose its stiffness balance and experience severe torsional forces.

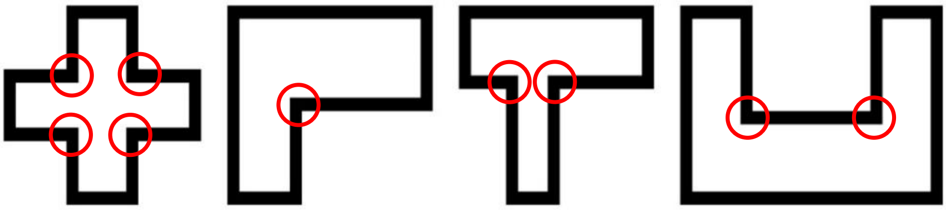



Figure 4.17. a) + plan type, b) L plan type, c) T plan type, d) U plan type. Red circles represent the areas where stress accumulates.

### 4.1.8.2.4. Diaphragm Openings

In transferring seismic forces to the vertical load-bearing elements, the roofs and floors of the building play an important role. Large openings in these structural elements due to architectural design or other requirements weaken the diaphragm and make the structure vulnerable to seismic forces (Figure 4.18). If the ratio of this opening to the whole slab exceeds 50%, it should be marked as irregularity in the data collection form.

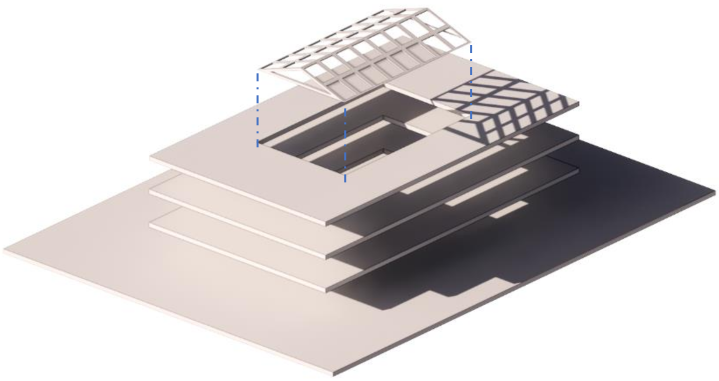


Figure 4.18. Illustration of diaphragm opening.

### 4.1.8.2.5. Beams Do Not Align with Columns

In cases where the widths of exterior beams and columns are different from each other, these two structural elements cannot be fully aligned. This situation causes irregularity (Figure 4.19).

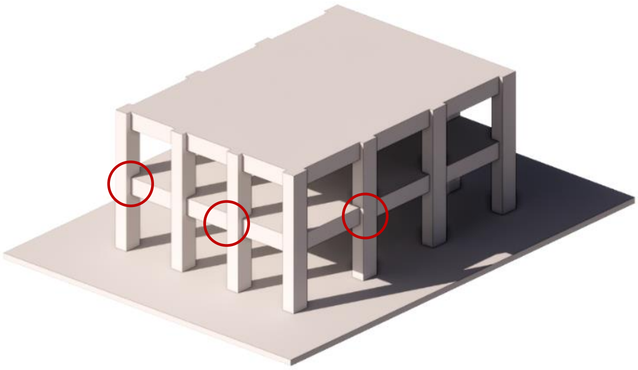
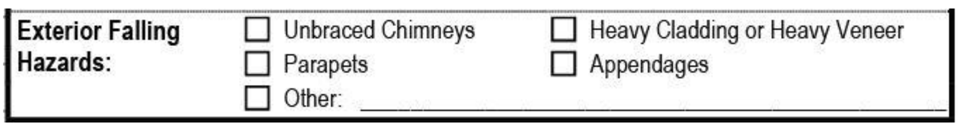


Figure 4.19. Illustration of beam-column misalignment.

## 4.1.9. Exterior Falling Hazards

Even if the structural system is adequate, some buildings may pose a risk during an earthquake due to the elements on their facades or roofs. These elements can be listed as follows: parapets, chimneys, water tanks, curtain wall cladding and signboards. In case of the presence of elements in danger of falling, the relevant parts of the form must be filled in (Figure 4.20).



**Exterior Falling Hazards:** ☐ Unbraced Chimneys ☐ Parapets ☐ Other: ______ ☐ Heavy Cladding or Heavy Veneer ☐ Appendages

Figure 4.20. FEMA p-154 form, exterior falling hazards. (Screenshot from FEMA p-154 very high seismicity form)

### 4.1.10. Damage and Deterioration

During the field work, the structural system of the building should be carefully checked for any visible damage. This damage can significantly affect the earthquake performance of the structure. If any damage is detected in the building's structural system, mark the 'damage/deterioration' section of the structural system in the 'other hazards' section of the form. The earthquake performance of a building can be seriously affected by deterioration such as 'X'-shaped damages in masonry walls and cracks in reinforced concrete elements from previous earthquakes that have not been repaired, corrosion in steel structural elements, deflection in the slab, and decay in the timber structural system.

### 4.1.11. Building Types Determined by FEMA p-154

Determining the structure type is crucial when applying the FEMA p-154 method. The basic score needed to obtain the final score is considered as different values for each structure type determined by FEMA. For example, while the basic score for the C2 category representing reinforced concrete buildings with shear columns is 1.2, the basic score for the URM category representing unreinforced masonry system structures should be 0.9.

- Wood frame structures (W1)
- Wood frame structures (W1A)
- Wood frame structures (W2)
- Steel moment-resisting frame buildings (S1)
- Braced steel frame buildings (S2)
- Light metal buildings (S3)
- Steel frame structures with reinforced concrete walls (S4)
- Steel frame systems with unreinforced infill walls (S5)
- Reinforced concrete frame systems (C1)
- Reinforced concrete shear wall systems (C2)
- Reinforced concrete frame system with unreinforced infill walls (C3)

- Prefabricated panel system (PC1)
- Prefabricated reinforced concrete frame system (PC2)
- Reinforced masonry system with flexible diaphragm (RM1)
- Rigid diaphragm reinforced masonry system (RM2)
- Unreinforced masonry system (URM)
- Modular system (MH)

### 4.1.12. Determination of the Final Score

Penalty points are applied to the basic score when determining the final score. The basic score is determined based on the building type, irregularities of the building, and ground class. During the assessment, irregularities present in the plan and vertical are marked according to their severe or moderate presence.

Another important point is pre-code and post-benchmark scores. For the building stock within the scope of the research, the limit was taken as the year 2000. While pre-2000 buildings are calculated as pre-code, post-2000 buildings are evaluated as post-benchmark (Figure 4.21).

Since it was not possible to access the soil class of the building stock, the unknown option was selected in the form and class D was accepted as stiff soil.

There is a minimum score ($S_{min}$ in Fig. 4.19) assigned for each of the building classes determined by FEMA. If the final level 1 score ($S_{L1}$ in Fig. 4.19) obtained as a result of the calculations is less than $S_{min}$, the structure is considered to be unstable against earthquake and detailed structural analysis is recommended.

| BASIC SCORE, MODIFIERS, AND FINAL LEVEL 1 SCORE, $S_{L1}$ | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FEMA BUILDING TYPE Do Not Know | W1 | W1A | W2 | S1 (MRF) | S2 (BR) | S3 (LM) | S4 (RC SW) | S5 (URM INF) | C1 (MRF) | C2 (SW) | C3 (URM INF) | PC1 (TU) | PC2 | RM1 (FD) | RM2 (RD) | URM | MH |
| **Basic Score** | **2.1** | **1.9** | **1.8** | **1.5** | **1.4** | **1.6** | **1.4** | **1.2** | **1.0** | **1.2** | **0.9** | **1.1** | **1.0** | **1.1** | **1.1** | **0.9** | **1.1** |
| Severe Vertical Irregularity, $V_{L1}$ | -0.9 | -0.9 | -0.9 | -0.8 | -0.7 | -0.8 | -0.7 | -0.7 | -0.7 | -0.8 | -0.6 | -0.7 | -0.7 | -0.7 | -0.7 | -0.6 | NA |
| Moderate Vertical Irregularity, $V_{L1}$ | -0.6 | -0.5 | -0.5 | -0.4 | -0.4 | -0.5 | -0.4 | -0.3 | -0.4 | -0.4 | -0.3 | -0.4 | -0.4 | -0.4 | -0.4 | -0.3 | NA |
| Plan Irregularity, $P_{L1}$ | -0.7 | -0.7 | -0.6 | -0.5 | -0.5 | -0.6 | -0.4 | -0.4 | -0.4 | -0.5 | -0.3 | -0.5 | -0.4 | -0.4 | -0.4 | -0.3 | NA |
| Pre-Code | -0.3 | -0.3 | -0.3 | -0.3 | -0.2 | -0.3 | -0.2 | -0.1 | -0.1 | -0.2 | 0.0 | -0.2 | -0.1 | -0.2 | -0.2 | 0.0 | 0.0 |
| Post-Benchmark | 1.9 | 1.9 | 2.0 | 1.0 | 1.1 | 1.1 | 1.5 | NA | 1.4 | 1.7 | NA | 1.5 | 1.7 | 1.6 | 1.6 | NA | 0.5 |
| Soil Type A or B | 0.5 | 0.5 | 0.4 | 0.3 | 0.3 | 0.4 | 0.3 | 0.2 | 0.2 | 0.3 | 0.1 | 0.3 | 0.2 | 0.3 | 0.3 | 0.1 | 0.1 |
| Soil Type E (1-3 stories) | 0.0 | -0.2 | -0.4 | -0.3 | -0.2 | -0.2 | -0.2 | -0.1 | -0.1 | -0.2 | 0.0 | -0.2 | -0.1 | -0.2 | -0.2 | 0.0 | -0.1 |
| Soil Type E (> 3 stories) | -0.4 | -0.4 | -0.4 | -0.3 | -0.3 | NA | -0.3 | -0.1 | -0.1 | -0.3 | -0.1 | NA | -0.1 | -0.2 | -0.2 | 0.0 | NA |
| Minimum Score, $S_{MIN}$ | *0.7* | *0.7* | *0.7* | *0.5* | *0.5* | *0.5* | *0.5* | *0.5* | *0.3* | *0.3* | *0.3* | *0.2* | *0.2* | *0.3* | *0.3* | *0.2* | *1.0* |

Figure 4.21. FEMA p-154 form, basic score, modifiers, and final score.
(Screenshot from FEMA p-154 very high seismicity form)

## 4.2. Sucuoğlu Rapid Visual Screening Procedure (Sucuoğlu et al. 2007)

The street surveying method developed by Sucuoğlu et al. (2007) utilizes various parameters to estimate the earthquake performance of reinforced concrete structures. This method provides a risk prioritization of the building stock using data that can be obtained from a simple street observation. During the survey, data that can be easily collected using the street scanning method is collected by people who have been trained before the field work. The data obtained is used to calculate a risk score for the structure. The parameters related to the structure are as follows. Number of floors, soft storey, heavy overhangs, apparent building quality, peak ground velocity (PGV) values, pounding effect, short column effect and topographical effect (Özkaynak and Özbay 2018).

When considering the number of floors, only those above ground should be considered. Apparent quality provides an assessment of the overall appearance of the building and allows buildings to be categorized into three levels: good, moderate, and poor. Although the year of construction is not a parameter for this method, a link can be established with apparent quality. The year of construction also gives an idea of the regulation year to which the building belongs. The vulnerability parameters for the effects considered when applying the method are as shown in Figure 4.22.

| Effects | Vulnerability Score Multipliers (VSM) | |
|---|---|---|
| | Does Not Exists | Exists |
| Soft Story Effect | (0) | (1) |
| Heavy Overhang | (0) | (1) |
| Short Column | (0) | (1) |
| Topographic Effect | (0) | (1) |
| Pounding Effect | (0) | (1) |
| Apparent Quality | Good (0) Moderate (1) Poor (2) | |

Figure. 4.22. Vulnerability parameter values (VSM) (Sucuoğlu et al., 2007)

When the structure is analyzed by this method, the calculation starts with different basic score (BS) values according to different storey numbers and '3 different seismic zones values separated according to PGV values'. Then, the performance score (PS) is obtained by subtracting the score values (VS) determined for each structural defect from this basic score (Figure 4.3).

Based on the attained performance scores (PS), structures are classified as follows: if $0 < PS \leq 30$, they are designated as highest priority; for scores within the range of $30 < PS \leq 60$, the classification is secondary priority; for $60 < PS \leq 100$, structures are categorized as moderate priority; and if PS exceeds 100, they are designated as lowest priority.

| | Base Scores (BS) | | | Vulnerability score (VS) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| # Stories | Zone-I 60 < PGV < 80 cm/sec | Zone-II 40 < PGV < 60 cm/sec | Zone-III 20 < PGV < 40 cm/sec | Soft Story | Apparent Quality | Heavy Overhang | Pounding | Short Column | Topographic |
| 1,2 | 100 | 130 | 150 | 0 | -5 | -5 | 0 | -5 | 0 |
| 3 | 90 | 120 | 140 | -15 | -10 | -10 | -2 | -5 | 0 |
| 4 | 75 | 100 | 120 | -20 | -10 | -10 | -3 | -5 | -2 |
| 5 | 65 | 85 | 100 | -25 | -15 | -15 | -3 | -5 | -2 |
| 6,7 | 60 | 80 | 90 | -30 | -15 | -15 | -3 | -5 | -2 |

Figure. 4.23. Base Scores (BS) and Vulnerability Scores (VS) (Sucuoğlu et al., 2006)

## 4.3. Canadian Seismic Screening Method (Rainer, Allen, and Jablonski 1992)

The Canadian seismic scanning method is a method that makes it possible to rapidly evaluate the earthquake performance of structures. Upon implementing the methodology on the given structure, the seismic index is computed by incorporating various parameters. These parameters encompass the seismicity prevalent in the region where the structure is situated, the regulatory year, the soil classification, the type of structural system employed, the structural significance, and any irregularities existing within the structure. In accordance with the acquired seismic index, an assessment of the structure's risk level is conducted, guiding subsequent prioritization for in-depth analysis (Işık et al. 2017).

When employing the methodology for buildings, it is feasible to conduct the study in the absence of architectural or structural system projects. The external examination of the building is undertaken by the assigned supervisor conducting the study, during which the data collection form is completed architects, engineers and property owners can also apply this method, provided they have sufficient knowledge. The Canadian seismic screening method allows for rapid performance evaluation of all types of structural systems such as FEMA p-154. The flow diagram of the method is as shown in Figure 4.24.

### 4.3.1 Structural System Types

The structural system types and short codes, which are one of the important parameters of the Canadian seismic method, are as follows.

Wood -Light timber frame system (WLF)
-Timber frame systems (WPB)

Steel -Steel frame systems (SMF)
-Diagonal steel frame systems (SBF)
-Light steel systems (SLF)

-Steel frame system with reinforced concrete walls (SCW)

-Steel frame system with infill wall (SIW)

RC -Reinforced concrete frame system (CMF)

-Reinforced concrete shear wall systems (CSW)

-Reinforced concrete frame system with infill walls (CIW)

-Prefabricated/refabricated reinforced concrete frame system (PCF)

-Pre-produced curtain system (PCW)

Masonry -Reinforced masonry system with timber board diaphragm (RML)

-Reinforced masonry system with reinforced concrete diaphragm (RMC)

-Unreinforced masonry system (URM)

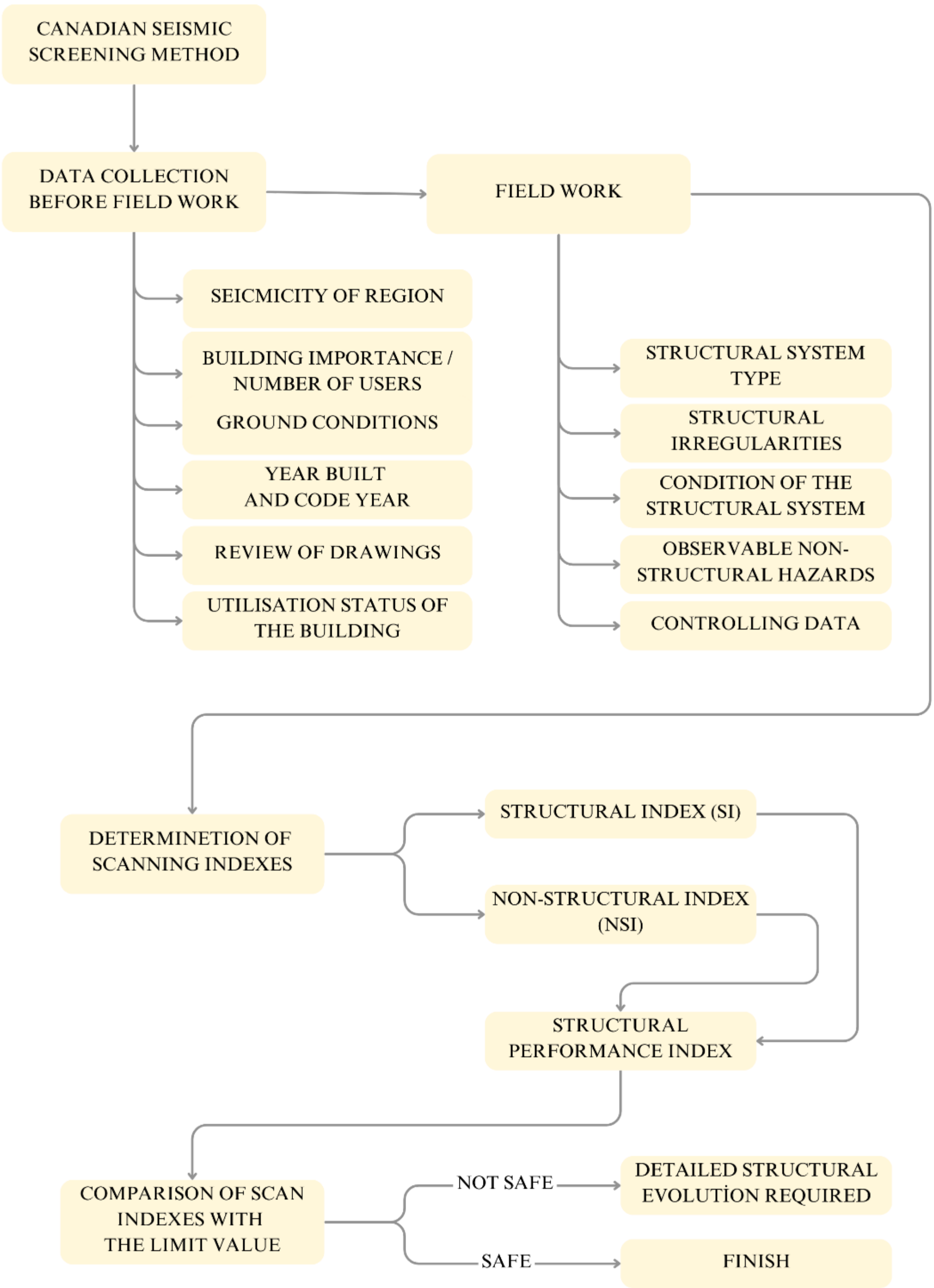



Figure. 4.24. Canadian seismic scanning method flowchart.

## 4.3.2. Seismicity Rating of the Region (A)

The seismicity of a region plays a pivotal role in determining the seismic index. Within the framework of the Canadian Seismic Screening Method, the seismicity of a given region is characterized by two parameters: $Z_a$ and $Z_v$ values, which correspond to the maximum ground acceleration and velocity, respectively. These values are linked to the division of earthquake zones into six categories. If $Z_v$ exceeds $Z_a$, the $Z_v$ value denotes the earthquake zone of the region. Conversely, if $Z_a$ surpasses $Z_v$, the value $Z_v$+1 signifies the earthquake zone. Higher $Z_a$ values signify zones of heightened risk, whereas lower values indicate less hazardous zones. Shown in figure 4.25.

| | | | Effective Seismic Zone ($Z_a$>$Z_v$, if $Z_v$ or $Z_v$+1) | | | | | A= |
|---|---|---|---|---|---|---|---|---|
| A | Seismicity | Regulation Year | 2 | 3 | 4 | 5 | 6 | |
| | | Before 1965 | 1.0 | 1,5 | 2.0 | 3.0 | 4.0 | |
| | | 1965-1984 | 1.0 | 1.0 | 1,3 | 1,5 | 2.0 | |
| | | After 1985 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | |

Figure. 4.25. Seismicity of the region scoring table.

## 4.3.3. Ground Conditions (B)

In the data collection form, ground groups are scored in 4 different categories.

The categorization of soil types is delineated as follows:

1. Rock and compacted soils: This group encompasses rock formations and compacted soils less than 50 meters in thickness, as well as substrates consisting of gravel, compacted clay, and stable sand soils situated over rock layers.

2. Compacted soils: Soil formations falling under this classification comprise compacted soils exceeding 50 meters in thickness, along with substrates composed of gravel, compacted clay, and stable sand soils overlying rock layers.

3. Soft ground: This group encompasses soils characterized by soft or medium dense clay and sand, or cohesionless soils with a thickness exceeding 15 meters.

4. Very soft soils with slip risk: This category comprises very soft clay and loose sandy-clay soils that pose a risk of slippage. Figure 4.26.

| | | | Ground Types | | | | | B= |
|---|---|---|---|---|---|---|---|---|
| B | Ground Conditions | Regulation Year | Rock Compacted Soil | Compacted Soil>50m | Soft ground>15m | Very weak or slippery ground | Unknown ground | |
| | | Before 1965 | 1.0 | 1,3 | 1,5 | 2.0 | 1,5 | |
| | | After 1965 | 1.0 | 1.0 | 1.0 | 1,5 | 1,5 | |

Figure. 4.26. Ground types of the region scoring table.

### 4.3.4. Structural System Type Score (C)

The correct determination of the type of structural system of the building is very important for the accuracy of the result obtained at the end of the scan. For the accurate determination of the structural system, a comprehensive examination of the structure is imperative, considering all relevant aspects. In instances where coating elements are present within the structure, their removal is necessary to facilitate a thorough assessment. Furthermore, if the building incorporates multiple types of structural systems, the structural system score is computed independently for each system, and the higher of the results obtained is accepted. Load bearing system scoring according to different types is as in figure 4.27. Structural system types represented by acronyms as shown in figure 4.28.

| | | | Structural System Type and Symbols | | | | | | | | | | | | | C= |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C | Structural System Type (BM=evaluation year) | Regulation Year | Wood | | Steel | | | | Reinforced Concrete | | Precast | | Masonry Fill | Masonry | | |
| | | | WLF | WPB | SLF | SMF | SBF | SCW | CMF | CSW | PCF | PCW | SIW,CIW | RML, RMC | URM | |
| | | Before 1970 | 1,2 | 2.0 | 1.0 | 1,2 | 1,5 | 2.0 | 2,5 | 2.0 | 2,5 | 2.0 | 3.0 | 2,5 | 3,5 | |
| | | 1970-BM | 1,2 | 2.0 | 1.0 | 1,2 | 1,5 | 1,5 | 1,5 | 1,5 | 1,8 | 1,5 | 2.0 | 1,5 | 3,5 | |
| | | After BM | 1,2 | 2.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | | |

Figure. 4.27. Structural system type scoring table.

| Structural System Type (circle the appropriate definition) | | |
|---|---|---|
| Wood | WLF | Light timber frame system |
| | WPB | Timber frame systems |
| Steel | SMF | Steel -Steel frame systems |
| | SBF | Diagonal steel frame systems |
| | SLF | Light steel systems |
| | SCW | Steel frame system with reinforced concrete walls |
| | SIW | Steel frame system with infill wall |
| Reinforced Concrete | CMF | Reinforced concrete frame system |
| | CSW | Reinforced concrete shear wall systems |
| | CIW | Reinforced concrete frame system with infill walls |
| | PCF | Prefabricated/refabricated reinforced concrete frame system |
| | PCW | Pre-produced curtain system |
| Masonry | RML | Reinforced masonry system with timber/trapezoidal board diaphragm |
| | RMC | Reinforced masonry system with reinforced concrete diaphragm |
| | URM | Unreinforced masonry system |

Figure 4.28. Structural system list.

## 4.3.5. Structural Irregularity Score (D)

When assessing the irregularities of a building, it is essential to identify both vertical and horizontal irregularities. These irregularities are delineated in the appropriate sections of the data collection form, as illustrated in Figure 4.29. Subsequently, the irregularity scores, which are contingent upon the regulatory years, are multiplied together to derive the "D" score.

| Structural Irregularities (circle the appropriate definition) | |
|---|---|
| 1. Vertical Irregularities | Sudden changes in the plan (e.g. retraction or building on sloping terrain) |
| 2. Irregularity in the Plan | Irregular building shapes; L, V, E, T, torsional irregularity, accumulation of shear columns in a region |
| 3. Reinforced Concrete-Short Columns | Short Columns |
| 4. Soft Story | Reduction in stiffness due to discontinuity in shear walls, openings |
| 5. Hammering Effect | If the gap between buildings is less than 20 x Zv x Number of Storeys (mm) |
| 6. Important Changes | Changes in the function and use of the building |
| 7. Structural Deformation | Deterioration of structural elements, weak or poured concrete, corroded reinforcement |
| 8. None | If none of the above irregularities are present |

Figure 4.29. Irregularities list.

### 4.3.6. Building Importance Score (E)

The usage status and user group of the building are very important in determining the result index. Particularly, structures such as schools, post-disaster facilities, and hospitals carry a high importance coefficient. When calculating the E value, the intended purpose of the building and its user capacity (N) are pivotal factors. The user capacity (N) is computed by multiplying the area of utilization, the intensity of usage, and the percentage representation of weekly usage hours shown in figure 4.30.

| | Building Importance | Regulation Year | Low Utilisation N<10 | Normal Utilisation N=10-300 | School or more Utilisation | After Disaster or Too Much Use. N>3000 | Private Business Requirements | E= |
|---|---|---|---|---|---|---|---|---|
| E | | Before 70 | 0.7 | 1.0 | 1,5 | 2.0 | 3.0 | |
| | | After 70 | 0.7 | 1.0 | 1,2 | 1,5 | 2.0 | |

N=Area of Use x Intensity of Use x Duration Factor= ..........................x..........................x..........................=

| Main Use | Intensity of Use person/m2 | Average Weekly Utilisation Hours |
|---|---|---|
| Meeting | 1 | 5,0 - 50 |
| Commercial, Service | 0,2 | 50 - 80 |
| Office, Institute, Production | 0,1 | 50 - 60 |
| Residential | 0,05 | 100 |
| Warehouse | 0,01-0,02 | 100 |

The Duration Factor is calculated as the average weekly utilization hours divided by 100, ensuring it does not exceed 1.0.

Figure 4.30. Building utilization scoring table.

## 4.3.7. Non-Structural Hazards (F)

Chimneys, parapets, claddings, curtain walls, facade claddings, and overhangs constitute non-structural hazards within the building, posing risks of potential collapse. The identification of these elements is crucial and should be indicated in the initial section of the form (Figure 4.31). Subsequently, the corresponding scores are calculated in section F, considering the regulatory year (Figure 4.32).

NON-STRUCTURAL HAZARDS (circle the appropriate definition)

F1 Fall Hazard

Exterior: chimneys, parapets, pre-fabricated panels, unsafe glazing, overhead covers over walkways

Interior: Heavy components: masonry partition elements, glazing at exits, collapsible shelves

F2 Hazards in Private Enterprises: Specialised equipment that private enterprises must use at all times.

The list of risky elements should be noted.

Figure 4.31. Non-structural hazards.

| | NON-STRUCTURAL HAZARDS | | Definition | Regulation Year | Doesn't Exist | Yes | Yes* | F= maks(F1, F2) |
|---|---|---|---|---|---|---|---|---|
| F | F1 | Elements with Fall Hazard | | Before 1970 | 1.0 | 3.0 | 6.0 | |
| | | | | After 1970 | 1.0 | 2.0 | 3.0 | |
| | F2 | Danger in Private Enterprises | | In any year | 1.0 | 3.0 | 6.0 | |
| | * If one or more of the SMF, CMF, soft storey, torsional irregularities are marked on the first page, the section with * should be marked. | | | | | | | |

Figure 4.32. Non-structural hazards scoring table.

### 4.3.8. Canadian Seismic Scanning Method Scoring System

In the Canadian Seismic Screening Method, the seismic index (SPI) calculated by equation 4.1, structural index score (SI) calculated by equation 4.2, and non-structural index score (NSI) calculated by equation 4.3 are computed by aggregating the structural and non-structural data of the building (Rainer, Allen, and Jablonski 1992).

$$SI = A \times B \times C \times D \times E \tag{4.1}$$

$$NSI = B \times E \times F \tag{4.2}$$

$$SPI = SI + NSI \tag{4.3}$$

A: Seismicity score of the region,
B: Ground conditions score,
C: Structural system type score,
D: Irregularity score,
E: Building importance score,
F: Max (F1, F2),
F1: Fall hazard elements score,
F2: Special operations.

### 4.3.9. Canada Seismic Scanning Method Determination of Limit Score

The seismic index score (SPI) is juxtaposed against the threshold score, enabling the identification of priority buildings warranting detailed analysis. Seismic performance assessments of the buildings based on the threshold score are outlined as follows.

| | |
|---|---|
| SI or NSI 1.0~2.0 | Adequate earthquake safety |
| SPI < 10 | Low priority buildings |
| SPI 10~20 | Medium priority buildings |
| SPI > 20 | High priority buildings |
| SPI > 30 | Very dangerous buildings |

# CHAPTER 5

# RESULTS AND DISCUSSIONS

This section of the thesis discusses the results of the studies on 477 buildings, described in detail under Chapter 3, section 3.3, Building Inventory Database. The selected 477 buildings are analyzed with the help of FEMA p-154 (Federal Emergency Management Agency 2015), Canadian Seismic Screening Method (Rainer, Allen, and Jablonski 1992) and Sucuoğlu RVS procedure (Sucuoğlu, Yazgan, and Yakut 2007), which are the rapid earthquake performance assessment methods explained in detail in Chapter 4. The results obtained for each structure were evaluated according to the results of the examinations performed using three different methods. According to the results, the accuracy percentages of the decisions made by the analyzed methods about the structures are discussed, the coefficient changes required for the methods to predict the results correctly, and the issues to be considered are discussed in detail. Detailed data tables of fast earthquake performance evaluation methods are presented in the appendices section.

## 5.1. FEMA p-154 Method (FEMA, 2015)

FEMA p-154 method evaluates the seismicity of the geographical location, construction techniques such as steel frame (S1), reinforced concrete frame (C1), masonry (URM), number of storeys, the intended use of the building, year of construction and structural irregularities in the building with the help of a form. It evaluates whether the earthquake performance of the building is in the safe range by obtaining an S score according to the penalty points applied (Şebnem et al. 2021).

While evaluating the structures with the help of the FEMA method, a form is selected depending on the seismicity of the structure's location. After the form is selected, the structures are first scanned with the level 1 evaluation form and then with the level 2 evaluation form if the building performance is not found to be sufficient. As a result of the score shaped according to the structure data, the earthquake performance of the structure is considered adequate or inadequate (Doğan et al. 2021). Getting support from an expert for structures whose earthquake performance is not considered adequate is recommended. According to the result, the FEMA p-154 RVS method divides the structures into two sharp classes such as black and white. As observed in the Kahramanmaraş earthquakes, not every building determined as risky by the regulations has collapsed. Therefore, the FEMA p-154 method, which cannot perform risk prioritizations, should be improved regarding evaluation results. A result system in which the score value resulting from the penalty points it gives expresses certain risk groups in specific ranges would be more reliable.

While applying the FEMA p-154 method, the very high-risk form was selected from the forms suitable for the seismicity of the region where the building is located. This selection is due to the Eastern Anatolian Fault Line (DAF) passing through the north of Adıyaman. This 580 km long fault line, which starts from Bingöl-Karlıova and connects to the Dead Sea fault system in the Antakya region, plays a vital role in the region's seismicity according to the results of the research carried out since 1969 (Herece and Akay 1992).

At the beginning of the application of this method, the first of the evaluation scores given to the building is the "Basic Score", which can be determined by the type of structural system of the building. 63 of the 477 buildings are masonry structures, and 414 are reinforced concrete. For reinforced concrete structures, C1 for reinforced concrete frame systems and C2 for reinforced concrete shear wall systems were selected, while URM was selected for masonry structures. The basic score for C1 is 1.0, the basic score for C2 is 1.2, and the basic score for URM is 0.9. A total of 63 buildings were evaluated in the URM class with 0.9 points, 5 buildings in the C2 class with 1.2 points, and 409 buildings in the C1 class with 1.0 points.

After the basic score was determined, when the vertical severe irregularities found in the buildings were examined, 303 buildings for C1 received a penalty score of -0.7, 5 buildings for C2 received a penalty score of -0.8, 2 buildings for URM received a penalty score of -0.6. In comparison, no remarkable vertical irregularities were detected in 167 buildings. Regarding average vertical irregularity, 114 buildings for C1 received a penalty score of -0.4 and 57 buildings for URM received a penalty score of -0.3. In case of irregularities in the plan, a penalty points of -0.4 in 106 buildings for C1 and -0.3 in 1 building for URM was applied. Basic scores, modifiers and final scores of each building type are shown in detail in Figure 5.1.

| BASIC SCORE, MODIFIERS, AND FINAL LEVEL 1 SCORE, $S_{L1}$ | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FEMA BUILDING TYPE Do Not Know | W1 | W1A | W2 | S1 (MRF) | S2 (BR) | S3 (LM) | S4 (RC SW) | S5 (URM INF) | C1 (MRF) | C2 (SW) | C3 (URM INF) | PC1 (TU) | PC2 | RM1 (FD) | RM2 (RD) | URM | MH |
| **Basic Score** | **2.1** | **1.9** | **1.8** | **1.5** | **1.4** | **1.6** | **1.4** | **1.2** | **1.0** | **1.2** | **0.9** | **1.1** | **1.0** | **1.1** | **1.1** | **0.9** | **1.1** |
| Severe Vertical Irregularity, $V_{L1}$ | -0.9 | -0.9 | -0.9 | -0.8 | -0.7 | -0.8 | -0.7 | -0.7 | -0.7 | -0.8 | -0.6 | -0.7 | -0.7 | -0.7 | -0.7 | -0.6 | NA |
| Moderate Vertical Irregularity, $V_{L1}$ | -0.6 | -0.5 | -0.5 | -0.4 | -0.4 | -0.5 | -0.4 | -0.3 | -0.4 | -0.4 | -0.3 | -0.4 | -0.4 | -0.4 | -0.4 | -0.3 | NA |
| Plan Irregularity, $P_{L1}$ | -0.7 | -0.7 | -0.6 | -0.5 | -0.5 | -0.6 | -0.4 | -0.4 | -0.4 | -0.5 | -0.3 | -0.5 | -0.4 | -0.4 | -0.4 | -0.3 | NA |
| Pre-Code | -0.3 | -0.3 | -0.3 | -0.3 | -0.2 | -0.3 | -0.2 | -0.1 | -0.1 | -0.2 | 0.0 | -0.2 | -0.1 | -0.2 | -0.2 | 0.0 | 0.0 |
| Post-Benchmark | 1.9 | 1.9 | 2.0 | 1.0 | 1.1 | 1.1 | 1.5 | NA | 1.4 | 1.7 | NA | 1.5 | 1.7 | 1.6 | 1.6 | NA | 0.5 |
| Soil Type A or B | 0.5 | 0.5 | 0.4 | 0.3 | 0.3 | 0.4 | 0.3 | 0.2 | 0.2 | 0.3 | 0.1 | 0.3 | 0.2 | 0.3 | 0.3 | 0.1 | 0.1 |
| Soil Type E (1-3 stories) | 0.0 | -0.2 | -0.4 | -0.3 | -0.2 | -0.2 | -0.2 | -0.1 | -0.1 | -0.2 | 0.0 | -0.2 | -0.1 | -0.2 | -0.2 | 0.0 | -0.1 |
| Soil Type E (> 3 stories) | -0.4 | -0.4 | -0.4 | -0.3 | -0.3 | NA | -0.3 | -0.1 | -0.1 | -0.3 | -0.1 | NA | -0.1 | -0.2 | -0.2 | 0.0 | NA |
| Minimum Score, $S_{MIN}$ | *0.7* | *0.7* | *0.7* | *0.5* | *0.5* | *0.5* | *0.5* | *0.5* | *0.3* | *0.3* | *0.3* | *0.2* | *0.2* | *0.3* | *0.3* | *0.2* | *1.0* |

Figure 5.1. FEMA p-154 form, basic score, modifiers, and final score.
(Adopted from FEMA p-154 very high seismicity form)

Pre-code and post-benchmark are another important topic to be considered when evaluating the performance of the structures with the help of this method. This factor, which can be called a threshold point, is accepted as the year 2000, which is also a turning point for Türkiye's building stock. For the buildings built before 2000, as indicated in Figure 5.1, a penalty score of -0.1 was applied to C1-type buildings and -0.2 to C2-type buildings. For C1-type buildings constructed after 2000, +1.4 points and +1.7 points were added to C2-type buildings. As a result of the building analyses, 63 URM buildings received 0 penalty points per form, while 159 buildings received -0.1 penalty points. 250 C1-type buildings received +1.4 points, and four buildings received +1.7 points.

As a result of the penalty points added to the basic score, the Final Level 1 score-$S_{L1}$ score is obtained. If the SL1 score is below the $S_{min}$ score, it is recommended that the second part of the building inspection form be applied in order to understand the risk status of the building correctly. $S_{min}$ score is 0.3 for C1 and C2 type structures and 0.2 for URM type structures. The $S_{min}$ score is 0.3 for C1 and C2 type structures and 0.2 for URM type structures. Following the 1st level assessments, it was found that the $S_{L1}$ score for 147 buildings was lower than the $S_{min}$ threshold, indicating a lack of earthquake resilience. However, for 330 buildings, the $S_{L1}$ value was deemed adequate for earthquake safety according to the first evaluation form of the FEMA p-154 method. However, the fact that these buildings were subsequently classified as heavily damaged, collapsed or requiring urgent demolition indicates that the earthquake performance of these 330 buildings was incorrectly assessed in the initial assessment form.

While evaluating the construction years, the accuracy of the data collected during the damage assessment studies carried out by the Ministry of Environment and Urbanization was verified with the help of the coordinates of the buildings and Google Earth data. As a result of the verifications made with aerial photographs, the construction years of 71 buildings were updated. This reveals that 14.88% of the initially collected data on construction years was inaccurate.

When the 2[nd] part of the building evaluation form is passed, the $S_{L2}$ score is expected to be greater than or equal to the $S_{min}$ value in order for the earthquake safety of the building to be considered adequate. Structures that cannot meet this condition are considered inadequate and directed to detailed analysis. While calculating the $S_{L2}$ score, S' score, $V_{L2}$ score, $P_{L2}$ score, and M score obtained from the first form are used. S' score is determined by equation (5.1). Equation (5.2) is used to calculate the SL2 score.

$$S' = (S_{L1} - V_{L1} - P_{L1}) \tag{5.1}$$

$$S_{L2} = (S' + V_{L2} + P_{L2} + M) \geq S_{MIN} \tag{5.2}$$

When calculating the VL2 score, the scores of the vertical irregularities are summed. These irregularities are as follows. The sloping site, weak and/or soft storey, setback, short column, split levels and other irregularities. For structures that are not in W1, i.e. wood frame structure class, -0.2 penalty points are applied in case of sloping site irregularity. All 477 buildings did not receive penalty points from this section.

The penalty score for Weak/Soft storey irregularity determined by the FEMA p-154 form is -0.7 for non-W1 structures if the difference between storey heights is two storeys or more and -0.4 if it is less. 307 of the 477 structures received a penalty score of -0.4 for having weak/soft storey irregularity, as shown in Figure 3.2. While deciding on this penalty score, the structures with differences between the storey heights and the structures with rigidity differences between the storeys were also considered. Since the storey height differences of the buildings were not two storeys or more, none of the buildings received a penalty score of -0.7.

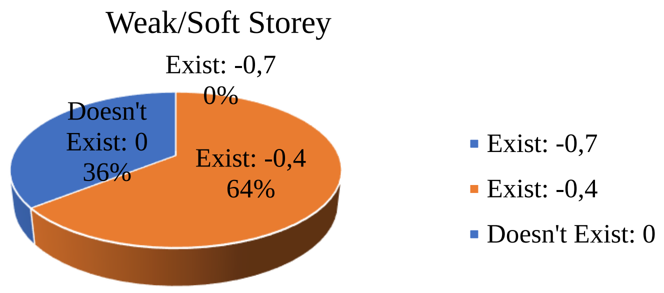



Figure 5.2. The distribution of 477 structures in the weak/soft storey irregularity.

Since the setback irregularity was not found in the selected buildings, no building received penalty points for this irregularity.

If short column effect irregularity is present, it causes -0.4 penalty points to be applied to the buildings. This irregularity is present in 107 of the 477 buildings examined within the scope of the study (Figure 5.3). It is assumed that short column effect is observed in buildings with band windows between two columns during visual screening.

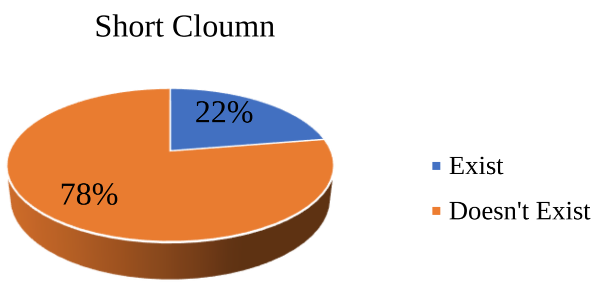



Figure 5.3. The distribution of 477 structures in the short column irregularity.

When there are inconsistent slabs in the building, split level irregularity can be mentioned. If this irregularity is found in the buildings, -0.4 penalty points are applied. There are no buildings with this irregularity among the 477 buildings analyzed.

Another vital part that is considered when calculating the VL2 score is other irregularities. Heavy overhangs in the analyzed buildings were evaluated in this category. If this irregularity is found at a severe level, a penalty score of -0.7 is applied, and if it is found at an average level, a penalty score of -0.4 is applied. Of the 477 buildings examined within the scope of the study, 278 have heavy overhangs as shown in Figure 5.4. This irregularity, found in 58.28% of the analyzed buildings, is considered quite risky since it disrupts the rigidity of the structure (İnan and Korkmaz 2012).

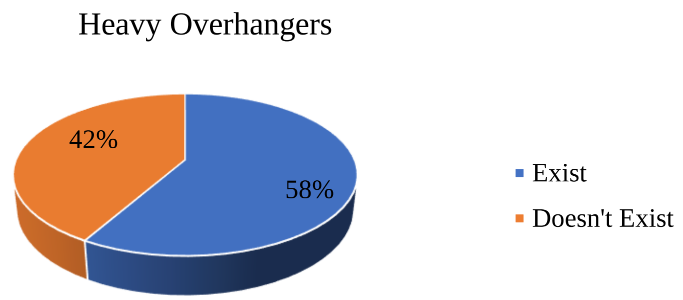



Figure 5.4. The distribution of 477 structures in the heavy over hangers irregularity.

The part where penalty points should be determined within the scope of the second form while evaluating the structure with the method developed by FEMA is PL2, irregularities in the plan. These irregularities evaluated in the plan plane are as follows: torsional irregularity, non-parallel system, reentrant corner, diaphragm openings and out-of-plane offset. A penalty of -0.5 points is applied to the structure when a torsional irregularity is found. Since the structural system layouts were not known while collecting the data about the buildings, it was assumed to be absent in all buildings and taken as 0. The structures with non-parallel system irregularity are penalized with -0.2 penalty points. When 477 structures were analyzed, it is assumed that the analyzed buildings were built with regular axes. Regarding reentrant corners, the method applies -0.2 penalty points to structures with this irregularity. Since the selected buildings have square or rectangular plan forms, their reentrant corner scores are accepted as 0. Diaphragm openings in the buildings cause the buildings to receive -0.2 penalty points. According to Google Earth satellite data, no large diaphragm openings were found in the selected buildings, so the penalty points were accepted as 0. Out-of-plane offset irregularity causes -0.2 penalty points to be applied to the structures where it exists. Heavy overhang irregularity was evaluated under the title of out-of-plane offset, and this irregularity was found in 278 of the 477 structures examined, and -0.2 penalty points were applied (Figure 5.5).

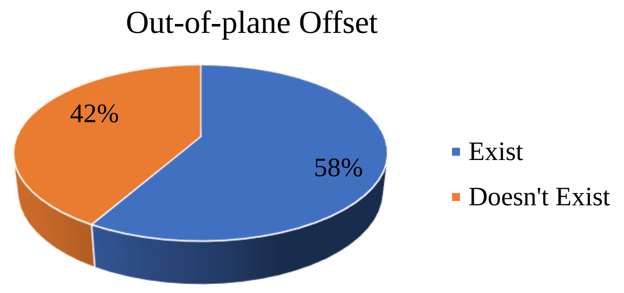



Figure 5.5. The distribution of structures with out-of-plane offset irregularity.

The last part of the Level 2 assessment form consists of the M score. While calculating the M score, the structural irregularities of the building are evaluated as in the previous stages, and these irregularities are as follows: redundancy, pounding/hammering, joistless slab and visible reinforcement. Redundancy exists if at least two bays of lateral elements are on each side of the building. 477 buildings received +0.2 points since all the analyzed buildings met this criterion.

When evaluating the hammering effect, if the slabs do not coincide with each other -0.7, if there is a difference of 2 floors or more between the building and the neighboring building -0.7, if the building is located at the end of the block -0.4, penalty points are applied. If a building fulfils all these conditions, a maximum of -0.9 penalty points is applied to the building. 162 of 477 structures, 33 received a penalty score of -0.7 (Figure 5.6).

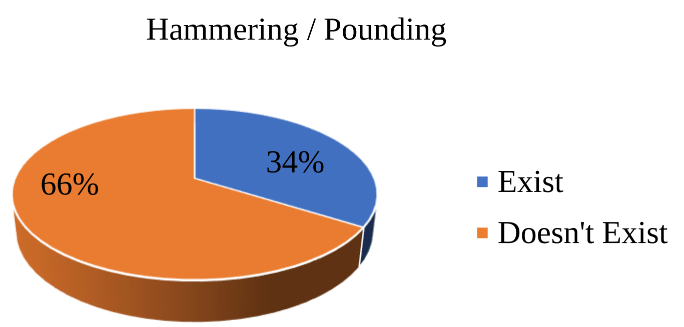



Figure 5.6. The Distribution of structures with hammering effect.

Among the analyzed buildings, -0.3 penalty points are applied for the buildings with no-beam slabs. This means that the floor of the building also works as a beam. It is used frequently in Türkiye as hollow floor, causes low rigidity in buildings, and causes heavy damage in earthquakes (İnce 2018). Within the scope of the study, 259 structures, which constitute 54.29% of the 477 structures analyzed, received a penalty score of -0.3 for having a no-beam slab irregularity. This irregularity plays a vital role for buildings regarding frequency of occurrence (Figure 5.7).

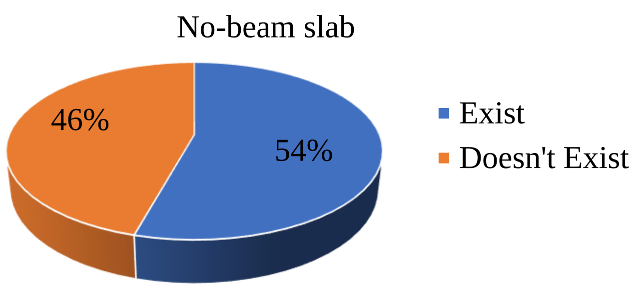



Figure 5.7. The Distribution of structures with no-beam slab

If a visible strengthening can be observed in the building, this brings +1.2 points to the building. In buildings where this could not be measured, it was assumed that no retrofitting was done.

Within the scope of the thesis, 477 structures were analyzed with the help of the FEMA p-154 method and evaluated with various irregularities. As a result of this evaluation, the $S_{L2}$ final score of the structure was calculated with the help of equation (5.2). It is compared with $S_{min}$, which is determined separately for each type of structural system specified in Figure 5.1. In cases where the $S_{L2}$ score is less than $S_{min}$, a detailed earthquake performance analysis is recommended for the structure.

The damage classes of the selected 477 buildings were divided into three categories: severely damaged, required urgent demolition and collapsed. These buildings did not survive the Kahramanmaraş earthquakes on 6 February safely. According to the results of the selected buildings according to the FEMA p154 evaluation form, the SL2 score of 286 buildings was below the Smin value, indicating that the building was unsafe and suggested detailed analysis. If such a study had been carried out before the earthquake, the decisions to be taken for these 286 structures could have prevented loss of life and property. 191 structures, which constitute 40.04% of 477 structures, were safe due to the studies carried out within the scope of the FEMA p-154 evaluation method (Figure 5.8). However, when the actual earthquake data is considered, we see that these structures cannot survive the earthquake safely. Here, we can conclude that the FEMA p154 RVS method for 477 structures is not correct in 40.04% of the structures.

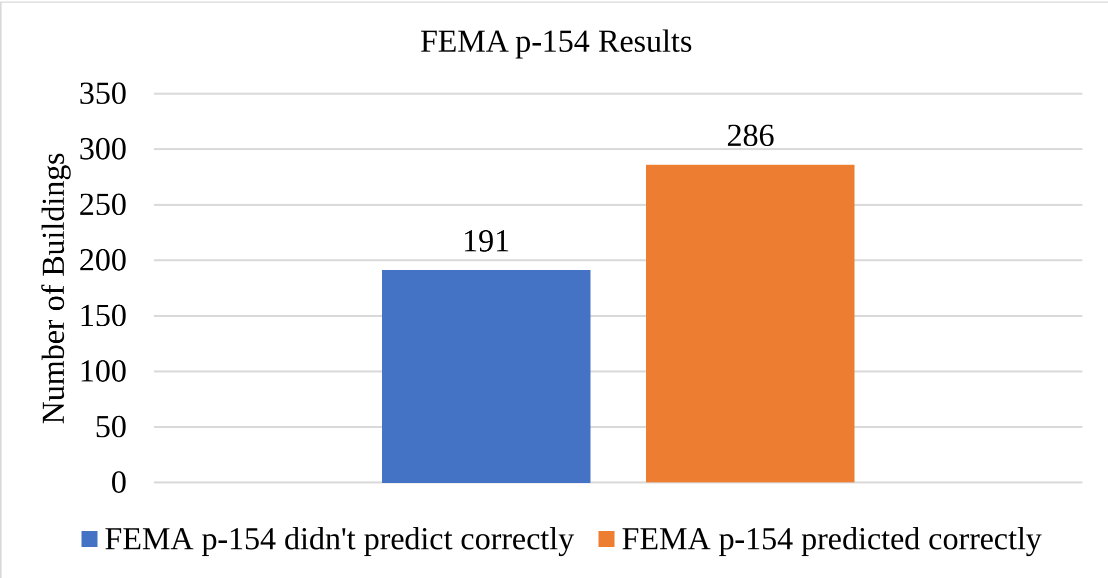



Figure 5.8. FEMA p-154 result distributions.

## 5.2. Sucuoğlu RVS Procedure (Sucuoğlu, Yazgan, and Yakut 2007)

This method, which is used as a street scanning method, provides information about the earthquake performance of the structure by evaluating the irregularities visible from the outside with specific penalty points. When the individual penalty points given to each irregularity are calculated, the resulting PS (Performance Score) score allows building risk prioritization (Özkaynak and Özsoy Özbay 2018). Sucuoğlu RVS procedure reveals the performance score of the building by applying the penalty points arising from structural irregularities together with the points determined according to the zone classes and the number of storeys of the building. These zone classes are determined depending on the PGV values of the region where the building is located. As the PGV value decreases, the Base Score (BS) of the building increases, while in buildings with the same PGV value, the Base Score (BS) decreases as the number of storeys increases. When the Vulnerability Score (VS) is subtracted from the Base Score, the Performance Score (PS) is obtained. The Performance Score (PS) obtained after examining the structures and applying penalty points shows which of the four priority classes the structure is suitable for. As a result, building owners and competent authorities can plan and implement the measures to be taken according to the risk priority of the building. After processing the structure data, the performance score (PS) is calculated with the help of the penalty scores obtained, as shown in equation (5.3).

$$PS = BS + \sum_{i=0}^{n} VSM_i + VS_i \tag{5.3}$$

After making these calculations structures are classified according to their performance scores (PS) as follows: If $0 < PS \leq 30$, the structure is considered highly risky and is categorized as highest priority; if the structure score is $30 < PS \leq 60$, the structure is categorized as second priority; for $60 < PS \leq 100$, structures are categorized as moderate priority; if the performance score of the structure is $PS > 100$, the structure will be categorized as lowest risk as it can be considered relatively safe compared to other situations.

The first issue to be decided about the structures to be studied while applying the method is the zone selection depending on the peak ground velocity (PGV) value of the structure. Seismic zone values based on the building's location are used to determine the Basic Score (BS) necessary for calculations. The rapid evaluation form determines the building's zone classification based on the Peak Ground Velocity (PGV) value, which varies with the seismic intensity of the building's location. Specifically, if $60 < PGV < 80$ cm/sec, the building falls into Zone I; if $40 < PGV < 60$ cm/sec, it is classified as Zone II; and if $20 < PGV < 40$ cm/sec, it is designated as Zone III. Within the scope of the study, all 477 buildings in Adıyaman examined by the author were accepted as Zone I due to the high seismicity of the region. After selecting the zone, the second critical issue affecting the Basic Score (BS) value is the number of storeys. Increasing the number of storeys decreases the BS value and affects the building's score. Following zone selection, the number of storeys is the next factor impacting the BS value: an increase in storeys reduces the BS, subsequently lowering the building's priority classification compared to structures with fewer storeys and higher BS values.

The Basic Score (BS) values, which vary according to the number of storeys, have been determined for Zone I buildings among the 477 structures selected in Adıyaman city center. For 1- and 2-storey buildings, the BS is set at 100 points, while 3-storey buildings receive 90 points, 4-storey buildings are assigned 75 points, 5-storey buildings receive 65 points, and for 6- and 7-storey buildings, the BS is set at 60 points as shown in detail in Figure 5.9 which taken directly from the documentation of the rapid evaluation method.

| Base Scores (BS) | | | | Vulnerability score (VS) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| # Stories | Zone-I 60 < PGV < 80 cm/sec | Zone-II 40 < PGV < 60 cm/sec | Zone-III 20 < PGV < 40 cm/sec | Soft Story | Apparent Quality | Heavy Overhang | Pounding | Short Column | Topographic |
| 1,2 | 100 | 130 | 150 | 0 | -5 | -5 | 0 | -5 | 0 |
| 3 | 90 | 120 | 140 | -15 | -10 | -10 | -2 | -5 | 0 |
| 4 | 75 | 100 | 120 | -20 | -10 | -10 | -3 | -5 | -2 |
| 5 | 65 | 85 | 100 | -25 | -15 | -15 | -3 | -5 | -2 |
| 6,7 | 60 | 80 | 90 | -30 | -15 | -15 | -3 | -5 | -2 |

Figure 5.9. Base Scores (BS) and Vulnerability Scores (VS) (Sucuoğlu et al., 2006)

Once the basic score is established for each structure under review, structural irregularities are assessed. The specific irregularities examined for the 477 buildings evaluated include the soft storey, apparent quality, heavy overhang, pounding, short column, and topographic effects.

Soft-storey irregularity is present in 305 out of 477 buildings, accounting for 63.94% (Figure 5.10). Penalty points associated with this irregularity vary depending on the building's number of storeys. For 1 and 2-storey buildings, no penalty points are applied, while 3-storey buildings receive a -15 penalty, 4-storey buildings receive -20, 5-storey buildings receive -25, and 6- to 7-storey buildings are penalized with -30 points.

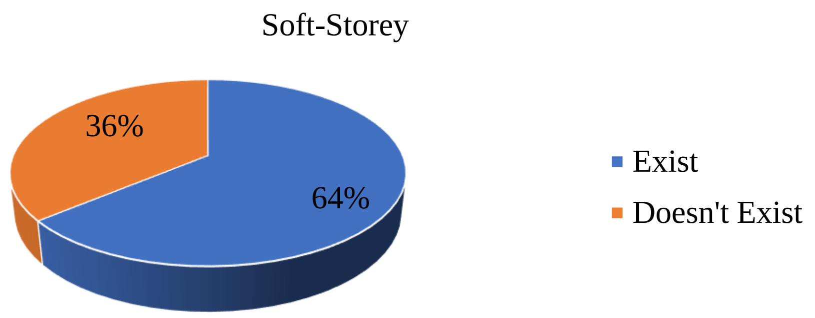



Figure 5.10. Distribution of buildings that have soft-storey irregularity.

Another issue taken into consideration by the method when assessing buildings is the apparent quality of the building. If the quality of the building is considered to be good when observed from the outside, no penalty points are applied to the building since the multiplier is 0. If the building has an average exterior appearance, one and 2-storey buildings -5, 3 and 4-storey buildings -10, 5-storey buildings -15, 6 and 7-storey buildings -15 penalty points. If the external appearance of the building is considered to be very bad, one and 2-storey buildings -10, 3 and 4-storey buildings -20, 5, 6 and 7-storey buildings -30 penalty points (Table 5.1).

Table. 5.1. Vulnerability score multipliers (VSM) (Sucuoğlu et al. 2007)

| Effects | Vulnerability Score Multipliers (VSM) | |
|---|---|---|
| | Does Not Exists | Exists |
| Soft Story Effect | (0) | (1) |
| Heavy Overhang | (0) | (1) |
| Short Column | (0) | (1) |
| Topographic Effect | (0) | (1) |
| Pounding Effect | (0) | (1) |
| Apparent Quality | Good (0) Moderate (1) Poor (2) | |

The RVS method developed by Sucuoğlu et al. (2007) also considers heavy overhangs a critical irregularity. A study conducted in Hatay, one of the cities most impacted by the Kahramanmaraş earthquakes, highlighted those heavy overhangs significantly contributed to severe structural damage (Işık, Buyuksarac, and Avcil 2023). The penalty points for structures with heavy overhangs vary by storey count: -5 points are applied to 1- and 2-storey buildings, -10 points to 3- and 4-storey buildings, and -15 points to 5-, 6-, and 7-storey buildings. Within the scope of the thesis, 477 buildings belonging to Adıyaman building stock were analyzed, and it was observed that 278 of these buildings had heavy overhangs. This number, which corresponds to 58.28% of the analyzed buildings, shows that the structural irregularity of heavy overhangs causes heavy damage to the buildings in Adıyaman as in Hatay (Figure 5.11).

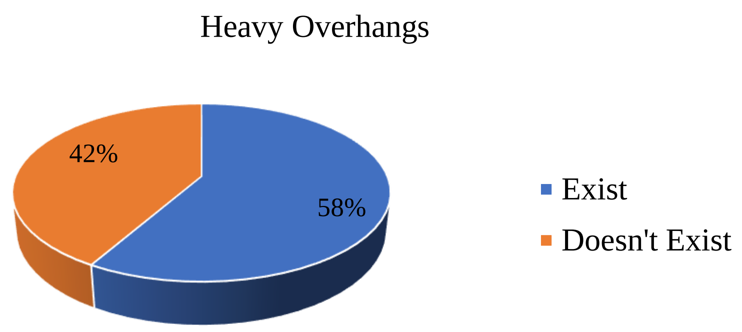



Figure 5.11. The distribution of structures with heavy over hangers irregularity.

The hammering effect causes the earthquake demands of the structures to change; in addition to these effects, it was observed in the study that the storey displacement rates can increase up to 67% (Işıkhan 2019). In cases where there is not enough space between adjacent buildings, it is assumed that there is a hammering effect between them. Among the 477 structures analysed, 162 structures have structural irregularity of the hammering effect. The penalty points applied by the RVS method to the buildings with this structural irregularity are as follows: 0 for one and 2-storey buildings, -2 for 3-storey buildings, and -3 for 4, 5, 6 and 7-storey buildings (Figure 5.12).

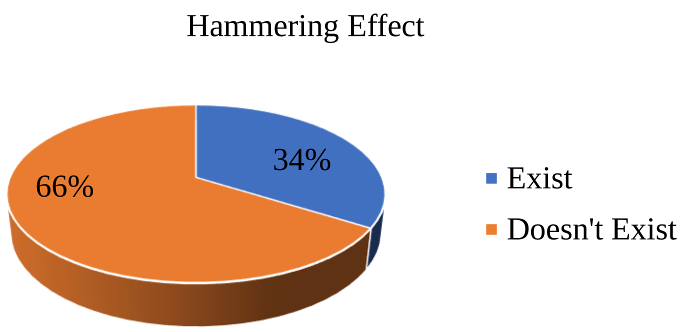



Figure 5.12. The distribution of structures with hammering effect irregularity.

The short-column effect is one of the structural irregularities considered when analyzing structures. According to a study comparing the short column effect in two 4-storey and 7-storey buildings built under the 2007 regulations, it was observed that the effect of the short column on the damage condition was directly proportional to the storey height (Meral 2019). According to the results of the study, it is expected that the penalty points applied by the methods will increase as the storey height increases. However, when we look at the penalty points of the Sucuoğlu RVS method, it applies the same -5 penalty points for both single-storey and 7-storey structures. The 110 structures containing the short column effect accounted for 23.06% of the analysed structures and received a penalty score of -5 (Figure 5.13).

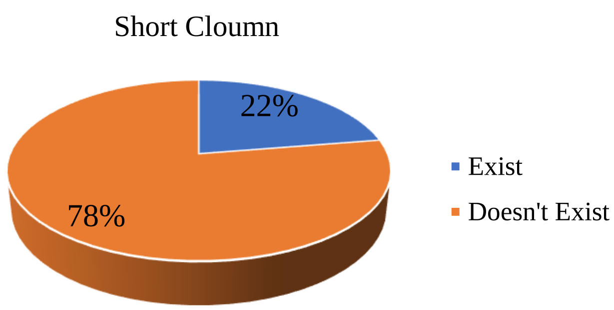



Figure 5.13. The distribution of structures with short column effect irregularity.

The topographic effect, which applies a penalty point related to the land on which the buildings are located, does not apply a penalty point for single-storey and 2-storey buildings. In contrast, it applies a -2 penalty point for 4, 5, 6 and 7-storey buildings. As none of the 477 selected buildings were situated on sloping terrain, no penalty points were assigned under the topographic effect category.

The Performance Score (PS) is calculated by subtracting penalty scores for relevant structural irregularities from the Basic Score (BS), which is determined individually for each structure based on its storey count and the seismicity of its location, following the formula outlined in equation (5.3). These PS values are then used to prioritize the risk level of each structure. The risk prioritization of the 477 buildings, which were meticulously examined by the author within the scope of this thesis, is presented according to the criteria outlined in the Sucuoğlu RVS Procedure, as shown below Figure 5.14.

The first class in risk prioritization is the highest risk group, with a performance score between 0 and 30. There are 149 buildings in this group, which are likely to have structural problems that may require urgent intervention. Buildings in this risk group are where time and money resources should be directed, and action should be taken as soon as possible to prevent possible loss of life and property in the event of an earthquake. The second class includes buildings with a performance score between 30 and 60. Buildings belonging to this risk group are second in priority, and 125 buildings were evaluated in this group. For buildings in the first and second priority group, retrofitting or demolition and reconstruction options should be evaluated, and action should be taken against earthquake risk. The third class includes 144 buildings with a performance score between 60 and 100, representing the medium risk level, and the condition of the buildings in this risk group is relatively better than the first two groups. The last class is reserved for buildings with a performance score above 100, but no buildings exist in this group. In addition, 63 masonry structures could not be assessed by the Sucuoğlu Rapid Visual Scanning (RVS) Method since the method does not intentionally cover masonry structures. Seismic risk of 149 out of 418 buildings was predicted to be of the highest priority by the method, which corresponds to approximately %35 accomplishment according to the post-earthquake classified real damage.

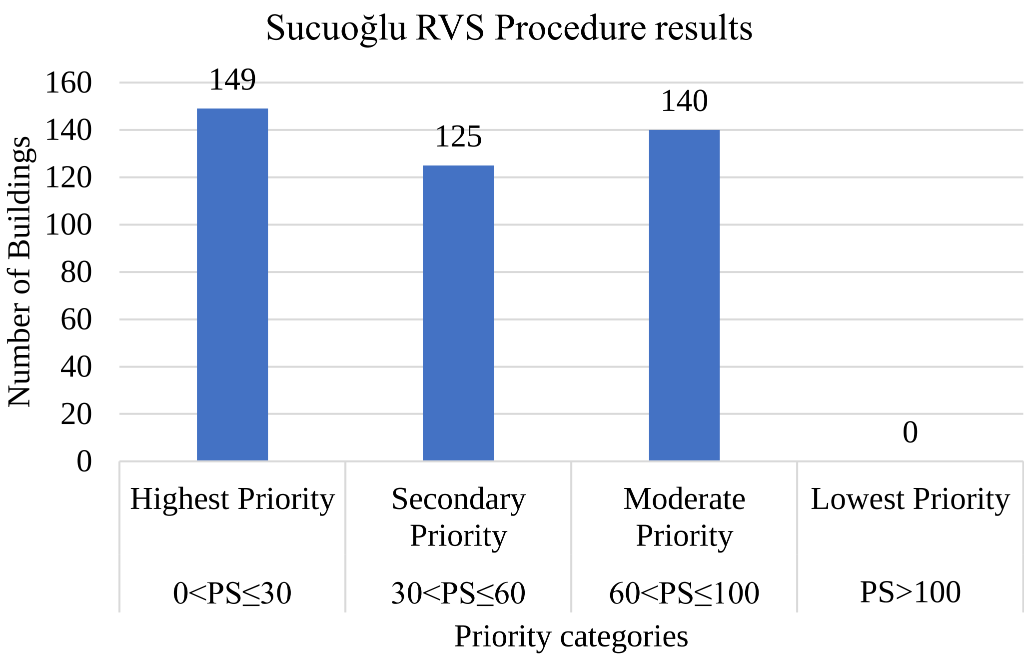



Figure 5.14. Sucuoğlu RVS Procedure results, risk priority categories.

## 5.3. Canadian Seismic Screening Method (Rainer, Allen, and Jablonski 1992)

The Canadian seismic method is used to evaluate the earthquake performance of structures in areas with high earthquake risk and to support the decisions taken within the scope of retrofitting works. The parameters to be considered while evaluating the buildings are as follows: seismicity of the buildings region, location of the building, the regulations to which the building is subjected, soil classes, construction techniques, number of storeys and structural irregularities (Saatçioğlu, Shooshtari, and Foo 2013).

In this method, each parameter is represented by a letter. A final score is obtained for each structure by multiplying the coefficient numbers given according to the parameters. The method first requires calculating the structure's structural index (SI) score. The SI score is calculated as given in Equation 5.4. The method also assigns points to non-structural components. Equation 5.5 is used to calculate the non-structural index (NSI). Finally, the structural performance index (SPI) is found by summing the structural and non-structural indices as expressed in Equation 5.6.

$$SI = A * B * C * D * E \tag{5.4}$$

$$NSI = B * E * F \tag{5.5}$$

$$SPI = SI + NSI \tag{5.6}$$

When applying the Canadian seismic method (Rainer, Allen, and Jablonski 1992), the region's seismicity is the first variable to be decided about the structure which is referred to as parameter “A”. When determining the seismicity of the location of the building, the number of storeys varies according to the categories of year of construction: the year 2000 was considered as the milestone for the evaluation. For the 477 buildings analyzed, the construction years classify them in two main groups: pre and post 2000. Given the high seismic activity in the central district of Adıyaman, the 6th active seismicity zone was used, where the “A” value is assigned as 1.0 for buildings built after 2000 and 2.0 for those built in 2000 or earlier. In this context, 266 buildings scored 1.0 and 211 buildings scored 2.0 (Figure 5.15).

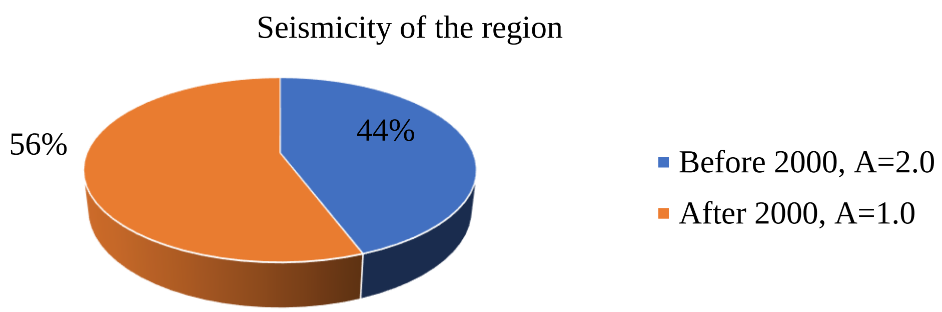



Figure 5.15. Seismicity of the region scoring table.

The second data to be collected when applying the method is the soil class of the structure as a “B” score. When deciding the soil class of the building, the unknown ground specified in Figure 4.24 should be used since the individual data of 477 buildings cannot be accessed. In this case, the “B” score is accepted as 1.5 for all 477 structures. When determining the B score, rock-compacted soil, which is the safest soil type, received a score of 1.0, while bad soil expressed as very weak/slippery ground, was calculated as 2.0 points. For this reason, an average value of 1.5 points is used for structures with unknown soil types. The year of construction is also an important factor in soil classes, but for unknown soil type, the building is evaluated as 1.5 points regardless of whether it was built before or after 1985 (Table 5.2).

Table. 5.2. Ground types of the region scoring table. Screenshot from original evaluation form.

| | | | Ground Types | | | | | B= |
|---|---|---|---|---|---|---|---|---|
| B | Ground Conditions | Regulation Year | Rock Compacted Soil | Compacted Soil>50m | Soft ground>15m | Very weak or slippery ground | Unknown ground | |
| | | Before 1965 | 1.0 | 1,3 | 1,5 | 2.0 | 1,5 | |
| | | After 1965 | 1.0 | 1.0 | 1.0 | 1,5 | 1,5 | |

The type of structural system constitutes the C score in this RVS method. When calculating the C score, after determining the type of structural system, penalty points are calculated by considering the years of construction. There are reinforced concrete (CMF, CSW) and masonry structures (URM) in 477 buildings analysed within the scope of the study. This method imposes a penalty of 1.5 points for reinforced concrete structures before 2000, 1.0 points for 2000 and after, and 3.5 points for masonry structures without any year difference (Figure 5.16).

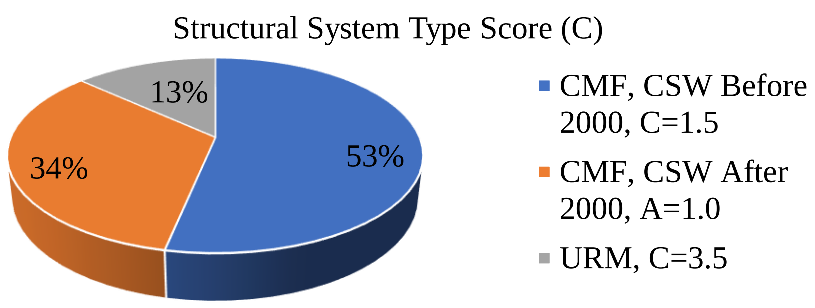



Figure 5.16. The distribution of structural system types.

Rapid earthquake performance evaluation methods rely heavily on structural irregularities to draw conclusions about building stability. These methods often assign varying penalty points for different types of structural irregularities. In the Canada seismic method, the coefficients assigned to these irregularities are represented as D points, as detailed below. Penalty points for structural irregularities may also vary depending on the year of construction. When calculating the D score, 2000 was used as the method threshold year. However, the D value can be maximum 4.0.

While the buildings were analysed regarding vertical irregularities, A2 - Floor discontinuity, A3 - Projection discontinuity in plan and B1 - Weak Storey irregularities were evaluated. If one or more of these three irregularities are found, the building is found defective regarding vertical irregularity; the penalty applied for both before and after 1970 is 1.3 points. While evaluating the horizontal irregularities, penalty points were applied to the structures with A1 - torsional irregularity and L, V, E and T-shaped structures. This penalty score was applied as 1.5 for both pre-2000 and post-2000 buildings. The short column effect is one of the critical irregularities considered in this method, resulting in a penalty of 1.5 points, applicable to buildings constructed both before and after 2000. B2 soft-storey irregularity is found in 36% of 477 buildings. While applying this method, 2.0 penalty points are applied to the buildings built before 2000 and 1.5 penalty points are applied to the buildings built after 2000. The pounding effect is another significant irregularity to be considered when analysing the method. This irregularity, which can be found at different levels in % of the analysed structures, is evaluated with 1.3 points for all construction years within the method's scope. Significant interventions made after the building has been constructed are also subject to a penalty point with this method. The addition or removal of walls and extra facade cladding are considered in this context. 1.0 penalty point is applied for post-2000 and 1.3 penalty points for pre-2000. Deformations in the structure are assessed by applying 1.3 penalty points for all construction years. If there are no structural irregularities in the building, the" D" score should be accepted as 1.0. The distribution of "D" score values calculated with the existing irregularities is as shown in figure 5.17.

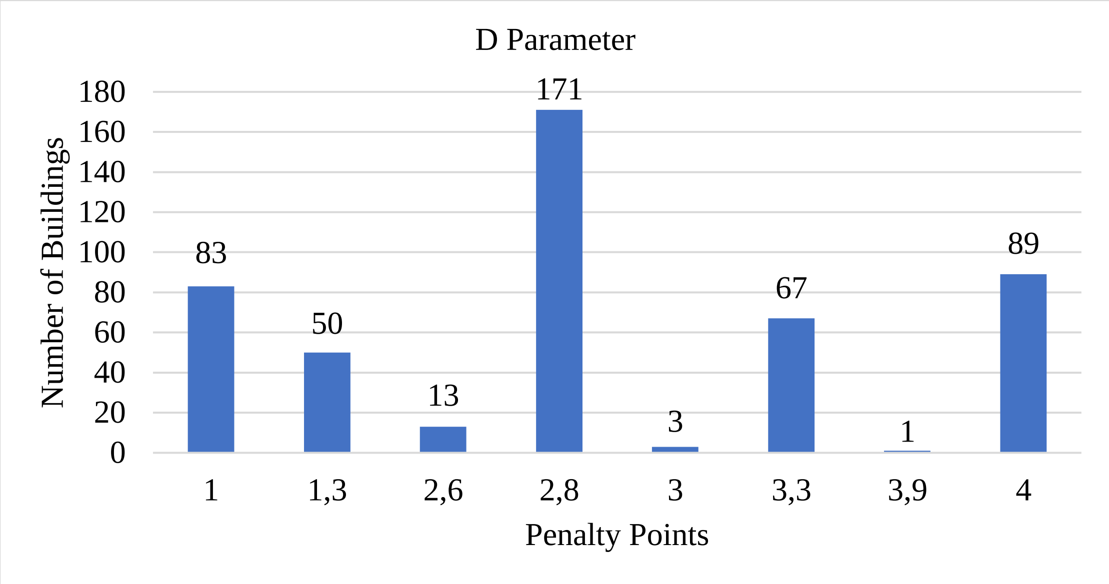



Figure 5.17. The distribution of D parameter points.

Canada's seismic method evaluates the earthquake performance of the building by considering the intended use and intensity of the building. Building importance score is considered as an "E" score. The user capacity (N) is calculated by multiplying the utilization area, usage intensity, and the percentage of weekly usage hours. Since all of the 477 buildings selected within the scope of the study are residential, the E value should be taken as 1.0 for all construction years both before and after 2000. Non-structural damage is denoted by "F". Non-structural hazards within the building, such as chimneys, parapets, cladding, curtain walls, facade cladding and overhangs, pose a potential collapse risk. The F score is divided into 2. F1, when scoring components with fall hazards, applies a penalty score of 3.0 if present and 1.0 if absent in pre-1970 buildings, 2.0 if present and 1.0 if absent in post-2000 buildings; F2, when scoring hazards in private enterprises, applies a penalty score of 3.0 if present and 1.0 if absent, regardless of the year of construction. If any of the following descriptors (SMF, eMF, soft story or torsion) is marked on page 1 of the assessment form, a penalty of 3.0 points will be applied for the F1 value for structures after 2000, 6.0 points will be applied for structures before 1970, and a penalty of 6.0 points will be applied for the F2 value regardless of the year of construction. The distribution of F parameter points is shown in figure 5.18.

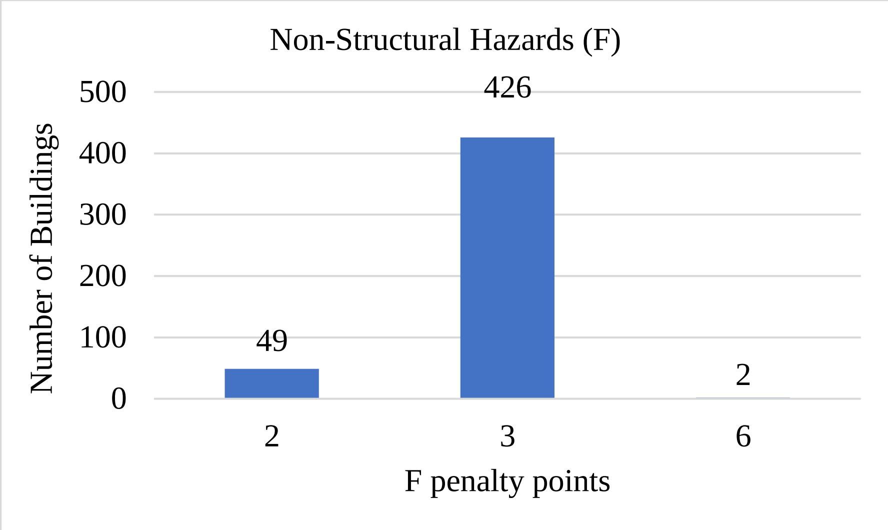



Figure 5.18. The distribution of F parameter points.

In the context of earthquake safety evaluation, buildings are categorized based on their Structural Performance Index (SPI) as follows: For structures classified under the Seismic Index (SI) or Non-Seismic Index (NSI) with an SPI ranging from 1.0 to 2.0, they are considered to have adequate earthquake safety measures. Buildings with an SPI of less than 10 are designated as low-priority structures. Those with an SPI between 10 and 20 are classified as medium-priority buildings. Buildings exhibiting an SPI greater than 20 are regarded as high-priority structures, while those with an SPI exceeding 30 are identified as hazardous buildings (Table 5.3).

The results obtained by examining the 477 buildings within the scope of the thesis according to this method are as follows and shown in Figure 5.21. A total of 40 of the buildings have SI or NSI score values between 1.0 and 2.0, so their earthquake safety is considered adequate. Since the SPI score of 189 buildings is less than 10, these buildings are considered less vulnerable to earthquakes and are classified as low-priority buildings. The SPI values of 207 structures examined were between 10 and 20 points. These structures were evaluated in the medium priority class. 39 structures were classified as high-priority structures since their SPI score was greater than 20 and less than 30. Finally, two buildings were classified as hazardous as their SPI value exceeded 30 points. This structure does not need any earthquake force to collapse, and it is in immediate danger of collapse due to its weight and structural defects. The distribution of the buildings whose risk priority classes were determined is given in Figure 5.19.

Table 5.3. Number of building distribution according to SPI values.

| Point Ranges | Priority Class | Number of Buildings |
|---|---|---|
| SI or NSI 1.0~2.0 | Adequate earthquake safety | 40 |
| SPI < 10 | Low priority buildings | 189 |
| SPI 10~20 | Medium priority buildings | 207 |
| SPI > 20 | High priority buildings | 39 |
| SPI > 30 | Very dangerous buildings | 2 |

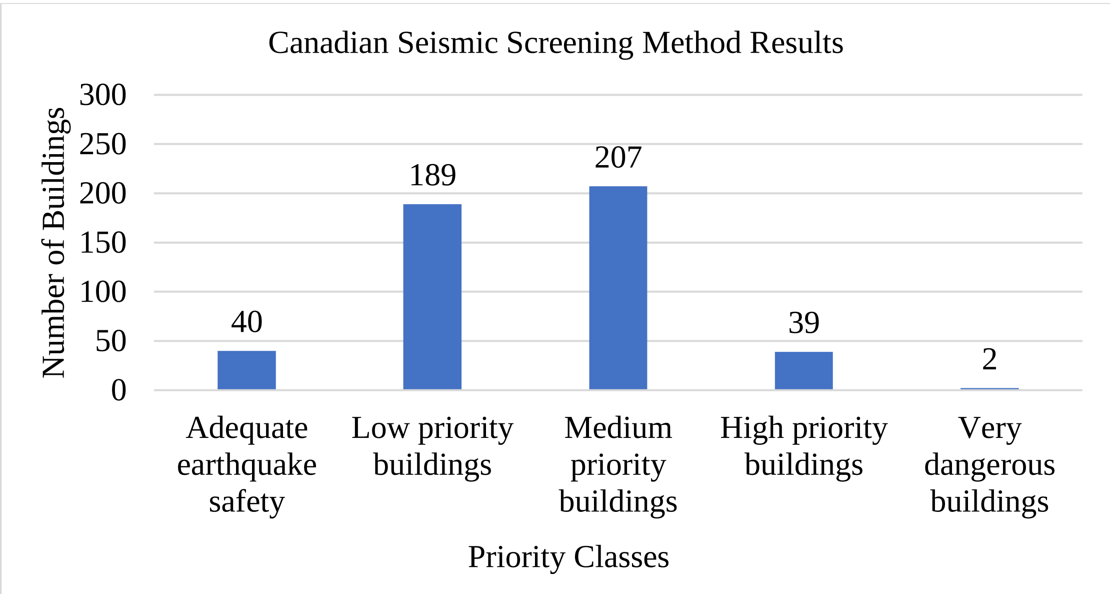



Figure 5.19. Canadian seismic screening method results.

## 5.4. Suggestions on Revisions of Penalty Coefficients Applied in Investigated Methods

This section discusses the coefficient calibrations and justifications for the changes that should be applied to make the rapid earthquake performance evaluation methods used in this study more suitable for Turkey's building stock.

### 5.4.1. Suggestions for FEMA p-154 (FEMA, 2015)

After 477 buildings selected from Adıyaman's building stock and severely affected by earthquakes were analyzed by the rapid earthquake performance evaluation methods, it was seen that each method predicted the results with different margins of error. The main reason for the difference in the results is the different penalty coefficients applied. The structural irregularities of the buildings have a significant impact on the application of penalty points. The distribution of structural irregularities in the 477 structures examined is shown in (Figure 5.20).

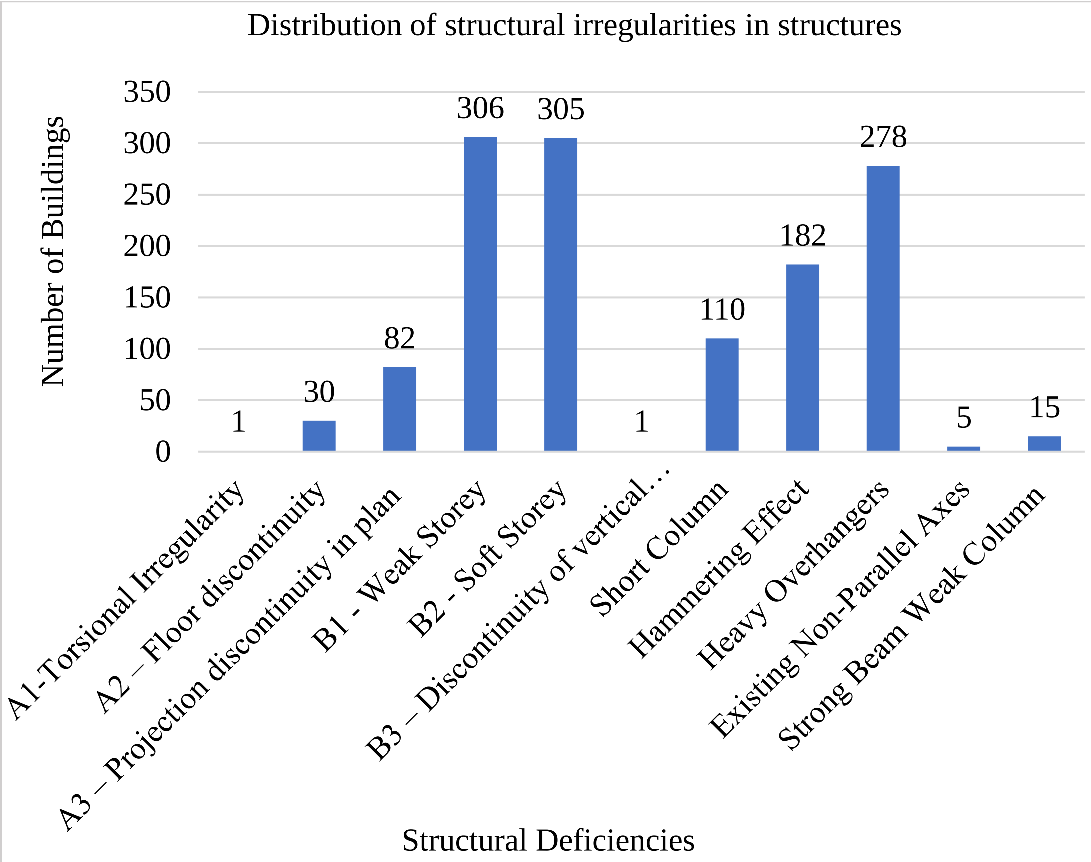



Figure 5.20. Distribution of structural irregularities in structures.

Structural irregularities are one of the most essential parameters for structures examined by rapid earthquake performance evaluation methods. In order to score these irregularities accurately, the frequency of their presence in the 477 structures examined within the scope of the thesis was considered. It is necessary to adjust the penalty values proportionally to obtain an output compatible with the data on earthquake-damaged structures. More frequent deficiencies receive a higher penalty score, while the penalty scores for rare deficiencies should be reduced. Each irregularity's frequency is normalized to determine its impact proportionally.

Penalties for each category were scaled according to their relative weights. For example, weak-storey and soft-storey irregularities were the most common in 477 structures. Since these irregularities pose a significant risk to the structure, the highest penalty points should be applied to these irregularities in the methods applied. Calibrating the data in this way will provide more reliable results while quickly assessing the earthquake performance of structures. Weak storey irregularity, one of the most common structural irregularities in 477 structures, was detected in 306 structures. Weak and soft storey irregularity can be evaluated together due to the qualifications of the analyzed buildings since both irregularities are observed in 305 buildings except for one building. The ground floors of these buildings, which have commercial spaces on the ground floors, were built higher than the other floors, and the infill walls were removed to expand the spaces. FEMA p-154 method recommends detailed analysis for only 93 of the 306 structures with weak story irregularity. Considering this situation, more penalty points can be applied when applying the method.

While re-evaluating the penalty scores, the distribution of structural irregularities in 477 buildings was considered. While calculating the $S_{L1}$ score, the scores for severe vertical irregularity ($V_{L1}$) were increased from -0.7 to -0.9 for C1-type buildings, from -0.8 to -1 for C2-type buildings, and from -0.6 to -0.8 for URM-type buildings. As for Moderate level vertical irregularity ($V_{L1}$) scores, -0.6 instead of -0.4 for C1-type buildings, -0.6 instead of -0.4 for C2-type buildings, and -0.5 instead of -0.3 for URM-type buildings. When calculating the $P_{L1}$ score, the penalty score for C1 type buildings was increased from -0.4 to -0.6, for C2 type buildings from -0.5 to -0.7, and URM type buildings from -0.3 to -0.5. In the scoring related to the year of construction of the buildings, low penalty points are applied for buildings before 2000, while high positive points are used for buildings after 2000. This situation causes the buildings constructed after 2000 to be evaluated in a significantly safer area. The penalty score applied to C1-type buildings built before 2000 was increased from -0.1 to -0.3, and the penalty score applied to C2-type buildings was increased from -0.2 to -0.6. For buildings built after 2000, 1.4 points added to C1-type buildings were reduced to 1.2, and the points added to C2-type buildings were reduced from 1.7 to 1.4. The updated data is shown in Table 5.4 in orange.

Table 5.4. Calibrated $S_{L1}$ points expressed in orange color.

| | Original Points from Evaluatin Form | | | Calibrated Penalty Points | | |
|---|---|---|---|---|---|---|
| Building Types | C1 | C2 | URM | C1 | C2 | URM |
| Basic Score | 1 | 1,2 | 0,9 | 1 | 1,2 | 0,9 |
| Severe Vertical Irregularity VL1 | -0,7 | -0,8 | -0,6 | -0,9 | -1 | -0,8 |
| Moderate Vertical Irregularity VL1 | -0,4 | -0,4 | -0,3 | -0,6 | -0,6 | -0,5 |
| Plan Irregularity PL1 | -0,4 | -0,5 | -0,3 | -0,6 | -0,6 | -0,5 |
| Pre-Code=before 2000 | -0,1 | -0,2 | 0 | -0,3 | -0,6 | 0 |
| Post-Benchmark=after 2000 | 1,4 | 1,7 | 0 | 1,2 | 1,4 | 0 |
| Smin | 0,3 | 0,3 | 0,2 | 0,3 | 0,3 | 0,2 |

In calculating the $S_{L2}$ score, adjustments were made to penalty values for various structural irregularities. The penalty score for weak/soft storey irregularities was increased from -0.4 to -0.8 in the $V_{L2}$ score for vertical irregularities. Similarly, the short-column effect penalty was raised from -0.4 to -0.7. Heavy overhangs, another significant irregularity, now incur a penalty score of -0.5, up from -0.4. The updated data of vertical irregularities is shown in Table 5.5 in orange. In calculating the $P_{L2}$ score, the penalty for out-of-plane offset irregularity was increased to -0.5. For the hammering effect, considered under the M score, the penalty score was raised from -0.7 to -0.9. The updated data of horizontal irregularities is shown in Table 5.6 in orange. For the hammering effect calculated under the M score, -0.9 penalty points were applied instead of -0.7, while structures with beamless slabs received -0.7 penalty points instead of -0.3. The updated data is shown in Figure 5.24 in orange. The updated data of M points is shown in Table 5.7 in orange.

Table 5.5. Calibrated $V_{L2}$ points expressed in orange color.

| | VL2 Penalty Points - Vertical Irregularities | | | Calibrated Penalty points | |
|---|---|---|---|---|---|
| Sloping site | for non-W1 buildings | -0,2 | | -0,2 | |
| Weak/Soft Storey | for non-W1 buildings | If the difference between storey heights is 2 storeys or more -0.7 | if it's less -0,4 | -0,8 | |
| Setback | -0,4 | | | -0,4 | |
| Short Column | -0,4 | | | -0,7 | |
| Split Levels | If the slabs of the structure do not match each other | | -0,4 | -0,4 | |
| Other Irregularity | severe -0,7 | | moderate -0,4 | -0,8 | -0,5 |

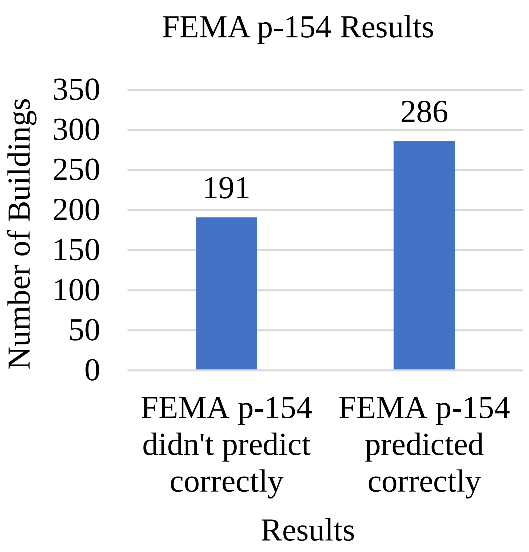
Table 5.6. Calibrated $P_{L2}$ points expressed in orange color.

| | PL2 Penalty Points - Horizontal Irregularities | Calibrated Penalty points |
|---|---|---|
| Torsional Irregularity | -0,5 | -0,5 |
| Non-parallel system | -0,2 | -0,2 |
| Reentrant corner | -0,2 | -0,2 |
| iaphragm opening | -0,2 | -0,2 |
| ut-of-plane offset | -0,2 | -0,5 |

Table 5.7. Calibrated M points expressed in orange color.

| | M Penalty Points | | Calibrated Penalty points |
|---|---|---|---|
| Redundancy | At least two bays of lateral elements on each side | 0,2 | 0,2 |
| Pounding and Hammering (max -0,9) | The floors do not align vertically within 2 feet. | -0,7 | -0,9 |
| | One building is 2 or more stories taller than the other. | -0,9 | |
| | The building is at the end of the block. | -0,4 | |
| Kirişşsiz döşeme | Flat plate serves as the beam in the moment frame. | -0,3 | -0,7 |
| | Those unidentified by street screening are considered 0 | 0 | |
| Retrofit | Comprehensive seismic retrofit is visible or known from drawings. | +1.2 | 0 |

The adjusted values according to the distribution of structural irregularities led to significant changes in the predicted structural performance values. According to FEMA p-154, the earthquake performance of 191 structures was deemed adequate when the values were as in the original evaluation form. In comparison, 286 structures were considered risky and detailed structural analysis was recommended. According to the first case, FEMA p-154 was 60% successful in predicting the earthquake performance of the structures (Figure 5.21). After the values were updated, the earthquake performance of 417 out of 477 structures was deemed inadequate and detailed structural analysis studies were recommended. On the other hand, the earthquake performance of 60 structures was deemed adequate. According to the new values, FEMA p-154 is 87.42% accurate (Figure 5.22).



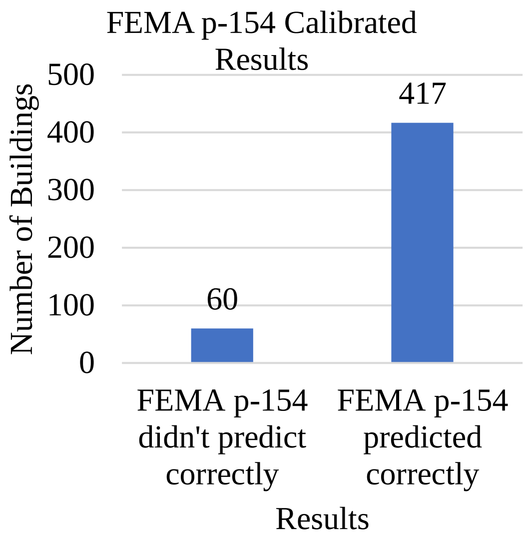




Figure 5.21. FEMA p-154 Results

Figure 5.22. FEMA p-154 Calibrated Results

### 5.4.2. Suggestions for Canadian Seismic Screening Method (Rainer et al., 1992)

The Canadian seismic screening method (Rainer, Allen, and Jablonski 1992) considers structural irregularities in the D parameter included in the product when calculating the structural index. This method applies 1.3 penalty points if there is A2-floor discontinuity, A3-projection discontinuity, pounding effect, and B1 weak floor irregularity. Torsional irregularity, 1.5 penalty points if there is an L, V, E or T-shaped building and a weak floor irregularity. The distribution in Figure 5.23 shows that the penalty points should not be so equal and close to each other. In order to increase the precision of the results obtained from the methods, it is essential to analyze the frequency of structural irregularities and assess their impact on structural performance. According to the results of the study conducted on earthquake-affected buildings, irregularities with higher incidence should receive higher penalty scores. The following adjusted penalty scores are proposed based on the observed data distributions.

Structural irregularities, which are the parameters that most affect the earthquake performance of structures, are evaluated under the D score heading in this method. Revisions to the scoring system were proposed based on the distribution of irregularities presented in Figure 5.23. For Vertical Irregularities, the original penalty of 1.3 points was increased to 2.5 points for post-2000 structures and 3.0 points for pre-2000 structures. Similarly, the Horizontal Irregularity score, initially 1.5 points for all buildings, was adjusted to 2.2 points for post-2000 structures and 2.5 points for pre-2000 structures. The penalty for the short column effect rose from 1.5 points to 2.2 points for post-2000 buildings and 2.5 points for pre-2000 buildings. The penalty for the soft storey effect was increased from 1.5 to 2.5 points in post-2000 structures and from 2.0 to 3.0 points in pre-2000 structures. The penalty for the hammering effect was revised from 1.3 to 2.4 points, while the penalty for visible deformations increased from 1.3 to 1.8. The updated data of D parameter is shown in Table 5.8 in orange.

Table 5.8. Calibrated penalty points of D parameter expressed in orange color.

| | D Parameter - Penalty Points | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1.Vertical Irregularities | 2.Horizontal Irregularities | 3.Short Columns | 4-Soft Storey | 5-Pounding | 6-Important changes | 7-Deformation | 8-None |
| 2000 sonrası | 2,0 | 1,5 | 1,5 | 2,0 | 1,8 | 1,0 | 1,3 | 1,0 |
| 2000 öncesi | 1,3 | 1,5 | 1,5 | 2,0 | 1,8 | 1,3 | 1,3 | 1,0 |
| | D Parameter - Calibrated Penalty Points | | | | | | | |
| | 1.Vertical Irregularities | 2.Horizontal Irregularities | 3.Short Columns | 4-Soft Storey | 5-Pounding | 6-Important changes | 7-Deformation | 8-None |
| 2000 sonrası | 2,5 | 2,2 | 2,2 | 2,5 | 2,4 | 1,5 | 1,8 | 1,0 |
| 2000 öncesi | 3,0 | 2,5 | 2,5 | 3,0 | 2,4 | 2,0 | 1,8 | 1,0 |

Proposed changes to the F score, which evaluates non-structural irregularities, included increasing the penalty for elements posing a falling hazard (e.g., chimneys and parapets). The moderate hazard score was increased from 2 to 4, while the severe hazard score from 6 to 8. Additionally, the building importance coefficient (E score) for residential buildings was revised from 1.0 to 1.2. The updated data of F parameter is shown in Table 5.9 in orange.

Table 5.9. Calibrated penalty points of F parameter expressed in orange color.

| F Parameter | | | | | F Parameter Calibrates Penalty points | | |
|---|---|---|---|---|---|---|---|
| | | none | yes | yes* | none | yes | yes* |
| F1=düşme tehlikesi olan elemanlar | post2000 | 1,0 | 2,0 | 3,0 | 1,0 | 4,0 | 5,0 |
| | pre2000 | 1,0 | 3,0 | 6,0 | 1,0 | 5,0 | 8,0 |
| F2=Hayati Operasyonlara Yönelik Tehlikeler | any year | 1,0 | 3,0 | 6,0 | 1,0 | 6,0 | 8,0 |
| *If one or more of the following descriptors on page 1 are circled: SMF, eMF, soft storey, torsion | | | | | | | |

After these changes, the distribution of risk groups determined for the buildings has changed significantly. According to the original evaluation form, the performance of 40 structures was found to be adequate; 189 structures were assessed as low priority, 207 structures as medium priority, 39 structures as high priority, and two structures were assessed as very dangerous (Figure 5.23). When the earthquake performances of the structures evaluated with the original evaluation form of the method were compared with Kahramanmaraş earthquake data, 41 structures with 8.59% successful predictions were found. The results obtained after calibrating the penalty scores are as follows. The seismic performance of 17 structures was found to be adequate. Four were assessed as low priority, 233 as medium priority, 94 as high priority and 129 structures were determined as very high risk. The calibrated version of the method reached a success rate of 46.75% with 223 structures (Figure 5.24).

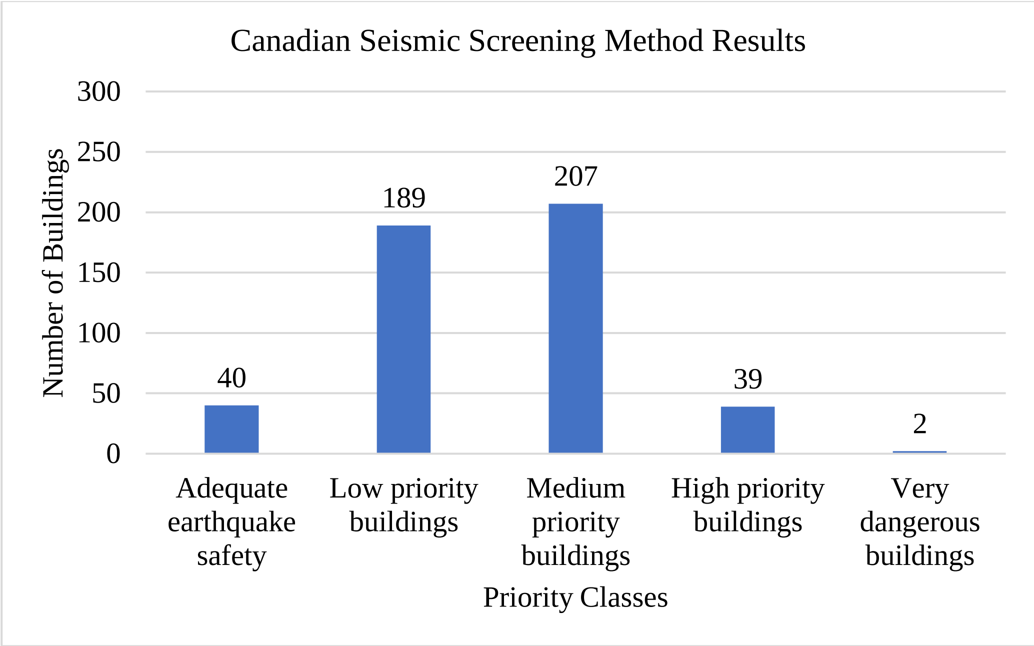



Figure 5.23. Canadian seismic screening method results.

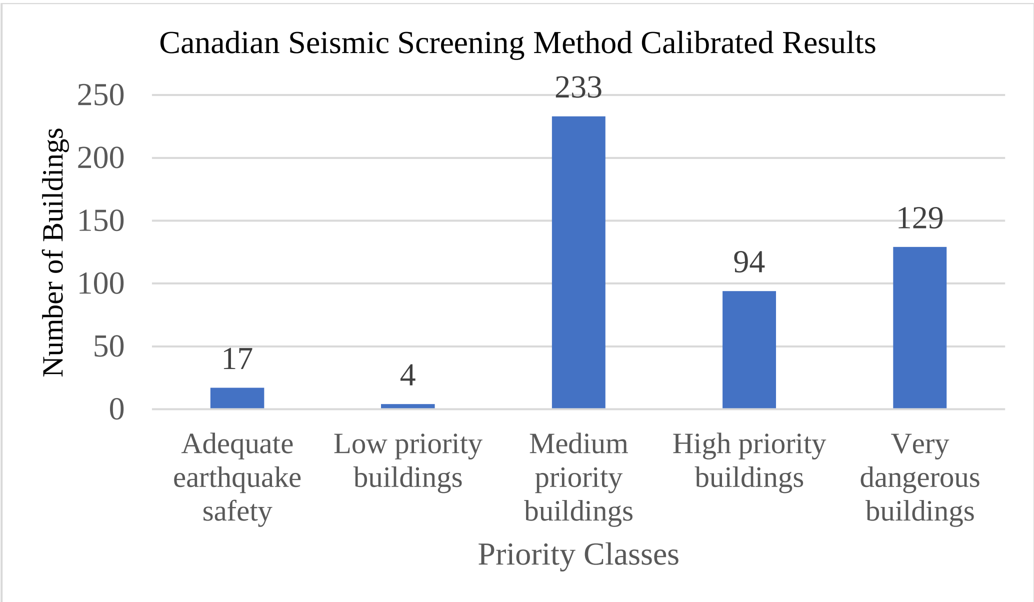



Figure 5.24. Canadian seismic screening method results with calibrated penalty points.

### 5.4.3. Suggestions for Sucuoğlu RVS Procedure (Sucuoğlu et al., 2007)

When the predicted earthquake performances of the structures are evaluated with the method developed by Sucuoğlu et al. (2007), the results mainly coincide with the actual earthquake data. When a calibration of structural irregularities was attempted, it was observed that this method evaluated only soft story irregularity, heavy overhangs, hammering effect and short column effect under the title of irregularities. The penalty points applied to the short column effect and hammering irregularities are low compared to the frequency of their presence in buildings. It is proposed to increase the score for short column effect to -10 from -5 for all buildings. In this method, the hammering effect is initially scored as 0 for 1- and 2-story buildings, -2 for 3-story buildings, and -3 for buildings with four or more stories. However, given the distribution of structural irregularities observed in the analyzed structures, these penalty scores are deemed insufficient. For this reason, the penalty points for one and 2-storey buildings were increased to -3, 3-storey buildings to -8, and for buildings with 4 or more storeys to -12. No new penalty points were proposed as it was observed that other irregularities applied enough penalty points to the structures, and these penalty points were proportional to the frequency of structural irregularities. These changes decreased the score of 183 structures and moved the risk level of 33 structures to the next level. These calibrations enable the method developed by Sucuoğlu et al. (2007) to more accurately identify the condition of 477 buildings that survived the earthquake with severe damage.

According to the evaluation made with the method's penalty scores, 149 buildings have the highest risk priority, 125 buildings have the second level risk priority, 140 buildings have the average risk priority, and no building is at the lowest risk level. When we subtracted the masonry structures that could not be evaluated, the correct prediction rate was 35%, with 149 structures out of 414 structures (Figure 5.25). After the change in penalty points, 182 buildings have the highest risk priority, 97 buildings have the second level risk priority, 135 buildings have the average risk priority, and there is no building at the lowest risk level. When we look at the method results with the updated penalty scores, the method made 43.9% correct predictions with 182 structures (Figure 5.26). The updated data of vulnerability score (VS) is shown in Table 5.10 in orange.

Table 5.10. Calibrated penalty points of vulnerability score (VS) expressed in orange color.

| | Vulnerability Score (VS) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Soft Story Effect | | Apparent Quality Effect | | | Heavy Overhang Effect | | Pounding effect | | Short Column Effect | | Topoghraphic effect | |
| Number of Stories | Doesn't Exists | Exists | Good= x0 | Moderate = x1 | Poor= x2 | Doesn't Exists | Exists | Doesn't Exists | Exists | Doesn't Exists | Exists | Doesn't Exists | Exists |
| 1,2 | 0 | 0 | 0 | -5 | -10 | 0 | -5 | 0 | 0 | 0 | -5 | 0 | 0 |
| 3 | 0 | -15 | 0 | -10 | -20 | 0 | -10 | 0 | -2 | 0 | -5 | 0 | 0 |
| 4 | 0 | -20 | 0 | -10 | -20 | 0 | -10 | 0 | -3 | 0 | -5 | 0 | -2 |
| 5 | 0 | -25 | 0 | -15 | -30 | 0 | -15 | 0 | -3 | 0 | -5 | 0 | -2 |
| 6,7 | 0 | -30 | 0 | -15 | -30 | 0 | -15 | 0 | -3 | 0 | -5 | 0 | -2 |

| | Vulnerability Score (VS) Calibrated Penalty Points | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Soft Story Effect | | Apparent Quality Effect | | | Heavy Overhang Effect | | Pounding effect | | Short Column Effect | | Topoghraphic effect | |
| Number of Stories | Doesn't Exists | Exists | Good= x0 | Moderate = x1 | Poor= x2 | Doesn't Exists | Exists | Doesn't Exists | Exists | Doesn't Exists | Exists | Doesn't Exists | Exists |
| 1,2 | 0 | 0 | 0 | -5 | -10 | 0 | -5 | 0 | -3 | 0 | -10 | 0 | 0 |
| 3 | 0 | -15 | 0 | -10 | -20 | 0 | -10 | 0 | -8 | 0 | -10 | 0 | 0 |
| 4 | 0 | -20 | 0 | -10 | -20 | 0 | -10 | 0 | -12 | 0 | -10 | 0 | -2 |
| 5 | 0 | -25 | 0 | -15 | -30 | 0 | -15 | 0 | -12 | 0 | -10 | 0 | -2 |
| 6,7 | 0 | -30 | 0 | -15 | -30 | 0 | -15 | 0 | -12 | 0 | -10 | 0 | -2 |

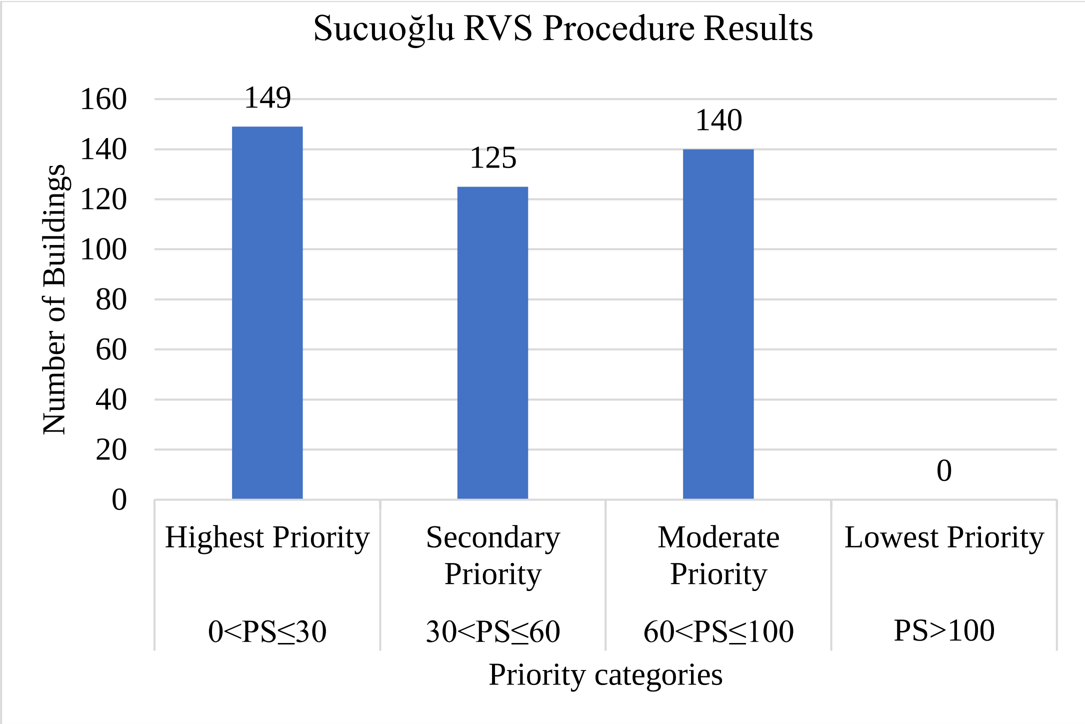



Figure 5.25. Sucuoğlu RVS Procedure results.

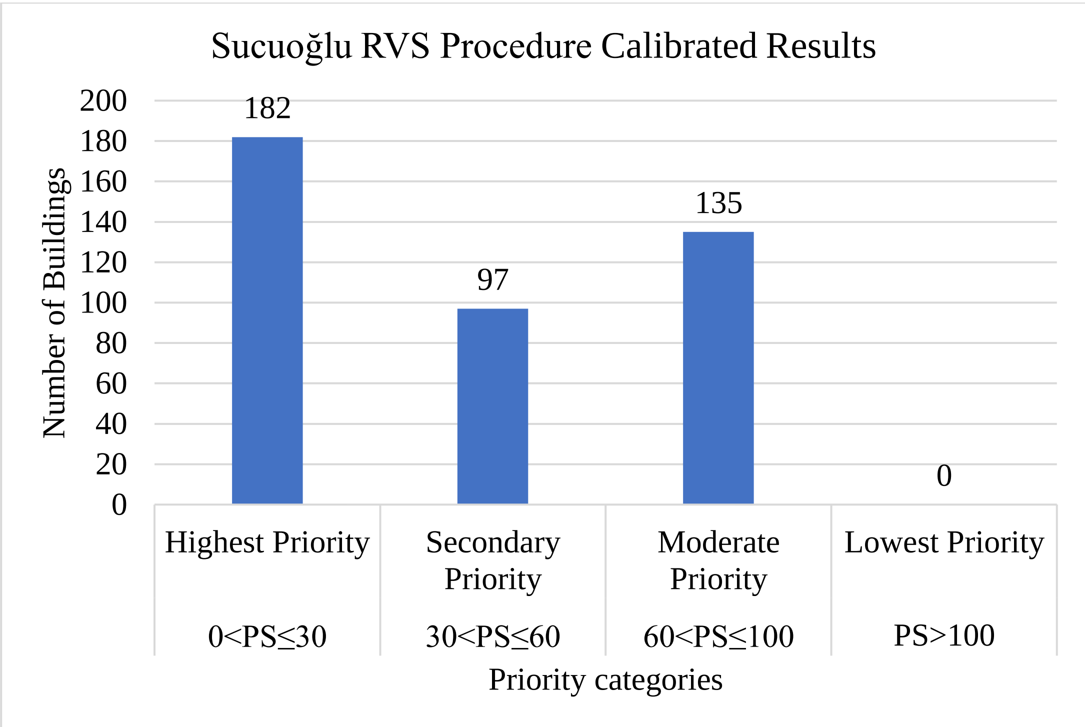



Figure 5.26. Sucuoğlu RVS Procedure results with calibrated penalty points.

# CHAPTER 6

# CONCLUSION

Within the scope of the thesis, studies were carried out on the building stock of Adıyaman, one of the most severely impacted cities by the February 6 Kahramanmaraş earthquakes. The thesis focused on 477 buildings selected among the earthquake-affected buildings that survived the earthquake as heavily damaged, requiring urgent demolition and collapsed during the earthquake.

The years of construction, number of storeys, load-bearing systems, locations, general conditions, intended uses and structural irregularities of these buildings were evaluated. When the structural irregularities of the buildings are considered, it is observed that 306 of 477 buildings have weak floor/soft floor irregularities, and 278 of the buildings have heavy overhangs. These irregularities, which impact the earthquake performance of the buildings at supreme level, arise as a result of the decisions taken to increase the profit margin obtained from the constructions and to create a showcase on the ground floors. Structural irregularities, combined with the above-mentioned defects, have led to worsening of earthquake damage to buildings. These structural irregularities and the problems they cause arise from the decisions made during the architectural design phase. It is concluded that architects have a crucial role in preventing the frequency of structural irregularities, which are examined in detail within the scope of this study, as well as the loss of life and property caused by earthquakes. With this study, it has been revealed how effective the architects' decisions taken during the design phase, which can be easily changed. When the causes of damage are evaluated in the light of these parameters, the reasons for damage are as follows:

- insufficient concrete strength and quality,
- low quality of reinforcement type and detailing,
- lack of adequate inspections,
- lack of implementation on structural projects,
- many irregularities stemming from architectural projects which exaggerate the extent of damage

Moreover, in the first stage of the study, which was conducted for 477 selected buildings, the question of how the performance of the buildings would be if rapid earthquake performance evaluation methods evaluated these buildings was sought to be answered. Three methods were selected at the street scanning level, which can evaluate the structures with unique calculations according to different parameters. Among these methods, FEMA p-154 (FEMA 2015) found 191 structures risky among 477 structures and recommended detailed structural analysis. Sucuoğlu et al. (2007) divided the structures into risk groups and selected 149 structures in the highest-risk group. Finally, the Canadian seismic screening method (Rainer et al., 1992) divided the structures into priority classes and selected 2 very dangerous and 39 high-priority structures.

The rapid earthquake performance evaluation methods examined rated some buildings severely damaged in the earthquake as a safe or low-risk priority. When the reasons for this result are examined, it is observed that the penalty points applied for structural irregularities are low. This situation is relatively better in the method Sucuoğlu et al. (2007) developed for the Türkiye building stock compared to the other two methods. For this reason, while modifying the penalty scores, rearrangement of the short column effect and hammering effect parameters, which had low scores, enabled the method to perform better. One of the most important disadvantages of this method is that it cannot evaluate masonry structures, unlike the other two methods.

Since the FEMA p-154 method (FEMA 2015) was prepared for the American building stock, the penalty points applied are less compatible with the Türkiye building stock. For this reason, the structural irregularity score, explained in detail in Chapter 5, increased significantly, and the method's success rate increased from 40% to 87.24%.

The Canadian seismic screening method (Rainer et al., 1992) was developed for the Canadian building stock. In the method with similar approaches to FEMA, the penalty points applied to structural irregularities were limited, and a maximum of "-4" penalty points could be applied for a structure. In the first proposal for the method, this limit was removed, and the penalty points applied to structural irregularities were updated according to their frequency of occurrence in the analyzed building stock. Thanks to these updates, the method evaluates 94 buildings high priority and 129 buildings very dangerous. These changes increased the success rate to %46.75. Additionally, it was suggested to update the building importance coefficient determined for residential buildings from 1 to 1.2. This parameter is determined according to the frequency of people's presence, and it is seen that people are caught in the houses when the earthquake occurs at night, as in the February 6 earthquakes. Therefore, it was suggested to increase the importance coefficient.

Suggestions for future studies on the subject are as follows:

- The number of analyzed buildings can be increased, enabling the developed database to yield more precise and reliable results regarding the prevalence of structural irregularities.
- While increasing the number of buildings examined, the number of buildings with different construction techniques such as masonry, wood, and steel can be increased, and the performance of the methods in different construction techniques can be evaluated.
- The buildings examined in this study were exclusively selected from the Adıyaman building stock. Expanding the scope of the study to include buildings from various regions, soil classifications, and seismic zones could enhance the methods' performance. Such an approach would also enable calibration studies to yield more accurate and representative results applicable to buildings nationwide.
- The data collection, which is necessary for applying the methods, can be made easier with the help of various software. Collecting the different parameters needed by different methods to evaluate the structural performance of different methods through a single software can enable the observation of the structural performance prediction of more than one method at the same time.
- The analyzed structures can be processed into geographic information systems (GIS) such as ArcGIS. In this way, an extensive building library can be created for future studies, while information about the status of the building stock can be obtained from a constantly growing database.

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# APPENDICES

# APPENDIX A

## DATA OF 477 BUILDINGS SELECTED FROM ADIYAMAN BUILDING STOCK AND PRESENCE OF STRUCTURAL IRREGULARITIES

Table A.1 Data from 477 buildings which are selected from Adıyaman building stock and the presence of structural irregularities in these buildings

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 1 | 8 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | NO | YES | NO | NO | NO |
| 2 | 10 | 2023 | 2023 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 3 | 10 | 2010 | 2007 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 4 | 7 | 1999 | 1999 | Collapsed | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 5 | 9 | 1999 | 1999 | Collapsed | Frame Structure - Reinforced Concrete | NO | YES | NO | YES | YES | NO | YES | YES | NO | NO | NO | NO |
| 6 | 3 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | NO |
| 7 | 5 | No data | 2000 | Collapsed | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | YES | NO |
| 8 | 2 | No data | 2003 | Collapsed | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 9 | 4 | 2000 | 2000 | Collapsed | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | YES | YES |
| 10 | 8 | 2000 | 2000 | Collapsed | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | NO |
| 11 | 7 | 2000 | 2000 | Collapsed | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | NO |
| 12 | 5 | 2010 | 2020 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | YES | NO | YES | NO | NO | NO |
| 13 | 5 | 2005 | 2017 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | YES |
| 14 | 2 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | YES |

(Cont. on next page)

(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 15 | 7 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | NO | NO | NO | YES |
| 16 | 2 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | NO |
| 17 | 1 | 1990 | 1990 | Heavy Damage | Masonry Walled Structure - Bricket | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 18 | 4 | 2021 | 2021 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 19 | 4 | 2021 | 2021 | Heavy Damage | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | NO |
| 20 | 4 | 2020 | 2020 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | NO | YES | NO | NO | NO |
| 21 | 1 | 1980 | 1980 | Heavy Damage | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | NO |
| 22 | 3 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | NO | NO | YES | NO | NO | YES |
| 23 | 2 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 24 | 2 | 2005 | 2005 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | NO | YES | NO | NO | NO | NO |
| 25 | 5 | 2010 | 2019 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | YES | NO | YES | YES | YES | NO | NO | YES |
| 26 | 3 | 2005 | 2005 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | NO | NO | YES | NO | NO | NO |
| 27 | 3 | 1970 | 1970 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | NO | NO | YES | NO |
| 28 | 3 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | NO | NO | NO | YES |
| 29 | 3 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | YES |

(Cont. on next page)

(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 30 | 3 | 1995 | 1995 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | NO |
| 31 | 3 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 32 | 2 | 1995 | 1995 | Heavy Damage | Masonry Walled Structure - Bricket | NO | NO | NO | NO | NO | NO | NO | YES | NO | NO | NO | YES |
| 33 | 3 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | NO | YES | YES | NO | YES | NO |
| 34 | 1 | 1985 | 1985 | Heavy Damage | Masonry Walled Structure - Bricket | NO | NO | NO | NO | NO | NO | YES | YES | NO | NO | YES | YES |
| 35 | 2 | 1950 | 1950 | Heavy Damage | Masonry Walled Structure - Bricket | NO | NO | YES | NO | NO | NO | NO | YES | NO | NO | NO | YES |
| 36 | 1 | 1980 | 1980 | Heavy Damage | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 37 | 2 | 1998 | 1998 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | YES | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 38 | 2 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | YES | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 39 | 5 | 1995 | 1995 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 40 | 5 | 1995 | 1995 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 41 | 6 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | YES | YES | NO | NO | NO | NO | NO | YES | NO | NO | YES |
| 42 | 6 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | YES | YES | NO | NO | NO | NO | NO | YES | NO | NO | NO |
| 43 | 4 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | YES | YES | YES | YES | NO | NO | YES | YES | NO | NO | NO |

(Cont. on next page)

(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 44 | 3 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | NO | NO | NO | NO |
| 45 | 5 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | NO | NO | NO | YES |
| 46 | 5 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | YES | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 47 | 1 | 2005 | 2005 | Heavy Damage | Frame Structure - Steel | - | - | - | - | - | - | - | - | - | - | - | YES |
| 48 | 4 | 2000 | 2005 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | NO |
| 49 | 4 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | NO |
| 50 | 4 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | YES | YES | YES | NO | YES | YES | NO | NO | NO | YES |
| 51 | 5 | 1990 | 2005 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | YES | YES | YES | NO | YES | YES | NO | NO | NO | YES |
| 52 | 4 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | NO | NO | NO | YES |
| 53 | 2 | 1990 | 2005 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | NO | NO | NO | YES |
| 54 | 3 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | NO | NO | NO | YES |
| 55 | 2 | 1990 | 1990 | Heavy Damage | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 56 | 6 | 1995 | 1995 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | NO | NO | NO | YES |
| 57 | 5 | 1995 | 1995 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | YES | NO | NO | YES |

(Cont. on next page)

(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 58 | 5 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | YES | NO | NO | YES |
| 59 | 3 | 1985 | 1985 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | NO | NO | NO | YES |
| 60 | 3 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | NO |
| 61 | 2 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | YES | YES | YES | YES | NO | NO | YES | NO | NO | NO | NO |
| 62 | 5 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | YES | YES | YES | NO | NO | YES | NO | NO | NO | NO |
| 63 | 5 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | YES | YES | YES | NO | NO | YES | NO | NO | NO | NO |
| 64 | 5 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | NO |
| 65 | 5 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | YES | YES | YES | NO | YES | YES | NO | NO | NO | YES |
| 66 | 6 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 67 | 6 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 68 | 4 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | NO | NO | NO | NO |
| 69 | 6 | 1984 | 1984 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | YES | NO |
| 70 | 3 | 2012 | 2012 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | YES |
| 71 | 1 | 2000 | 2000 | Heavy Damage | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | NO |

(Cont. on next page)

(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 72 | 1 | 1990 | 1990 | Heavy Damage | Masonry Walled Structure - Bricket | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 73 | 5 | 1985 | 1985 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | NO | NO | NO | NO |
| 74 | 3 | 1960 | 1960 | To be Urgently Demolished | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 75 | 5 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | NO | NO | YES | NO | NO | YES |
| 76 | 2 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | YES | YES | YES | NO | YES | NO | YES | NO | NO | NO |
| 77 | 5 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | YES | NO | NO | NO | NO | NO | YES | YES | NO | NO | YES |
| 78 | 2 | 2005 | 2005 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | NO | YES | NO | NO | NO | YES |
| 79 | 1 | 2000 | 2000 | Heavy Damage | Masonry Walled Structure - Bricket | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | YES |
| 80 | 3 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | NO | NO | YES | NO | NO | NO |
| 81 | 1 | 1975 | 1975 | Heavy Damage | Masonry Walled Structure - Bricket | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | YES |
| 82 | 4 | 1980 | 1980 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | YES | NO | YES | YES | NO | NO | YES | NO | NO | NO | NO |
| 83 | 3 | 1980 | 1980 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | NO |
| 84 | 9 | 2010 | 2010 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 85 | 9 | 2005 | 2005 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |

(Cont. on next page)

(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 86 | 10 | 2023 | 2023 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | YES | YES | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 87 | 5 | 2016 | 2016 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | YES |
| 88 | 3 | 2007 | 2007 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 89 | 5 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | NO |
| 90 | 4 | 2014 | 2014 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | NO |
| 91 | 5 | 2015 | 2015 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | NO |
| 92 | 5 | 1985 | 1985 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | YES |
| 93 | 5 | 1985 | 1985 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | YES | NO |
| 94 | 4 | No data | 2003 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | YES | YES | NO |
| 95 | 3 | No data | 2003 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 96 | 3 | No data | 2003 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 97 | 7 | No data | 2003 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | NO | NO | YES | NO |
| 98 | 8 | No data | 2003 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | YES | YES | NO |
| 99 | 2 | No data | 2003 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | YES | NO |

(Cont. on next page)

(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 100 | 3 | No data | 2003 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | YES | YES |
| 101 | 2 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | NO | NO | NO | NO |
| 102 | 2 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | YES | YES |
| 103 | 2 | 2014 | 2014 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 104 | 1 | 2010 | 2010 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | NO | NO | NO | NO |
| 105 | 2 | 2015 | 2003 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | NO |
| 106 | 1 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | NO | NO | NO | NO |
| 107 | 4 | 2010 | 2014 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 108 | 1 | 2010 | 2010 | Heavy Damage | Masonry Walled Structure - Brick | - | - | - | - | - | - | - | - | - | - | - | YES |
| 109 | 1 | 1995 | 1995 | Heavy Damage | Masonry Walled Structure - Brick | - | - | - | - | - | - | - | - | - | - | - | YES |
| 110 | 1 | 1995 | 1995 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 111 | 1 | 1995 | 1995 | Heavy Damage | Frame Structure - Reinforced Concrete | - | - | - | - | - | - | - | - | - | - | - | YES |
| 112 | 9 | 2015 | 2015 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | NO |
| 113 | 9 | 2015 | 2015 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | NO | NO | NO | NO |

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(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 114 | 9 | 2015 | 2015 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 115 | 9 | 2010 | 2010 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | YES | NO | YES | NO | NO | YES |
| 116 | 9 | 2010 | 2010 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | YES | NO | YES | NO | NO | YES |
| 117 | 9 | 2010 | 2010 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | YES | NO | YES | NO | NO | YES |
| 118 | 9 | 2010 | 2010 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | YES | NO | YES | NO | NO | YES |
| 119 | 9 | 2015 | 2015 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | YES |
| 120 | 9 | 2010 | 2010 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | YES | NO | YES | NO | NO | NO |
| 121 | 9 | 2010 | 2010 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | YES | NO | YES | NO | NO | NO |
| 122 | 9 | 2010 | 2010 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | YES | NO | YES | NO | NO | NO |
| 123 | 9 | 2010 | 2010 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | YES | NO | YES | NO | NO | NO |
| 124 | 1 | 1998 | 1998 | Heavy Damage | Masonry Walled Structure - Brick | - | - | - | - | - | - | - | - | - | - | - | YES |
| 125 | 4 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | YES |
| 126 | 2 | 1980 | 1980 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | YES | YES |
| 127 | 1 | 1970 | 1970 | To be Urgently Demolished | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |

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(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 128 | 2 | 1980 | 1980 | To be Urgently Demolished | Masonry Walled Structure - Bricket | NO | NO | NO | NO | NO | NO | NO | YES | NO | NO | NO | YES |
| 129 | 4 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | YES | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 130 | 2 | 2019 | 2019 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 131 | 1 | 2008 | 2008 | Heavy Damage | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 132 | 1 | 2008 | 2008 | Heavy Damage | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 133 | 2 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | YES |
| 134 | 1 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | YES |
| 135 | 4 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 136 | 9 | 2015 | 2015 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | NO | NO | YES | NO | NO | NO |
| 137 | 9 | 2015 | 2015 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | NO | NO | YES | NO | NO | NO |
| 138 | 9 | 2015 | 2015 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | NO | NO | YES | NO | NO | NO |
| 139 | 9 | 2021 | 2021 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | YES | NO | YES | NO | NO | NO |
| 140 | 9 | 2022 | 2022 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | YES | NO | YES | NO | NO | NO |
| 141 | 9 | 2022 | 2022 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | YES | NO | YES | NO | NO | NO |

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(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 142 | 8 | 2023 | 2023 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | YES | NO | YES | NO | NO | NO |
| 143 | 7 | 2017 | 2017 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | YES | NO | YES | NO | NO | NO |
| 144 | 7 | 2017 | 2017 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | YES | NO | YES | NO | NO | NO |
| 145 | 9 | 2008 | 2008 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | NO | NO | YES | NO | NO | YES |
| 146 | 8 | 2008 | 2008 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | NO | NO | YES | NO | NO | YES |
| 147 | 8 | 2008 | 2008 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 148 | 8 | 2008 | 2008 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | YES | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 149 | 3 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | NO | YES | NO | NO | NO | YES |
| 150 | 1 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO |
| 151 | 2 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | NO |
| 152 | 1 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | YES | NO |
| 153 | 1 | 1980 | 1980 | Heavy Damage | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | NO |
| 154 | 4 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 155 | 4 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | YES |

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(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 156 | 2 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 157 | 3 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | NO | YES | NO | NO | YES |
| 158 | 4 | 2009 | 2009 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | YES | YES | YES | NO | NO | YES |
| 159 | 3 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 160 | 4 | 2012 | 2012 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | YES | NO | YES | NO | NO | NO |
| 161 | 5 | 2010 | 2010 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | YES | NO | YES | NO | NO | NO |
| 162 | 2 | 2007 | 2007 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | YES | NO | YES | YES | NO | NO | YES | YES | NO | NO | NO |
| 163 | 2 | 2002 | 2002 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | YES |
| 164 | 3 | 2009 | 2009 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 165 | 5 | 2012 | 2012 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | YES |
| 166 | 1 | 2008 | 2008 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | NO | NO | NO | YES | YES | NO | NO | NO |
| 167 | 4 | 2007 | 2007 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | NO | YES | YES | NO | NO | NO |
| 168 | 9 | 2009 | 2009 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | NO |
| 169 | 4 | 2006 | 2006 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | YES |

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(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 170 | 2 | 2007 | 2007 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | YES |
| 171 | 5 | 2008 | 2008 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | NO | YES | YES | NO | NO | NO |
| 172 | 3 | 2008 | 2008 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | YES |
| 173 | 4 | 2018 | 2018 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | NO | NO | YES | NO | NO | NO |
| 174 | 4 | 2008 | 2008 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 175 | 5 | 2005 | 2005 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | YES | NO | NO | NO | YES | NO | YES | YES | NO | NO | YES |
| 176 | 2 | 1999 | 1999 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | NO | NO | YES | NO | NO | YES |
| 177 | 4 | 2009 | 2009 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | YES |
| 178 | 5 | 2009 | 2009 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | NO | NO | YES | NO | NO | YES |
| 179 | 4 | 2008 | 2008 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | YES | NO | YES | NO | NO | NO |
| 180 | 4 | 2009 | 2009 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | NO | YES | YES | NO | NO | YES |
| 181 | 3 | 2007 | 2007 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | NO |
| 182 | 5 | 2010 | 2010 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | YES |
| 183 | 5 | 2010 | 2010 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | YES |

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(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 184 | 4 | 2008 | 2008 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | NO | NO | YES | YES | NO | YES |
| 185 | 6 | 2015 | 2015 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 186 | 4 | 1999 | 1999 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | YES | NO | YES |
| 187 | 4 | 1999 | 1999 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | YES | NO | YES |
| 188 | 1 | 2010 | 2010 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | NO | NO | YES | NO | NO | YES |
| 189 | 9 | 2018 | 2018 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | NO | NO | NO | YES |
| 190 | 4 | 2010 | 2010 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 191 | 1 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | NO | YES | NO | NO | NO | YES |
| 192 | 9 | 2005 | 2005 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | YES |
| 193 | 2 | 1985 | 1985 | Heavy Damage | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 194 | 2 | 1970 | 1970 | Heavy Damage | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 195 | 1 | 1980 | 1980 | Heavy Damage | Melez Yapı - Yarı Karkas | NO | NO | NO | NO | NO | NO | NO | NO | YES | NO | NO | NO |
| 196 | 4 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | YES |
| 197 | 5 | 2008 | 2008 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | YES |

(Cont. on next page)

(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 198 | 2 | 1980 | 1980 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | NO | YES | NO | NO | NO | NO |
| 199 | 2 | 1960 | 1960 | Heavy Damage | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 200 | 1 | 1950 | 1950 | Heavy Damage | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 201 | 2 | 1960 | 1960 | Heavy Damage | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 202 | 2 | 1980 | 1980 | Heavy Damage | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 203 | 4 | 2008 | 2008 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | YES | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | YES |
| 204 | 11 | 2015 | 2015 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | NO |
| 205 | 11 | 2015 | 2015 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 206 | 11 | 2015 | 2015 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 207 | 11 | 2015 | 2015 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | YES | YES | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 208 | 3 | No data | 2003 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 209 | 6 | No data | 2003 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 210 | 3 | No data | 2003 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 211 | 5 | No data | 2014 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |

(Cont. on next page)

(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 212 | 5 | No data | 2003 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | NO |
| 213 | 3 | No data | 2003 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | YES | NO | YES | YES | NO | NO | YES | NO | NO | NO | NO |
| 214 | 3 | No data | 2003 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | NO |
| 215 | 4 | No data | 2003 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 216 | 3 | No data | 2003 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 217 | 5 | No data | 2003 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | YES | YES | YES | YES | NO | NO | NO | YES | NO | NO | YES |
| 218 | 5 | No data | 2003 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | YES |
| 219 | 2 | No data | 2003 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | YES |
| 220 | 5 | No data | 2003 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 221 | 5 | No data | 2003 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 222 | 4 | No data | 2003 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | NO |
| 223 | 5 | No data | 2003 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | YES |
| 224 | 4 | No data | 2003 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | YES |

(Cont. on next page)

(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 225 | 3 | No data | 2003 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 226 | 4 | No data | 2003 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | YES |
| 227 | 4 | No data | 2003 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 228 | 5 | No data | 2003 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 229 | 2 | No data | 2003 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | YES |
| 230 | 3 | No data | 2003 | To be Urgently Demolished | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 231 | 5 | 1998 | 1998 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | NO |
| 232 | 6 | 1998 | 1998 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | NO |
| 233 | 5 | 1998 | 1998 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | NO |
| 234 | 2 | 1998 | 1998 | To be Urgently Demolished | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 235 | 1 | 1998 | 1998 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 236 | 6 | 1998 | 1998 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | YES | YES | YES | YES | NO | NO | NO | YES | NO | NO | NO |

(Cont. on next page)

(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 237 | 9 | 1998 | 1998 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | YES |
| 238 | 1 | 1998 | 1998 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 239 | 2 | 1975 | 1975 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | NO |
| 240 | 8 | 1995 | 1995 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 241 | 5 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | NO |
| 242 | 5 | 2016 | 2010 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | YES |
| 243 | 3 | 1998 | 1998 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | YES | YES | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 244 | 4 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 245 | 3 | 1995 | 1995 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | YES |
| 246 | 5 | 2012 | 2016 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | NO |
| 247 | 10 | 2010 | 2010 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | NO |
| 248 | 6 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | NO |
| 249 | 6 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 250 | 5 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | YES | YES | YES | YES | NO | NO | NO | YES | NO | NO | NO |

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(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 251 | 4 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | YES |
| 252 | 5 | 1985 | 1985 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 253 | 2 | 1982 | 1982 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | NO |
| 254 | 2 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | NO |
| 255 | 3 | 1970 | 1970 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | NO |
| 256 | 5 | 1980 | 1980 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | YES |
| 257 | 2 | 1980 | 1980 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | NO |
| 258 | 3 | 1985 | 1985 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 259 | 4 | 1986 | 1986 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | NO |
| 260 | 4 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 261 | 4 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | YES | YES | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 262 | 2 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |

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(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 263 | 1 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 264 | 1 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | NO |
| 265 | 4 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | NO |
| 266 | 4 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | NO |
| 267 | 3 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | YES |
| 268 | 5 | 2005 | 2005 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 269 | 5 | 2017 | 2018 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 270 | 2 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | YES |
| 271 | 4 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | YES |
| 272 | 9 | 2010 | 2010 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | YES | YES | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 273 | 9 | 2015 | 2015 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | YES |
| 274 | 10 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 275 | 4 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |

(Cont. on next page)

(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 276 | 3 | 1995 | 1995 | Heavy Damage | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 277 | 1 | 1985 | 1985 | To be Urgently Demolished | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 278 | 3 | 1995 | 1995 | To be Urgently Demolished | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 279 | 1 | 1990 | 1990 | To be Urgently Demolished | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 280 | 1 | 1980 | 1980 | To be Urgently Demolished | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 281 | 2 | 1995 | 1995 | To be Urgently Demolished | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 282 | 2 | 1995 | 1995 | To be Urgently Demolished | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 283 | 1 | 1960 | 1960 | To be Urgently Demolished | Masonry Walled Structure - Adobe | - | - | - | - | - | - | - | - | - | - | - | YES |
| 284 | 1 | 1965 | 1965 | To be Urgently Demolished | Masonry Walled Structure - Adobe | - | - | - | - | - | - | - | - | - | - | - | YES |
| 285 | 1 | 1970 | 1970 | To be Urgently Demolished | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 286 | 1 | 1999 | 1999 | To be Urgently Demolished | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 287 | 1 | 1970 | 1970 | To be Urgently Demolished | Masonry Walled Structure - Adobe | - | - | - | - | - | - | - | - | - | - | - | YES |

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(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 288 | 1 | 1970 | 1970 | To be Urgently Demolished | Masonry Walled Structure - Adobe | - | - | - | - | - | - | - | - | - | - | - | YES |
| 289 | 2 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 290 | 1 | 1980 | 1980 | To be Urgently Demolished | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 291 | 1 | 1970 | 1970 | To be Urgently Demolished | Masonry Walled Structure - Adobe | - | - | - | - | - | - | - | - | - | - | - | YES |
| 292 | 1 | 1970 | 1970 | To be Urgently Demolished | Masonry Walled Structure - Adobe | - | - | - | - | - | - | - | - | - | - | - | YES |
| 293 | 5 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | YES |
| 294 | 2 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | YES | YES | YES | YES | NO | NO | NO | YES | NO | NO | YES |
| 295 | 2 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 296 | 5 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 297 | 5 | 1980 | 1980 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 298 | 3 | 1999 | 1999 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | NO |

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(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 299 | 4 | 1999 | 1999 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | NO |
| 300 | 9 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 301 | 10 | 2012 | 2017 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | NO |
| 302 | 7 | 2005 | 2005 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 303 | 7 | 2005 | 2005 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | YES |
| 304 | 7 | 2005 | 2005 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | YES | YES | YES | YES | NO | NO | NO | YES | NO | NO | YES |
| 305 | 7 | 2005 | 2005 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | YES |
| 306 | 4 | 2014 | 2014 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 307 | 9 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 308 | 3 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 309 | 5 | 2010 | 2010 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | YES |
| 310 | 3 | 2007 | 2007 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | YES |

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(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 311 | 1 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 312 | 1 | 1970 | 1970 | Heavy Damage | Masonry Walled Structure - Adobe | - | - | - | - | - | - | - | - | - | - | - | YES |
| 313 | 1 | 1980 | 1980 | Heavy Damage | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 314 | 3 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | YES |
| 315 | 7 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 316 | 7 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 317 | 7 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | YES |
| 318 | 7 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 319 | 7 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 320 | 7 | 2005 | 2005 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | NO |
| 321 | 8 | 2010 | 2010 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | YES |
| 322 | 3 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | NO |
| 323 | 1 | 1980 | 1980 | To be Urgently Demolished | Masonry Walled Structure - Brick | - | - | - | - | - | - | - | - | - | - | - | YES |

(Cont. on next page)

(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 324 | 3 | 2008 | 2008 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | YES |
| 325 | 2 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 326 | 2 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 327 | 3 | No data | 2003 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | NO |
| 328 | 2 | No data | 2010 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 329 | 5 | No data | 2007 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 330 | 5 | No data | 2017 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | YES |
| 331 | 5 | No data | 2017 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | NO | NO | NO | NO | NO | YES | NO | NO | NO |
| 332 | 5 | No data | 2017 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | YES |
| 333 | 2 | No data | 2003 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | YES |
| 334 | 5 | No data | 2010 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 335 | 4 | No data | 2010 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | NO |
| 336 | 4 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | YES |
| 337 | 4 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | NO |

(Cont. on next page)

(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 338 | 3 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 339 | 1 | 1990 | 1990 | Heavy Damage | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 340 | 2 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | NO |
| 341 | 2 | 2010 | 2010 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | NO |
| 342 | 1 | 1990 | 1990 | Heavy Damage | Masonry Walled Structure - Bricket | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | YES |
| 343 | 1 | 1995 | 1995 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | NO |
| 344 | 1 | 1990 | 1990 | Heavy Damage | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 345 | 3 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 346 | 1 | 1990 | 1990 | Heavy Damage | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 347 | 4 | 2015 | 2015 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 348 | 1 | 2002 | 2002 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | YES |
| 349 | 1 | 1993 | 1993 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 350 | 2 | 2010 | 2010 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | NO |
| 351 | 3 | 2005 | 2005 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |

(Cont. on next page)

(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 352 | 2 | 2005 | 2005 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | NO |
| 353 | 9 | 2018 | 2018 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | YES |
| 354 | 3 | 2010 | 2010 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 355 | 1 | 1990 | 1990 | Heavy Damage | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 356 | 1 | 1980 | 1980 | Heavy Damage | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 357 | 3 | 2014 | 2014 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 358 | 4 | 2009 | 2009 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 359 | 5 | 2018 | 2017 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 360 | 5 | 1995 | 1995 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 361 | 5 | 1995 | 1995 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | NO |
| 362 | 2 | 1980 | 1980 | To be Urgently Demolished | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 363 | 5 | 1983 | 1983 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | NO |
| 364 | 1 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 365 | 1 | 1980 | 1980 | Heavy Damage | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |

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(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 366 | 1 | 1993 | 1993 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 367 | 2 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 368 | 2 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | NO |
| 369 | 1 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 370 | 3 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | NO |
| 371 | 1 | 2000 | 2000 | Heavy Damage | Masonry Walled Structure - Brick | - | - | - | - | - | - | - | - | - | - | - | YES |
| 372 | 1 | 2000 | 2000 | Heavy Damage | Masonry Walled Structure - Brick | - | - | - | - | - | - | - | - | - | - | - | YES |
| 373 | 2 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 374 | 2 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | NO |
| 375 | 1 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | NO |
| 376 | 2 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | NO |
| 377 | 2 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | YES |
| 378 | 3 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | YES | YES | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 379 | 2 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |

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(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 380 | 2 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 381 | 2 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 382 | 4 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 383 | 4 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | NO |
| 384 | 3 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 385 | 4 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | NO |
| 386 | 4 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 387 | 11 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | YES |
| 388 | 8 | 2015 | 2023 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | NO |
| 389 | 4 | 1995 | 1995 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | NO |
| 390 | 4 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | YES |
| 391 | 4 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | YES |

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(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **No** | **Number of Storeys** | **Construction Years** | **Year Data Checked on Google Earth** | **Damage Classes** | **Load Bearing System Type** | **A1-Torsional Irregularity** | **A2-Floor Discontinuity** | **A3-Projection Discont. in plan** | **B1-Weak Storey** | **B2-Soft Storey** | **B3-Discontinuity of vertical members** | **Short Column** | **Hammering Effect** | **Heavy Overhangers** | **Existing Non-Parallel Axes** | **Strong Beam Weak Column** | **Beamless Slab** |
| 392 | 3 | 1995 | 1995 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | YES | YES | YES | YES | NO | NO | NO | YES | NO | NO | YES |
| 393 | 2 | 1995 | 1995 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 394 | 2 | 1995 | 1995 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 395 | 3 | 2005 | 2005 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 396 | 4 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 397 | 2 | No data | 2003 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | YES |
| 398 | 4 | No data | 2003 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 399 | 5 | No data | 2010 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | NO |
| 400 | 3 | No data | 2010 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | NO |
| 401 | 1 | No data | 2010 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 402 | 8 | 2008 | 2008 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 403 | 3 | 1995 | 1995 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | NO |

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(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 404 | 3 | 2001 | 2001 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | YES |
| 405 | 4 | 1995 | 1995 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 406 | 5 | 1995 | 1995 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | YES | YES | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 407 | 4 | 1995 | 1995 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 408 | 4 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 409 | 3 | 1998 | 1998 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | NO |
| 410 | 3 | 1998 | 1998 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | NO |
| 411 | 4 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | YES |
| 412 | 5 | 1996 | 1996 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | YES |
| 413 | 3 | 1995 | 1995 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 414 | 4 | 1995 | 1995 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |

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(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 415 | 3 | 1995 | 1995 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | YES |
| 416 | 3 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 417 | 2 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 418 | 3 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | YES |
| 419 | 7 | 2013 | 2013 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 420 | 8 | 2010 | 2010 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | YES | YES | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 421 | 6 | 1995 | 1995 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | YES |
| 422 | 6 | 1995 | 1995 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 423 | 4 | 2012 | 2012 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | NO |
| 424 | 1 | 1965 | 1965 | Heavy Damage | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 425 | 5 | 1998 | 1998 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | YES |
| 426 | 5 | 1988 | 1988 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 427 | 2 | 1995 | 1995 | Heavy Damage | Hybrid Structure - Semi-Frame | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | NO |
| 428 | 4 | 1999 | 1999 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |

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(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 429 | 5 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | YES |
| 430 | 5 | 2022 | 2022 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | NO |
| 431 | 5 | 2005 | 2005 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | NO |
| 432 | 10 | 1999 | 1999 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | NO |
| 433 | 2 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | YES |
| 434 | 8 | 1999 | 1999 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | YES | YES | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 435 | 4 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 436 | 5 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 437 | 4 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 438 | 4 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | NO |
| 439 | 4 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | YES |
| 440 | 3 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | YES |

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(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 441 | 5 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 442 | 4 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 443 | 4 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 444 | 5 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | NO |
| 445 | 4 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | NO |
| 446 | 3 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | NO |
| 447 | 4 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 448 | 2 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | YES | YES | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 449 | 4 | 1995 | 1995 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 450 | 6 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | YES |
| 451 | 2 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |

(Cont. on next page)

(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 452 | 4 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 453 | 4 | 2000 | 2000 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | NO |
| 454 | 3 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | YES |
| 455 | 5 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 456 | 4 | 2012 | 2012 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 457 | 5 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | YES |
| 458 | 5 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | NO |
| 459 | 3 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 460 | 4 | 2005 | 2005 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | YES |
| 461 | 5 | 1990 | 1990 | To be Urgently Demolished | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | YES | NO | NO | NO |
| 462 | 3 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | YES | YES | YES | YES | NO | NO | NO | YES | NO | NO | NO |

(Cont. on next page)

(Table A.1 cont.)

| Building Data | | | | | | Structural Irregularities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Number of Storeys | Construction Years | Year Data Checked on Google Earth | Damage Classes | Load Bearing System Type | A1-Torsional Irregularity | A2-Floor Discontinuity | A3-Projection Discont. in plan | B1-Weak Storey | B2-Soft Storey | B3-Discontinuity of vertical members | Short Column | Hammering Effect | Heavy Overhangers | Existing Non-Parallel Axes | Strong Beam Weak Column | Beamless Slab |
| 463 | 1 | 1980 | 1980 | Heavy Damage | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 464 | 2 | 1990 | 1990 | Heavy Damage | Melez Yapı - Yarı Karkas | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 465 | 1 | 1975 | 1975 | Heavy Damage | Melez Yapı - Yarı Karkas | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 466 | 1 | 1950 | 1950 | Heavy Damage | Masonry Walled Structure - Adobe | - | - | - | - | - | - | - | - | - | - | - | YES |
| 467 | 2 | 1980 | 1980 | Heavy Damage | Masonry Walled Structure - Adobe | - | - | - | - | - | - | - | - | - | - | - | YES |
| 468 | 3 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | YES |
| 469 | 3 | 1980 | 1980 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 470 | 6 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | NO |
| 471 | 4 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 472 | 3 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | YES | YES | YES | NO | NO | YES |
| 473 | 2 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 474 | 2 | 2000 | 2000 | Heavy Damage | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 475 | 1 | 1990 | 1990 | Heavy Damage | Masonry Walled Structure - Bricket | - | - | - | - | - | - | - | - | - | - | - | YES |
| 476 | 3 | 2000 | 2000 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES |
| 477 | 5 | 1990 | 1990 | Heavy Damage | Frame Structure - Reinforced Concrete | NO | NO | NO | YES | YES | NO | NO | NO | NO | NO | NO | NO |

# APPENDIX B

# FEMA p-154 DATA COLLECTION FORMS

**Rapid Visual Screening of Buildings for Potential Seismic Hazards** — **Level 1**

FEMA P-154 Data Collection Form — **VERY HIGH Seismicity**

PHOTOGRAPH

**Address:** ____________________

**Zip:** ____________________

**Other Identifiers:** ____________________

**Building Name:** ____________________

**Use:** ____________________

**Latitude:** ____________ **Longitude:** ____________

$S_S$: ____________ $S_1$: ____________

**Screener(s):** ____________ **Date/Time:** ____________

**No. Stories:** Above Grade: ______ Below Grade: ______ **Year Built:** ______ ☐ EST

**Total Floor Area (sq. ft.):** ______ **Code Year:** ______

**Additions:** ☐ None ☐ Yes, Year(s) Built: ______

**Occupancy:** Assembly, Commercial, Emer. Services, ☐ Historic, ☐ Shelter, Industrial, Office, School, ☐ Government, Utility, Warehouse, Residential, # Units: ______

**Soil Type:** ☐A Hard Rock ☐B Avg Rock ☐C Dense Soil ☐D Stiff Soil ☐E Soft Soil ☐F Poor Soil DNK *If DNK, assume Type D.*

**Geologic Hazards:** Liquefaction: Yes/No/DNK Landslide: Yes/No/DNK Surf. Rupt.: Yes/No/DNK

**Adjacency:** ☐ Pounding ☐ Falling Hazards from Taller Adjacent Building

**Irregularities:** ☐ Vertical (type/severity) ______ ☐ Plan (type) ______

**Exterior Falling Hazards:** ☐ Unbraced Chimneys ☐ Heavy Cladding or Heavy Veneer ☐ Parapets ☐ Appendages ☐ Other: ______

**COMMENTS:**

SKETCH

☐ Additional sketches or comments on separate page

**BASIC SCORE, MODIFIERS, AND FINAL LEVEL 1 SCORE, $S_{L1}$**

| FEMA BUILDING TYPE | Do Not Know | W1 | W1A | W2 | S1 (MRF) | S2 (BR) | S3 (LM) | S4 (RC SW) | S5 (URM INF) | C1 (MRF) | C2 (SW) | C3 (URM INF) | PC1 (TU) | PC2 | RM1 (FD) | RM2 (RD) | URM | MH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Basic Score** | | **2.1** | **1.9** | **1.8** | **1.5** | **1.4** | **1.6** | **1.4** | **1.2** | **1.0** | **1.2** | **0.9** | **1.1** | **1.0** | **1.1** | **1.1** | **0.9** | **1.1** |
| Severe Vertical Irregularity, $V_{L1}$ | | -0.9 | -0.9 | -0.9 | -0.8 | -0.7 | -0.8 | -0.7 | -0.7 | -0.7 | -0.8 | -0.6 | -0.7 | -0.7 | -0.7 | -0.7 | -0.6 | NA |
| Moderate Vertical Irregularity, $V_{L1}$ | | -0.6 | -0.5 | -0.5 | -0.4 | -0.4 | -0.5 | -0.4 | -0.3 | -0.4 | -0.4 | -0.3 | -0.4 | -0.4 | -0.4 | -0.4 | -0.3 | NA |
| Plan Irregularity, $P_{L1}$ | | -0.7 | -0.7 | -0.6 | -0.5 | -0.5 | -0.6 | -0.4 | -0.4 | -0.4 | -0.5 | -0.3 | -0.5 | -0.4 | -0.4 | -0.4 | -0.3 | NA |
| Pre-Code | | -0.3 | -0.3 | -0.3 | -0.3 | -0.2 | -0.3 | -0.2 | -0.1 | -0.1 | -0.2 | 0.0 | -0.2 | -0.1 | -0.2 | -0.2 | 0.0 | 0.0 |
| Post-Benchmark | | 1.9 | 1.9 | 2.0 | 1.0 | 1.1 | 1.1 | 1.5 | NA | 1.4 | 1.7 | NA | 1.5 | 1.7 | 1.6 | 1.6 | NA | 0.5 |
| Soil Type A or B | | 0.5 | 0.5 | 0.4 | 0.3 | 0.3 | 0.4 | 0.3 | 0.2 | 0.2 | 0.3 | 0.1 | 0.3 | 0.2 | 0.3 | 0.3 | 0.1 | 0.1 |
| Soil Type E (1-3 stories) | | 0.0 | -0.2 | -0.4 | -0.3 | -0.2 | -0.2 | -0.2 | -0.1 | -0.1 | -0.2 | 0.0 | -0.2 | -0.1 | -0.2 | -0.2 | 0.0 | -0.1 |
| Soil Type E (> 3 stories) | | -0.4 | -0.4 | -0.4 | -0.3 | -0.3 | NA | -0.3 | -0.1 | -0.1 | -0.3 | -0.1 | NA | -0.1 | -0.2 | -0.2 | 0.0 | NA |
| Minimum Score, $S_{MIN}$ | | *0.7* | *0.7* | *0.7* | *0.5* | *0.5* | *0.5* | *0.5* | *0.5* | *0.3* | *0.3* | *0.3* | *0.2* | *0.2* | *0.3* | *0.3* | *0.2* | *1.0* |

**FINAL LEVEL 1 SCORE, $S_{L1} \geq S_{MIN}$:**

**EXTENT OF REVIEW**

**Exterior:** ☐ Partial ☐ All Sides ☐ Aerial

**Interior:** ☐ None ☐ Visible ☐ Entered

**Drawings Reviewed:** ☐ Yes ☐ No

**Soil Type Source:** ______

**Geologic Hazards Source:** ______

**Contact Person:** ______

**LEVEL 2 SCREENING PERFORMED?**

☐ Yes, Final Level 2 Score, $S_{L2}$ ______ ☐ No

Nonstructural hazards? ☐ Yes ☐ No

**OTHER HAZARDS**

**Are There Hazards That Trigger A Detailed Structural Evaluation?**

☐ Pounding potential (unless $S_{L2}$ > cut-off, if known)

☐ Falling hazards from taller adjacent building

☐ Geologic hazards or Soil Type F

☐ Significant damage/deterioration to the structural system

**ACTION REQUIRED**

**Detailed Structural Evaluation Required?**

☐ Yes, unknown FEMA building type or other building

☐ Yes, score less than cut-off

☐ Yes, other hazards present

☐ No

**Detailed Nonstructural Evaluation Recommended?** *(check one)*

☐ Yes, nonstructural hazards identified that should be evaluated

☐ No, nonstructural hazards exist that may require mitigation, but a detailed evaluation is not necessary

☐ No, no nonstructural hazards identified ☐ DNK

***Where information cannot be verified, screener shall note the following: EST = Estimated or unreliable data OR DNK = Do Not Know***

Legend: MRF = Moment-resisting frame; BR = Braced frame; RC = Reinforced concrete; SW = Shear wall; URM INF = Unreinforced masonry infill; TU = Tilt up; MH = Manufactured Housing; LM = Light metal; FD = Flexible diaphragm; RD = Rigid diaphragm

Figure B.1 FEMA p154 data collection form for very high seismic regions level 1 (adopted from FEMA p-154 Handbook)

**Rapid Visual Screening of Buildings for Potential Seismic Hazards** — **Level 2 (Optional)**

FEMA P-154 Data Collection Form — **VERY HIGH Seismicity**

Optional Level 2 data collection to be performed by a civil or structural engineering professional, architect, or graduate student with background in seismic evaluation or design of buildings.

| | | | |
|---|---|---|---|
| **Bldg Name:** | **Final Level 1 Score:** | *$S_{L1}$ =* | *(do not consider $S_{MIN}$)* |
| **Screener:** | **Level 1 Irregularity Modifiers:** | *Vertical Irregularity, $V_{L1}$ =* | *Plan Irregularity, $P_{L1}$ =* |
| **Date/Time:** | **ADJUSTED BASELINE SCORE:** | *S' = ($S_{L1} - V_{L1} - P_{L1}$) =* | |

**STRUCTURAL MODIFIERS TO ADD TO ADJUSTED BASELINE SCORE**

| Topic | Statement *(If statement is true, circle the "Yes" modifier; otherwise cross out the modifier.)* | | Yes | Subtotals |
|---|---|---|---|---|
| Vertical Irregularity, $V_{L2}$ | Sloping Site | W1 building: There is at least a full story grade change from one side of the building to the other. | -0.9 | |
| | | Non-W1 building: There is at least a full story grade change from one side of the building to the other. | -0.2 | |
| | Weak and/or Soft Story *(circle one maximum)* | W1 building cripple wall: An unbraced cripple wall is visible in the crawl space. | -0.5 | |
| | | W1 house over garage: Underneath an occupied story, there is a garage opening without a steel moment frame, and there is less than 8' of wall on the same line (for multiple occupied floors above, use 16' of wall minimum). | -0.9 | |
| | | W1A building open front: There are openings at the ground story (such as for parking) over at least 50% of the length of the building. | -0.9 | |
| | | Non-W1 building: Length of lateral system at any story is less than 50% of that at story above or height of any story is more than 2.0 times the height of the story above. | -0.7 | |
| | | Non-W1 building: Length of lateral system at any story is between 50% and 75% of that at story above or height of any story is between 1.3 and 2.0 times the height of the story above. | -0.4 | |
| | Setback | Vertical elements of the lateral system at an upper story are outboard of those at the story below causing the diaphragm to cantilever at the offset. | -0.7 | |
| | | Vertical elements of the lateral system at upper stories are inboard of those at lower stories. | -0.4 | |
| | | There is an in-plane offset of the lateral elements that is greater than the length of the elements. | -0.2 | |
| | Short Column/ Pier | C1,C2,C3,PC1,PC2,RM1,RM2: At least 20% of columns (or piers) along a column line in the lateral system have height/depth ratios less than 50% of the nominal height/depth ratio at that level. | -0.4 | |
| | | C1,C2,C3,PC1,PC2,RM1,RM2: The column depth (or pier width) is less than one half of the depth of the spandrel, or there are infill walls or adjacent floors that shorten the column. | -0.4 | |
| | Split Level | There is a split level at one of the floor levels or at the roof. | -0.4 | |
| | Other Irregularity | There is another observable severe vertical irregularity that obviously affects the building's seismic performance. | -0.7 | $V_{L2}$ = ______ |
| | | There is another observable moderate vertical irregularity that may affect the building's seismic performance. | -0.4 | *(Cap at -0.9)* |
| Plan Irregularity, $P_{L2}$ | Torsional irregularity: Lateral system does not appear relatively well distributed in plan in either or both directions. *(Do not include the W1A open front irregularity listed above.)* | | -0.5 | |
| | Non-parallel system: There are one or more major vertical elements of the lateral system that are not orthogonal to each other. | | -0.2 | |
| | Reentrant corner: Both projections from an interior corner exceed 25% of the overall plan dimension in that direction. | | -0.2 | |
| | Diaphragm opening: There is an opening in the diaphragm with a width over 50% of the total diaphragm width at that level. | | -0.2 | |
| | C1, C2 building out-of-plane offset: The exterior beams do not align with the columns in plan. | | -0.2 | $P_{L2}$ = ______ |
| | Other irregularity: There is another observable plan irregularity that obviously affects the building's seismic performance. | | -0.5 | *(Cap at -0.7)* |
| Redundancy | The building has at least two bays of lateral elements on each side of the building in each direction. | | +0.2 | |
| Pounding | Building is separated from an adjacent structure by less than 1.5% of the height of the shorter of the building and adjacent structure and: | The floors do not align vertically within 2 feet. *(Cap total pounding modifiers at -0.9)* | -0.7 | |
| | | One building is 2 or more stories taller than the other. | -0.7 | |
| | | The building is at the end of the block. | -0.4 | |
| S2 Building | "K" bracing geometry is visible. | | -0.7 | |
| C1 Building | Flat plate serves as the beam in the moment frame. | | -0.3 | |
| PC1/RM1 Bldg | There are roof-to-wall ties that are visible or known from drawings that do not rely on cross-grain bending. *(Do not combine with post-benchmark or retrofit modifier.)* | | +0.2 | |
| PC1/RM1 Bldg | The building has closely spaced, full height interior walls (rather than an interior space with few walls such as in a warehouse). | | +0.2 | |
| URM | Gable walls are present. | | -0.3 | |
| MH | There is a supplemental seismic bracing system provided between the carriage and the ground. | | +0.5 | |
| Retrofit | Comprehensive seismic retrofit is visible or known from drawings. | | +1.2 | M= ______ |

**FINAL LEVEL 2 SCORE, $S_{L2} = (S' + V_{L2} + P_{L2} + M) \geq S_{MIN}$:** *(Transfer to Level 1 form)*

There is observable damage or deterioration or another condition that negatively affects the building's seismic performance: ☐ Yes ☐ No

*If yes, describe the condition in the comment box below and indicate on the Level 1 form that detailed evaluation is required independent of the building's score.*

**OBSERVABLE NONSTRUCTURAL HAZARDS**

| Location | Statement *(Check "Yes" or "No")* | Yes | No | Comment |
|---|---|---|---|---|
| Exterior | There is an unbraced unreinforced masonry parapet or unbraced unreinforced masonry chimney. | | | |
| | There is heavy cladding or heavy veneer. | | | |
| | There is a heavy canopy over exit doors or pedestrian walkways that appears inadequately supported. | | | |
| | There is an unreinforced masonry appendage over exit doors or pedestrian walkways. | | | |
| | There is a sign posted on the building that indicates hazardous materials are present. | | | |
| | There is a taller adjacent building with an unanchored URM wall or unbraced URM parapet or chimney. | | | |
| | Other observed exterior nonstructural falling hazard: | | | |
| Interior | There are hollow clay tile or brick partitions at any stair or exit corridor. | | | |
| | Other observed interior nonstructural falling hazard: | | | |

**Estimated Nonstructural Seismic Performance** *(Check appropriate box and transfer to Level 1 form conclusions)*

☐ Potential nonstructural hazards with significant threat to occupant life safety → Detailed Nonstructural Evaluation recommended
☐ Nonstructural hazards identified with significant threat to occupant life safety → But no Detailed Nonstructural Evaluation required
☐ Low or no nonstructural hazard threat to occupant life safety → No Detailed Nonstructural Evaluation required

**Comments:**

Figure B.2 FEMA p154 data collection form for very high seismic regions level 2 (adopted from FEMA p-154 Handbook)

**Rapid Visual Screening of Buildings for Potential Seismic Hazards** **Level 1**
FEMA P-154 Data Collection Form **HIGH Seismicity**

PHOTOGRAPH

**Address:**
**Zip:**
**Other Identifiers:**
**Building Name:**
**Use:**
**Latitude:** **Longitude:**
$S_S$: $S_1$:
**Screener(s):** **Date/Time:**

**No. Stories:** Above Grade: Below Grade: **Year Built:** ☐ EST
**Total Floor Area (sq. ft.):** **Code Year:**
**Additions:** ☐ None ☐ Yes, Year(s) Built:
**Occupancy:** Assembly Commercial Emer. Services ☐ Historic ☐ Shelter
Industrial Office School ☐ Government
Utility Warehouse Residential, # Units:
**Soil Type:** ☐A Hard Rock ☐B Avg Rock ☐C Dense Soil ☐D Stiff Soil ☐E Soft Soil ☐F Poor Soil DNK *If DNK, assume Type D.*
**Geologic Hazards:** Liquefaction: Yes/No/DNK Landslide: Yes/No/DNK Surf. Rupt.: Yes/No/DNK
**Adjacency:** ☐ Pounding ☐ Falling Hazards from Taller Adjacent Building
**Irregularities:** ☐ Vertical (type/severity) ☐ Plan (type)
**Exterior Falling Hazards:** ☐ Unbraced Chimneys ☐ Heavy Cladding or Heavy Veneer ☐ Parapets ☐ Appendages ☐ Other:

**COMMENTS:**

SKETCH

☐ Additional sketches or comments on separate page

**BASIC SCORE, MODIFIERS, AND FINAL LEVEL 1 SCORE, $S_{L1}$**

| FEMA BUILDING TYPE | Do Not Know | W1 | W1A | W2 | S1 (MRF) | S2 (BR) | S3 (LM) | S4 (RC SW) | S5 (URM INF) | C1 (MRF) | C2 (SW) | C3 (URM INF) | PC1 (TU) | PC2 | RM1 (FD) | RM2 (RD) | URM | MH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Basic Score** | | **3.6** | **3.2** | **2.9** | **2.1** | **2.0** | **2.6** | **2.0** | **1.7** | **1.5** | **2.0** | **1.2** | **1.6** | **1.4** | **1.7** | **1.7** | **1.0** | **1.5** |
| Severe Vertical Irregularity, $V_{L1}$ | | -1.2 | -1.2 | -1.2 | -1.0 | -1.0 | -1.1 | -1.0 | -0.8 | -0.9 | -1.0 | -0.7 | -1.0 | -0.9 | -0.9 | -0.9 | -0.7 | NA |
| Moderate Vertical Irregularity, $V_{L1}$ | | -0.7 | -0.7 | -0.7 | -0.6 | -0.6 | -0.7 | -0.6 | -0.5 | -0.5 | -0.6 | -0.4 | -0.6 | -0.5 | -0.5 | -0.5 | -0.4 | NA |
| Plan Irregularity, $P_{L1}$ | | -1.1 | -1.0 | -1.0 | -0.8 | -0.7 | -0.9 | -0.7 | -0.6 | -0.6 | -0.8 | -0.5 | -0.7 | -0.6 | -0.7 | -0.7 | -0.4 | NA |
| Pre-Code | | -1.1 | -1.0 | -0.9 | -0.6 | -0.6 | -0.8 | -0.6 | -0.2 | -0.4 | -0.7 | -0.1 | -0.5 | -0.3 | -0.5 | -0.5 | 0.0 | -0.1 |
| Post-Benchmark | | 1.6 | 1.9 | 2.2 | 1.4 | 1.4 | 1.1 | 1.9 | NA | 1.9 | 2.1 | NA | 2.0 | 2.4 | 2.1 | 2.1 | NA | 1.2 |
| Soil Type A or B | | 0.1 | 0.3 | 0.5 | 0.4 | 0.6 | 0.1 | 0.6 | 0.5 | 0.4 | 0.5 | 0.3 | 0.6 | 0.4 | 0.5 | 0.5 | 0.3 | 0.3 |
| Soil Type E (1-3 stories) | | 0.2 | 0.2 | 0.1 | -0.2 | -0.4 | 0.2 | -0.1 | -0.4 | 0.0 | 0.0 | -0.2 | -0.3 | -0.1 | -0.1 | -0.1 | -0.2 | -0.4 |
| Soil Type E (> 3 stories) | | -0.3 | -0.6 | -0.9 | -0.6 | -0.6 | NA | -0.6 | -0.4 | -0.5 | -0.7 | -0.3 | NA | -0.4 | -0.5 | -0.6 | -0.2 | NA |
| Minimum Score, $S_{MIN}$ | | *1.1* | *0.9* | *0.7* | *0.5* | *0.5* | *0.6* | *0.5* | *0.5* | *0.3* | *0.3* | *0.3* | *0.2* | *0.2* | *0.3* | *0.3* | *0.2* | *1.0* |

**FINAL LEVEL 1 SCORE, $S_{L1} \geq S_{MIN}$:**

**EXTENT OF REVIEW**
**Exterior:** ☐ Partial ☐ All Sides ☐ Aerial
**Interior:** ☐ None ☐ Visible ☐ Entered
**Drawings Reviewed:** ☐ Yes ☐ No
**Soil Type Source:**
**Geologic Hazards Source:**
**Contact Person:**

**LEVEL 2 SCREENING PERFORMED?**
☐ Yes, Final Level 2 Score, $S_{L2}$ ________ ☐ No
Nonstructural hazards? ☐ Yes ☐ No

**OTHER HAZARDS**
**Are There Hazards That Trigger A Detailed Structural Evaluation?**
☐ Pounding potential (unless $S_{L2}$ > cut-off, if known)
☐ Falling hazards from taller adjacent building
☐ Geologic hazards or Soil Type F
☐ Significant damage/deterioration to the structural system

**ACTION REQUIRED**
**Detailed Structural Evaluation Required?**
☐ Yes, unknown FEMA building type or other building
☐ Yes, score less than cut-off
☐ Yes, other hazards present
☐ No
**Detailed Nonstructural Evaluation Recommended?** *(check one)*
☐ Yes, nonstructural hazards identified that should be evaluated
☐ No, nonstructural hazards exist that may require mitigation, but a detailed evaluation is not necessary
☐ No, no nonstructural hazards identified ☐ DNK

***Where information cannot be verified, screener shall note the following: EST = Estimated or unreliable data OR DNK = Do Not Know***

Legend: MRF = Moment-resisting frame; BR = Braced frame; RC = Reinforced concrete; SW = Shear wall; URM INF = Unreinforced masonry infill; TU = Tilt up; MH = Manufactured Housing; LM = Light metal; FD = Flexible diaphragm; RD = Rigid diaphragm

Figure B.3 FEMA p154 data collection form for high seismic regions level 1 (adopted from FEMA p-154 Handbook)

**Rapid Visual Screening of Buildings for Potential Seismic Hazards** — **Level 2 (Optional)**

FEMA P-154 Data Collection Form — **HIGH Seismicity**

Optional Level 2 data collection to be performed by a civil or structural engineering professional, architect, or graduate student with background in seismic evaluation or design of buildings.

| | | | |
|---|---|---|---|
| **Bldg Name:** | **Final Level 1 Score:** | $S_{L1}$ = | *(do not consider $S_{MIN}$)* |
| **Screener:** | **Level 1 Irregularity Modifiers:** | *Vertical Irregularity,* $V_{L1}$ = | *Plan Irregularity,* $P_{L1}$ = |
| **Date/Time:** | **ADJUSTED BASELINE SCORE:** | $S' = (S_{L1} - V_{L1} - P_{L1})$ = | |

**STRUCTURAL MODIFIERS TO ADD TO ADJUSTED BASELINE SCORE**

| Topic | Statement *(If statement is true, circle the "Yes" modifier; otherwise cross out the modifier.)* | | Yes | Subtotals |
|---|---|---|---|---|
| Vertical Irregularity, $V_{L2}$ | Sloping Site | W1 building: There is at least a full story grade change from one side of the building to the other. | -1.2 | |
| | | Non-W1 building: There is at least a full story grade change from one side of the building to the other. | -0.3 | |
| | Weak and/or Soft Story *(circle one maximum)* | W1 building cripple wall: An unbraced cripple wall is visible in the crawl space. | -0.6 | |
| | | W1 house over garage: Underneath an occupied story, there is a garage opening without a steel moment frame, and there is less than 8' of wall on the same line (for multiple occupied floors above, use 16' of wall minimum). | -1.2 | |
| | | W1A building open front: There are openings at the ground story (such as for parking) over at least 50% of the length of the building. | -1.2 | |
| | | Non-W1 building: Length of lateral system at any story is less than 50% of that at story above or height of any story is more than 2.0 times the height of the story above. | -0.9 | |
| | | Non-W1 building: Length of lateral system at any story is between 50% and 75% of that at story above or height of any story is between 1.3 and 2.0 times the height of the story above. | -0.5 | |
| | Setback | Vertical elements of the lateral system at an upper story are outboard of those at the story below causing the diaphragm to cantilever at the offset. | -1.0 | |
| | | Vertical elements of the lateral system at upper stories are inboard of those at lower stories. | -0.5 | |
| | | There is an in-plane offset of the lateral elements that is greater than the length of the elements. | -0.3 | |
| | Short Column/ Pier | C1,C2,C3,PC1,PC2,RM1,RM2: At least 20% of columns (or piers) along a column line in the lateral system have height/depth ratios less than 50% of the nominal height/depth ratio at that level. | -0.5 | |
| | | C1,C2,C3,PC1,PC2,RM1,RM2: The column depth (or pier width) is less than one half of the depth of the spandrel, or there are infill walls or adjacent floors that shorten the column. | -0.5 | |
| | Split Level | There is a split level at one of the floor levels or at the roof. | -0.5 | |
| | Other Irregularity | There is another observable severe vertical irregularity that obviously affects the building's seismic performance. | -1.0 | $V_{L2}$ = ______ |
| | | There is another observable moderate vertical irregularity that may affect the building's seismic performance. | -0.5 | *(Cap at -1.2)* |
| Plan Irregularity, $P_{L2}$ | Torsional irregularity: Lateral system does not appear relatively well distributed in plan in either or both directions. *(Do not include the W1A open front irregularity listed above.)* | | -0.7 | |
| | Non-parallel system: There are one or more major vertical elements of the lateral system that are not orthogonal to each other. | | -0.4 | |
| | Reentrant corner: Both projections from an interior corner exceed 25% of the overall plan dimension in that direction. | | -0.4 | |
| | Diaphragm opening: There is an opening in the diaphragm with a width over 50% of the total diaphragm width at that level. | | -0.2 | |
| | C1, C2 building out-of-plane offset: The exterior beams do not align with the columns in plan. | | -0.4 | $P_{L2}$ = ______ |
| | Other irregularity: There is another observable plan irregularity that obviously affects the building's seismic performance. | | -0.7 | *(Cap at -1.1)* |
| Redundancy | The building has at least two bays of lateral elements on each side of the building in each direction. | | +0.3 | |
| Pounding | Building is separated from an adjacent structure by less than 1% of the height of the shorter of the building and adjacent structure and: | The floors do not align vertically within 2 feet. *(Cap total pounding modifiers at -1.2)* | -1.0 | |
| | | One building is 2 or more stories taller than the other. | -1.0 | |
| | | The building is at the end of the block. | -0.5 | |
| S2 Building | "K" bracing geometry is visible. | | -1.0 | |
| C1 Building | Flat plate serves as the beam in the moment frame. | | -0.4 | |
| PC1/RM1 Bldg | There are roof-to-wall ties that are visible or known from drawings that do not rely on cross-grain bending. *(Do not combine with post-benchmark or retrofit modifier.)* | | +0.3 | |
| PC1/RM1 Bldg | The building has closely spaced, full height interior walls (rather than an interior space with few walls such as in a warehouse). | | +0.3 | |
| URM | Gable walls are present. | | -0.4 | |
| MH | There is a supplemental seismic bracing system provided between the carriage and the ground. | | +1.2 | |
| Retrofit | Comprehensive seismic retrofit is visible or known from drawings. | | +1.4 | *M* = ______ |

**FINAL LEVEL 2 SCORE, $S_{L2} = (S' + V_{L2} + P_{L2} + M) \geq S_{MIN}$:** *(Transfer to Level 1 form)*

There is observable damage or deterioration or another condition that negatively affects the building's seismic performance: ☐ Yes ☐ No

*If yes, describe the condition in the comment box below and indicate on the Level 1 form that detailed evaluation is required independent of the building's score.*

**OBSERVABLE NONSTRUCTURAL HAZARDS**

| Location | Statement *(Check "Yes" or "No")* | Yes | No | Comment |
|---|---|---|---|---|
| Exterior | There is an unbraced unreinforced masonry parapet or unbraced unreinforced masonry chimney. | | | |
| | There is heavy cladding or heavy veneer. | | | |
| | There is a heavy canopy over exit doors or pedestrian walkways that appears inadequately supported. | | | |
| | There is an unreinforced masonry appendage over exit doors or pedestrian walkways. | | | |
| | There is a sign posted on the building that indicates hazardous materials are present. | | | |
| | There is a taller adjacent building with an unanchored URM wall or unbraced URM parapet or chimney. | | | |
| | Other observed exterior nonstructural falling hazard: | | | |
| Interior | There are hollow clay tile or brick partitions at any stair or exit corridor. | | | |
| | Other observed interior nonstructural falling hazard: | | | |

**Estimated Nonstructural Seismic Performance** *(Check appropriate box and transfer to Level 1 form conclusions)*

☐ Potential nonstructural hazards with significant threat to occupant life safety → Detailed Nonstructural Evaluation recommended

☐ Nonstructural hazards identified with significant threat to occupant life safety → But no Detailed Nonstructural Evaluation required

☐ Low or no nonstructural hazard threat to occupant life safety → No Detailed Nonstructural Evaluation required

**Comments:**

Figure B.4 FEMA p154 data collection form for high seismic regions level 2 (adopted from FEMA p-154 Handbook)

**Rapid Visual Screening of Buildings for Potential Seismic Hazards**
FEMA P-154 Data Collection Form

**Level 1**
**MODERATELY HIGH Seismicity**

PHOTOGRAPH

**Address:** ____________________
____________________ **Zip:** __________
**Other Identifiers:** ____________________
**Building Name:** ____________________
**Use:** ____________________
**Latitude:** __________ **Longitude:** __________
$S_S$: __________ $S_1$: __________
**Screener(s):** __________ **Date/Time:** __________

**No. Stories:** Above Grade: ____ Below Grade: ____ **Year Built:** ____ ☐ EST
**Total Floor Area (sq. ft.):** __________ **Code Year:** ____
**Additions:** ☐ None ☐ Yes, Year(s) Built: ____

**Occupancy:** Assembly, Commercial, Emer. Services, ☐ Historic, ☐ Shelter, Industrial, Office, School, ☐ Government, Utility, Warehouse, Residential, # Units: ____

**Soil Type:** ☐A Hard Rock ☐B Avg Rock ☐C Dense Soil ☐D Stiff Soil ☐E Soft Soil ☐F Poor Soil DNK *If DNK, assume Type D.*

**Geologic Hazards:** Liquefaction: Yes/No/DNK Landslide: Yes/No/DNK Surf. Rupt.: Yes/No/DNK

**Adjacency:** ☐ Pounding ☐ Falling Hazards from Taller Adjacent Building

**Irregularities:** ☐ Vertical (type/severity) __________
☐ Plan (type) __________

**Exterior Falling Hazards:** ☐ Unbraced Chimneys ☐ Heavy Cladding or Heavy Veneer ☐ Parapets ☐ Appendages ☐ Other: __________

**COMMENTS:**

SKETCH

☐ Additional sketches or comments on separate page

**BASIC SCORE, MODIFIERS, AND FINAL LEVEL 1 SCORE, $S_{L1}$**

| FEMA BUILDING TYPE | Do Not Know | W1 | W1A | W2 | S1 (MRF) | S2 (BR) | S3 (LM) | S4 (RC SW) | S5 (URM INF) | C1 (MRF) | C2 (SW) | C3 (URM INF) | PC1 (TU) | PC2 | RM1 (FD) | RM2 (RD) | URM | MH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Basic Score** | | **4.1** | **3.7** | **3.2** | **2.3** | **2.2** | **2.9** | **2.2** | **2.0** | **1.7** | **2.1** | **1.4** | **1.8** | **1.5** | **1.8** | **1.8** | **1.2** | **2.2** |
| Severe Vertical Irregularity, $V_{L1}$ | | -1.3 | -1.3 | -1.3 | -1.1 | -1.0 | -1.2 | -1.0 | -0.9 | -1.0 | -1.1 | -0.8 | -1.0 | -0.9 | -1.0 | -1.0 | -0.8 | NA |
| Moderate Vertical Irregularity, $V_{L1}$ | | -0.8 | -0.8 | -0.8 | -0.7 | -0.6 | -0.8 | -0.6 | -0.6 | -0.6 | -0.6 | -0.5 | -0.6 | -0.6 | -0.6 | -0.6 | -0.5 | NA |
| Plan Irregularity, $P_{L1}$ | | -1.3 | -1.2 | -1.1 | -0.9 | -0.8 | -1.0 | -0.8 | -0.7 | -0.7 | -0.9 | -0.6 | -0.8 | -0.7 | -0.7 | -0.7 | -0.5 | NA |
| Pre-Code | | -0.8 | -0.9 | -0.9 | -0.5 | -0.5 | -0.7 | -0.6 | -0.2 | -0.4 | -0.7 | -0.1 | -0.4 | -0.3 | -0.5 | -0.5 | -0.1 | -0.3 |
| Post-Benchmark | | 1.5 | 1.9 | 2.3 | 1.4 | 1.4 | 1.0 | 1.9 | NA | 1.9 | 2.1 | NA | 2.1 | 2.4 | 2.1 | 2.1 | NA | 1.2 |
| Soil Type A or B | | 0.3 | 0.6 | 0.9 | 0.6 | 0.9 | 0.3 | 0.9 | 0.9 | 0.6 | 0.8 | 0.7 | 0.9 | 0.7 | 0.8 | 0.8 | 0.6 | 0.9 |
| Soil Type E (1-3 stories) | | 0.0 | -0.1 | -0.3 | -0.4 | -0.5 | 0.0 | -0.4 | -0.5 | -0.2 | -0.2 | -0.4 | -0.5 | -0.3 | -0.4 | -0.4 | -0.3 | -0.5 |
| Soil Type E (> 3 stories) | | -0.5 | -0.8 | -1.2 | -0.7 | -0.7 | NA | -0.7 | -0.6 | -0.6 | -0.8 | -0.4 | NA | -0.5 | -0.6 | -0.7 | -0.3 | NA |
| Minimum Score, $S_{MIN}$ | | *1.6* | *1.2* | *0.8* | *0.5* | *0.5* | *0.9* | *0.5* | *0.5* | *0.3* | *0.3* | *0.3* | *0.3* | *0.2* | *0.3* | *0.3* | *0.2* | *1.4* |

**FINAL LEVEL 1 SCORE, $S_{L1} \geq S_{MIN}$:**

**EXTENT OF REVIEW**
**Exterior:** ☐ Partial ☐ All Sides ☐ Aerial
**Interior:** ☐ None ☐ Visible ☐ Entered
**Drawings Reviewed:** ☐ Yes ☐ No
**Soil Type Source:** __________
**Geologic Hazards Source:** __________
**Contact Person:** __________

**LEVEL 2 SCREENING PERFORMED?**
☐ Yes, Final Level 2 Score, $S_{L2}$ ______ ☐ No
Nonstructural hazards? ☐ Yes ☐ No

**OTHER HAZARDS**
**Are There Hazards That Trigger A Detailed Structural Evaluation?**
☐ Pounding potential (unless $S_{L2}$ > cut-off, if known)
☐ Falling hazards from taller adjacent building
☐ Geologic hazards or Soil Type F
☐ Significant damage/deterioration to the structural system

**ACTION REQUIRED**
**Detailed Structural Evaluation Required?**
☐ Yes, unknown FEMA building type or other building
☐ Yes, score less than cut-off
☐ Yes, other hazards present
☐ No
**Detailed Nonstructural Evaluation Recommended?** *(check one)*
☐ Yes, nonstructural hazards identified that should be evaluated
☐ No, nonstructural hazards exist that may require mitigation, but a detailed evaluation is not necessary
☐ No, no nonstructural hazards identified ☐ DNK

***Where information cannot be verified, screener shall note the following: EST = Estimated or unreliable data OR DNK = Do Not Know***

Legend: MRF = Moment-resisting frame; BR = Braced frame; RC = Reinforced concrete; SW = Shear wall; URM INF = Unreinforced masonry infill; TU = Tilt up; MH = Manufactured Housing; LM = Light metal; FD = Flexible diaphragm; RD = Rigid diaphragm

Figure B.5 FEMA p154 data collection form for moderately high seismic regions level 1 (adopted from FEMA p-154 Handbook)

**Rapid Visual Screening of Buildings for Potential Seismic Hazards** — **Level 2 (Optional)**

FEMA P-154 Data Collection Form — **MODERATELY HIGH Seismicity**

Optional Level 2 data collection to be performed by a civil or structural engineering professional, architect, or graduate student with background in seismic evaluation or design of buildings.

| | | | |
|---|---|---|---|
| **Bldg Name:** | **Final Level 1 Score:** | $S_{L1}$ = | *(do not consider $S_{MIN}$)* |
| **Screener:** | **Level 1 Irregularity Modifiers:** | *Vertical Irregularity,* $V_{L1}$ = | *Plan Irregularity,* $P_{L1}$ = |
| **Date/Time:** | **ADJUSTED BASELINE SCORE:** | $S' = (S_{L1} - V_{L1} - P_{L1})$ = | |

**STRUCTURAL MODIFIERS TO ADD TO ADJUSTED BASELINE SCORE**

| Topic | Statement *(If statement is true, circle the "Yes" modifier; otherwise cross out the modifier.)* | | Yes | Subtotals |
|---|---|---|---|---|
| Vertical Irregularity, $V_{L2}$ | Sloping Site | W1 building: There is at least a full story grade change from one side of the building to the other. | -1.3 | |
| | | Non-W1 building: There is at least a full story grade change from one side of the building to the other. | -0.3 | |
| | Weak and/or Soft Story *(circle one maximum)* | W1 building cripple wall: An unbraced cripple wall is visible in the crawl space. | -0.6 | |
| | | W1 house over garage: Underneath an occupied story, there is a garage opening without a steel moment frame, and there is less than 8' of wall on the same line (for multiple occupied floors above, use 16' of wall minimum). | -1.3 | |
| | | W1A building open front: There are openings at the ground story (such as for parking) over at least 50% of the length of the building. | -1.3 | |
| | | Non-W1 building: Length of lateral system at any story is less than 50% of that at story above or height of any story is more than 2.0 times the height of the story above. | -1.0 | |
| | | Non-W1 building: Length of lateral system at any story is between 50% and 75% of that at story above or height of any story is between 1.3 and 2.0 times the height of the story above. | -0.5 | |
| | Setback | Vertical elements of the lateral system at an upper story are outboard of those at the story below causing the diaphragm to cantilever at the offset. | -1.0 | |
| | | Vertical elements of the lateral system at upper stories are inboard of those at lower stories. | -0.5 | |
| | | There is an in-plane offset of the lateral elements that is greater than the length of the elements. | -0.3 | |
| | Short Column/ Pier | C1,C2,C3,PC1,PC2,RM1,RM2: At least 20% of columns (or piers) along a column line in the lateral system have height/depth ratios less than 50% of the nominal height/depth ratio at that level. | -0.5 | |
| | | C1,C2,C3,PC1,PC2,RM1,RM2: The column depth (or pier width) is less than one half of the depth of the spandrel, or there are infill walls or adjacent floors that shorten the column. | -0.5 | |
| | Split Level | There is a split level at one of the floor levels or at the roof. | -0.5 | |
| | Other Irregularity | There is another observable severe vertical irregularity that obviously affects the building's seismic performance. | -1.0 | $V_{L2}$ = ______ |
| | | There is another observable moderate vertical irregularity that may affect the building's seismic performance. | -0.5 | *(Cap at -1.3)* |
| Plan Irregularity, $P_{L2}$ | Torsional irregularity: Lateral system does not appear relatively well distributed in plan in either or both directions. *(Do not include the W1A open front irregularity listed above.)* | | -0.8 | |
| | Non-parallel system: There are one or more major vertical elements of the lateral system that are not orthogonal to each other. | | -0.4 | |
| | Reentrant corner: Both projections from an interior corner exceed 25% of the overall plan dimension in that direction. | | -0.4 | |
| | Diaphragm opening: There is an opening in the diaphragm with a width over 50% of the total diaphragm width at that level. | | -0.3 | |
| | C1, C2 building out-of-plane offset: The exterior beams do not align with the columns in plan. | | -0.4 | $P_{L2}$ = ______ |
| | Other irregularity: There is another observable plan irregularity that obviously affects the building's seismic performance. | | -0.8 | *(Cap at -1.3)* |
| Redundancy | The building has at least two bays of lateral elements on each side of the building in each direction. | | +0.3 | |
| Pounding | Building is separated from an adjacent structure by less than 0.5% of the height of the shorter of the building and adjacent structure and: | The floors do not align vertically within 2 feet. *(Cap total pounding modifiers at -1.3)* | -1.0 | |
| | | One building is 2 or more stories taller than the other. | -1.0 | |
| | | The building is at the end of the block. | -0.5 | |
| S2 Building | "K" bracing geometry is visible. | | -1.0 | |
| C1 Building | Flat plate serves as the beam in the moment frame. | | -0.5 | |
| PC1/RM1 Bldg | There are roof-to-wall ties that are visible or known from drawings that do not rely on cross-grain bending. *(Do not combine with post-benchmark or retrofit modifier.)* | | +0.3 | |
| PC1/RM1 Bldg | The building has closely spaced, full height interior walls (rather than an interior space with few walls such as in a warehouse). | | +0.3 | |
| URM | Gable walls are present. | | -0.4 | |
| MH | There is a supplemental seismic bracing system provided between the carriage and the ground. | | +1.2 | |
| Retrofit | Comprehensive seismic retrofit is visible or known from drawings. | | +1.4 | M= ______ |

**FINAL LEVEL 2 SCORE, $S_{L2} = (S' + V_{L2} + P_{L2} + M) \geq S_{MIN}$:** *(Transfer to Level 1 form)*

There is observable damage or deterioration or another condition that negatively affects the building's seismic performance: ☐ Yes ☐ No
*If yes, describe the condition in the comment box below and indicate on the Level 1 form that detailed evaluation is required independent of the building's score.*

**OBSERVABLE NONSTRUCTURAL HAZARDS**

| Location | Statement *(Check "Yes" or "No")* | Yes | No | Comment |
|---|---|---|---|---|
| Exterior | There is an unbraced unreinforced masonry parapet or unbraced unreinforced masonry chimney. | | | |
| | There is heavy cladding or heavy veneer. | | | |
| | There is a heavy canopy over exit doors or pedestrian walkways that appears inadequately supported. | | | |
| | There is an unreinforced masonry appendage over exit doors or pedestrian walkways. | | | |
| | There is a sign posted on the building that indicates hazardous materials are present. | | | |
| | There is a taller adjacent building with an unanchored URM wall or unbraced URM parapet or chimney. | | | |
| | Other observed exterior nonstructural falling hazard: | | | |
| Interior | There are hollow clay tile or brick partitions at any stair or exit corridor. | | | |
| | Other observed interior nonstructural falling hazard: | | | |

**Estimated Nonstructural Seismic Performance** *(Check appropriate box and transfer to Level 1 form conclusions)*

☐ Potential nonstructural hazards with significant threat to occupant life safety → Detailed Nonstructural Evaluation recommended
☐ Nonstructural hazards identified with significant threat to occupant life safety → But no Detailed Nonstructural Evaluation required
☐ Low or no nonstructural hazard threat to occupant life safety → No Detailed Nonstructural Evaluation required

**Comments:**

Figure B.6 FEMA p154 data collection form for moderately high seismic regions level 2 (adopted from FEMA p-154 Handbook)

**Rapid Visual Screening of Buildings for Potential Seismic Hazards** — **Level 1**
FEMA P-154 Data Collection Form — **MODERATE Seismicity**

PHOTOGRAPH

**Address:**
**Zip:**
**Other Identifiers:**
**Building Name:**
**Use:**
**Latitude:** **Longitude:**
$S_S$: $S_1$:
**Screener(s):** **Date/Time:**

**No. Stories:** Above Grade: Below Grade: **Year Built:** ☐ EST
**Total Floor Area (sq. ft.):** **Code Year:**
**Additions:** ☐ None ☐ Yes, Year(s) Built:

**Occupancy:** Assembly, Commercial, Emer. Services, ☐ Historic, ☐ Shelter, Industrial, Office, School, ☐ Government, Utility, Warehouse, Residential, # Units:

**Soil Type:** ☐A Hard Rock ☐B Avg Rock ☐C Dense Soil ☐D Stiff Soil ☐E Soft Soil ☐F Poor Soil DNK *If DNK, assume Type D.*

**Geologic Hazards:** Liquefaction: Yes/No/DNK Landslide: Yes/No/DNK Surf. Rupt.: Yes/No/DNK

**Adjacency:** ☐ Pounding ☐ Falling Hazards from Taller Adjacent Building

**Irregularities:** ☐ Vertical (type/severity) ☐ Plan (type)

**Exterior Falling Hazards:** ☐ Unbraced Chimneys ☐ Heavy Cladding or Heavy Veneer ☐ Parapets ☐ Appendages ☐ Other:

**COMMENTS:**

SKETCH

☐ Additional sketches or comments on separate page

**BASIC SCORE, MODIFIERS, AND FINAL LEVEL 1 SCORE, $S_{L1}$**

| FEMA BUILDING TYPE | Do Not Know | W1 | W1A | W2 | S1 (MRF) | S2 (BR) | S3 (LM) | S4 (RC SW) | S5 (URM INF) | C1 (MRF) | C2 (SW) | C3 (URM INF) | PC1 (TU) | PC2 | RM1 (FD) | RM2 (RD) | URM | MH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Basic Score** | | **5.1** | **4.5** | **3.8** | **2.7** | **2.6** | **3.5** | **2.5** | **2.7** | **2.1** | **2.5** | **2.0** | **2.1** | **1.9** | **2.1** | **2.1** | **1.7** | **2.9** |
| Severe Vertical Irregularity, $V_{L1}$ | | -1.4 | -1.4 | -1.4 | -1.2 | -1.2 | -1.4 | -1.1 | -1.2 | -1.1 | -1.2 | -1.0 | -1.1 | -1.0 | -1.1 | -1.1 | -1.0 | NA |
| Moderate Vertical Irregularity, $V_{L1}$ | | -0.9 | -0.9 | -0.9 | -0.8 | -0.7 | -0.9 | -0.7 | -0.7 | -0.7 | -0.7 | -0.6 | -0.7 | -0.6 | -0.7 | -0.7 | -0.6 | NA |
| Plan Irregularity, $P_{L1}$ | | -1.4 | -1.3 | -1.2 | -1.0 | -0.9 | -1.2 | -0.9 | -0.9 | -0.8 | -1.0 | -0.8 | -0.9 | -0.8 | -0.8 | -0.8 | -0.7 | NA |
| Pre-Code | | -0.3 | -0.5 | -0.6 | -0.3 | -0.2 | -0.2 | -0.3 | -0.3 | -0.3 | -0.4 | -0.3 | -0.2 | -0.2 | -0.2 | -0.2 | -0.1 | -0.5 |
| Post-Benchmark | | 1.4 | 2.0 | 2.5 | 1.5 | 1.5 | 0.8 | 2.1 | NA | 2.0 | 2.3 | NA | 2.1 | 2.5 | 2.3 | 2.3 | NA | 1.2 |
| Soil Type A or B | | 0.7 | 1.2 | 1.8 | 1.1 | 1.4 | 0.6 | 1.5 | 1.6 | 1.1 | 1.5 | 1.3 | 1.6 | 1.3 | 1.4 | 1.4 | 1.3 | 1.6 |
| Soil Type E (1-3 stories) | | -1.2 | -1.3 | -1.4 | -0.9 | -0.9 | -1.0 | -0.9 | -0.9 | -0.7 | -1.0 | -0.7 | -0.8 | -0.7 | -0.8 | -0.8 | -0.6 | -0.9 |
| Soil Type E (> 3 stories) | | -1.8 | -1.6 | -1.3 | -0.9 | -0.9 | NA | -0.9 | -1.0 | -0.8 | -1.0 | -0.8 | NA | -0.7 | -0.7 | -0.8 | -0.6 | NA |
| Minimum Score, $S_{MIN}$ | | *1.6* | *1.2* | *0.9* | *0.6* | *0.6* | *0.8* | *0.6* | *0.6* | *0.3* | *0.3* | *0.3* | *0.3* | *0.2* | *0.3* | *0.3* | *0.2* | *1.5* |

**FINAL LEVEL 1 SCORE, $S_{L1} \geq S_{MIN}$:**

**EXTENT OF REVIEW**
**Exterior:** ☐ Partial ☐ All Sides ☐ Aerial
**Interior:** ☐ None ☐ Visible ☐ Entered
**Drawings Reviewed:** ☐ Yes ☐ No
**Soil Type Source:**
**Geologic Hazards Source:**
**Contact Person:**

**LEVEL 2 SCREENING PERFORMED?**
☐ Yes, Final Level 2 Score, $S_{L2}$ ______ ☐ No
Nonstructural hazards? ☐ Yes ☐ No

**OTHER HAZARDS**
**Are There Hazards That Trigger A Detailed Structural Evaluation?**
☐ Pounding potential (unless $S_{L2}$ > cut-off, if known)
☐ Falling hazards from taller adjacent building
☐ Geologic hazards or Soil Type F
☐ Significant damage/deterioration to the structural system

**ACTION REQUIRED**
**Detailed Structural Evaluation Required?**
☐ Yes, unknown FEMA building type or other building
☐ Yes, score less than cut-off
☐ Yes, other hazards present
☐ No
**Detailed Nonstructural Evaluation Recommended?** *(check one)*
☐ Yes, nonstructural hazards identified that should be evaluated
☐ No, nonstructural hazards exist that may require mitigation, but a detailed evaluation is not necessary
☐ No, no nonstructural hazards identified ☐ DNK

***Where information cannot be verified, screener shall note the following: EST = Estimated or unreliable data OR DNK = Do Not Know***

Legend: MRF = Moment-resisting frame; BR = Braced frame; RC = Reinforced concrete; SW = Shear wall; URM INF = Unreinforced masonry infill; TU = Tilt up; MH = Manufactured Housing; LM = Light metal; FD = Flexible diaphragm; RD = Rigid diaphragm

Figure B.7 FEMA p154 data collection form for moderate seismic regions level 1 (adopted from FEMA p-154 Handbook)

**Rapid Visual Screening of Buildings for Potential Seismic Hazards** — **Level 2 (Optional)**

FEMA P-154 Data Collection Form — **MODERATE Seismicity**

Optional Level 2 data collection to be performed by a civil or structural engineering professional, architect, or graduate student with background in seismic evaluation or design of buildings.

| | | | |
|---|---|---|---|
| **Bldg Name:** | **Final Level 1 Score:** | $S_{L1}$ = | *(do not consider $S_{MIN}$)* |
| **Screener:** | **Level 1 Irregularity Modifiers:** | *Vertical Irregularity, $V_{L1}$* = | *Plan Irregularity, $P_{L1}$* = |
| **Date/Time:** | **ADJUSTED BASELINE SCORE:** | $S' = (S_{L1} - V_{L1} - P_{L1})$ = | |

**STRUCTURAL MODIFIERS TO ADD TO ADJUSTED BASELINE SCORE**

| Topic | Statement *(If statement is true, circle the "Yes" modifier; otherwise cross out the modifier.)* | | Yes | Subtotals |
|---|---|---|---|---|
| Vertical Irregularity, $V_{L2}$ | Sloping Site | W1 building: There is at least a full story grade change from one side of the building to the other. | -1.4 | |
| | | Non-W1 building: There is at least a full story grade change from one side of the building to the other. | -0.4 | |
| | Weak and/or Soft Story *(circle one maximum)* | W1 building cripple wall: An unbraced cripple wall is visible in the crawl space. | -0.7 | |
| | | W1 house over garage: Underneath an occupied story, there is a garage opening without a steel moment frame, and there is less than 8' of wall on the same line (for multiple occupied floors above, use 16' of wall minimum). | -1.4 | |
| | | W1A building open front: There are openings at the ground story (such as for parking) over at least 50% of the length of the building. | -1.4 | |
| | | Non-W1 building: Length of lateral system at any story is less than 50% of that at story above or height of any story is more than 2.0 times the height of the story above. | -1.1 | |
| | | Non-W1 building: Length of lateral system at any story is between 50% and 75% of that at story above or height of any story is between 1.3 and 2.0 times the height of the story above. | -0.6 | |
| | Setback | Vertical elements of the lateral system at an upper story are outboard of those at the story below causing the diaphragm to cantilever at the offset. | -1.2 | |
| | | Vertical elements of the lateral system at upper stories are inboard of those at lower stories. | -0.6 | |
| | | There is an in-plane offset of the lateral elements that is greater than the length of the elements. | -0.4 | |
| | Short Column/ Pier | C1,C2,C3,PC1,PC2,RM1,RM2: At least 20% of columns (or piers) along a column line in the lateral system have height/depth ratios less than 50% of the nominal height/depth ratio at that level. | -0.5 | |
| | | C1,C2,C3,PC1,PC2,RM1,RM2: The column depth (or pier width) is less than one half of the depth of the spandrel, or there are infill walls or adjacent floors that shorten the column. | -0.5 | |
| | Split Level | There is a split level at one of the floor levels or at the roof. | -0.6 | |
| | Other Irregularity | There is another observable severe vertical irregularity that obviously affects the building's seismic performance. | -1.2 | $V_{L2}$ = _______ |
| | | There is another observable moderate vertical irregularity that may affect the building's seismic performance. | -0.6 | *(Cap at -1.4)* |
| Plan Irregularity, $P_{L2}$ | Torsional irregularity: Lateral system does not appear relatively well distributed in plan in either or both directions. *(Do not include the W1A open front irregularity listed above.)* | | -1.0 | |
| | Non-parallel system: There are one or more major vertical elements of the lateral system that are not orthogonal to each other. | | -0.5 | |
| | Reentrant corner: Both projections from an interior corner exceed 25% of the overall plan dimension in that direction. | | -0.5 | |
| | Diaphragm opening: There is an opening in the diaphragm with a width over 50% of the total diaphragm width at that level. | | -0.3 | |
| | C1, C2 building out-of-plane offset: The exterior beams do not align with the columns in plan. | | -0.4 | $P_{L2}$ = _______ |
| | Other irregularity: There is another observable plan irregularity that obviously affects the building's seismic performance. | | -1.0 | *(Cap at -1.4)* |
| Redundancy | The building has at least two bays of lateral elements on each side of the building in each direction. | | +0.4 | |
| Pounding | Building is separated from an adjacent structure by less than 0.25% of the height of the shorter of the building and adjacent structure and: | The floors do not align vertically within 2 feet. *(Cap total pounding modifiers at -1.4)* | -1.2 | |
| | | One building is 2 or more stories taller than the other. | -1.2 | |
| | | The building is at the end of the block. | -0.6 | |
| S2 Building | "K" bracing geometry is visible. | | -1.2 | |
| C1 Building | Flat plate serves as the beam in the moment frame. | | -0.5 | |
| PC1/RM1 Bldg | There are roof-to-wall ties that are visible or known from drawings that do not rely on cross-grain bending. *(Do not combine with post-benchmark or retrofit modifier.)* | | +0.4 | |
| PC1/RM1 Bldg | The building has closely spaced, full height interior walls (rather than an interior space with few walls such as in a warehouse). | | +0.4 | |
| URM | Gable walls are present. | | -0.5 | |
| MH | There is a supplemental seismic bracing system provided between the carriage and the ground. | | +1.2 | |
| Retrofit | Comprehensive seismic retrofit is visible or known from drawings. | | +1.4 | M = _______ |

**FINAL LEVEL 2 SCORE, $S_{L2} = (S' + V_{L2} + P_{L2} + M) \geq S_{MIN}$:** *(Transfer to Level 1 form)*

There is observable damage or deterioration or another condition that negatively affects the building's seismic performance: ☐ Yes ☐ No

*If yes, describe the condition in the comment box below and indicate on the Level 1 form that detailed evaluation is required independent of the building's score.*

**OBSERVABLE NONSTRUCTURAL HAZARDS**

| Location | Statement *(Check "Yes" or "No")* | Yes | No | Comment |
|---|---|---|---|---|
| Exterior | There is an unbraced unreinforced masonry parapet or unbraced unreinforced masonry chimney. | | | |
| | There is heavy cladding or heavy veneer. | | | |
| | There is a heavy canopy over exit doors or pedestrian walkways that appears inadequately supported. | | | |
| | There is an unreinforced masonry appendage over exit doors or pedestrian walkways. | | | |
| | There is a sign posted on the building that indicates hazardous materials are present. | | | |
| | There is a taller adjacent building with an unanchored URM wall or unbraced URM parapet or chimney. | | | |
| | Other observed exterior nonstructural falling hazard: | | | |
| Interior | There are hollow clay tile or brick partitions at any stair or exit corridor. | | | |
| | Other observed interior nonstructural falling hazard: | | | |

**Estimated Nonstructural Seismic Performance** *(Check appropriate box and transfer to Level 1 form conclusions)*

☐ Potential nonstructural hazards with significant threat to occupant life safety → Detailed Nonstructural Evaluation recommended

☐ Nonstructural hazards identified with significant threat to occupant life safety → But no Detailed Nonstructural Evaluation required

☐ Low or no nonstructural hazard threat to occupant life safety → No Detailed Nonstructural Evaluation required

**Comments:**

Figure B.8 FEMA p154 data collection form for moderate seismic regions level 2 (adopted from FEMA p-154 Handbook)

**Rapid Visual Screening of Buildings for Potential Seismic Hazards** **Level 1**
FEMA P-154 Data Collection Form **LOW Seismicity**

PHOTOGRAPH

**Address:**
**Zip:**
**Other Identifiers:**
**Building Name:**
**Use:**
**Latitude:** **Longitude:**
$S_S$: $S_1$:
**Screener(s):** **Date/Time:**

**No. Stories:** Above Grade: Below Grade: **Year Built:** ☐ EST
**Total Floor Area (sq. ft.):** **Code Year:**
**Additions:** ☐ None ☐ Yes, Year(s) Built:

**Occupancy:** Assembly Commercial Emer. Services ☐ Historic ☐ Shelter
Industrial Office School ☐ Government
Utility Warehouse Residential, # Units:

**Soil Type:** ☐A Hard Rock ☐B Avg Rock ☐C Dense Soil ☐D Stiff Soil ☐E Soft Soil ☐F Poor Soil DNK *If DNK, assume Type D.*

**Geologic Hazards:** Liquefaction: Yes/No/DNK Landslide: Yes/No/DNK Surf. Rupt.: Yes/No/DNK

**Adjacency:** ☐ Pounding ☐ Falling Hazards from Taller Adjacent Building

**Irregularities:** ☐ Vertical (type/severity)
☐ Plan (type)

**Exterior Falling Hazards:** ☐ Unbraced Chimneys ☐ Heavy Cladding or Heavy Veneer
☐ Parapets ☐ Appendages
☐ Other:

**COMMENTS:**

SKETCH

☐ Additional sketches or comments on separate page

**BASIC SCORE, MODIFIERS, AND FINAL LEVEL 1 SCORE, $S_{L1}$**

| FEMA BUILDING TYPE | Do Not Know | W1 | W1A | W2 | S1 (MRF) | S2 (BR) | S3 (LM) | S4 (RC SW) | S5 (URM INF) | C1 (MRF) | C2 (SW) | C3 (URM INF) | PC1 (TU) | PC2 | RM1 (FD) | RM2 (RD) | URM | MH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Basic Score** | | **6.2** | **5.9** | **5.7** | **3.8** | **3.9** | **4.4** | **4.1** | **4.5** | **3.3** | **4.2** | **3.5** | **3.8** | **3.3** | **3.7** | **3.7** | **3.2** | **4.6** |
| Severe Vertical Irregularity, $V_{L1}$ | | -1.5 | -1.5 | -1.5 | -1.4 | -1.3 | -1.6 | -1.2 | -1.3 | -1.3 | -1.2 | -1.1 | -1.3 | -1.1 | -1.1 | -1.1 | -1.2 | NA |
| Moderate Vertical Irregularity, $V_{L1}$ | | -1.0 | -0.9 | -0.9 | -0.9 | -0.8 | -1.0 | -0.7 | -0.7 | -0.7 | -0.7 | -0.6 | -0.8 | -0.6 | -0.6 | -0.6 | -0.7 | NA |
| Plan Irregularity, $P_{L1}$ | | -1.6 | -1.4 | -1.3 | -1.2 | -1.1 | -1.4 | -1.0 | -1.1 | -1.0 | -1.0 | -0.9 | -1.2 | -0.9 | -0.9 | -0.9 | -1.0 | NA |
| Pre-Code | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Post-Benchmark | | 2.2 | 2.4 | 2.5 | 2.0 | 1.6 | 1.4 | 2.1 | NA | 2.3 | 2.2 | NA | 1.9 | 2.6 | 2.3 | 2.3 | NA | 1.8 |
| Soil Type A or B | | 0.9 | 1.1 | 1.3 | 1.0 | 1.2 | 0.8 | 1.3 | 1.4 | 0.9 | 1.2 | 1.2 | 1.3 | 1.3 | 1.4 | 1.4 | 1.3 | 0.9 |
| Soil Type E (1-3 stories) | | -1.2 | -1.7 | -2.3 | -1.2 | -1.4 | -1.0 | -1.7 | -2.0 | -1.4 | -2.0 | -1.6 | -1.7 | -1.6 | -1.7 | -1.7 | -1.5 | -2.1 |
| Soil Type E (> 3 stories) | | -1.7 | -2.0 | -2.2 | -1.2 | -1.4 | NA | -1.7 | -1.9 | -1.3 | -1.9 | -1.6 | NA | -1.6 | -1.6 | -1.7 | -1.4 | NA |
| Minimum Score, $S_{MIN}$ | | *2.7* | *2.1* | *1.5* | *0.9* | *0.8* | *1.2* | *0.8* | *0.9* | *0.5* | *0.6* | *0.5* | *0.6* | *0.4* | *0.6* | *0.5* | *0.4* | *2.5* |

**FINAL LEVEL 1 SCORE, $S_{L1} \geq S_{MIN}$:**

**EXTENT OF REVIEW**
**Exterior:** ☐ Partial ☐ All Sides ☐ Aerial
**Interior:** ☐ None ☐ Visible ☐ Entered
**Drawings Reviewed:** ☐ Yes ☐ No
**Soil Type Source:**
**Geologic Hazards Source:**
**Contact Person:**

**LEVEL 2 SCREENING PERFORMED?**
☐ Yes, Final Level 2 Score, $S_{L2}$ ☐ No
Nonstructural hazards? ☐ Yes ☐ No

**OTHER HAZARDS**
**Are There Hazards That Trigger A Detailed Structural Evaluation?**
☐ Pounding potential (unless $S_{L2}$ > cut-off, if known)
☐ Falling hazards from taller adjacent building
☐ Geologic hazards or Soil Type F
☐ Significant damage/deterioration to the structural system

**ACTION REQUIRED**
**Detailed Structural Evaluation Required?**
☐ Yes, unknown FEMA building type or other building
☐ Yes, score less than cut-off
☐ Yes, other hazards present
☐ No
**Detailed Nonstructural Evaluation Recommended?** *(check one)*
☐ Yes, nonstructural hazards identified that should be evaluated
☐ No, nonstructural hazards exist that may require mitigation, but a detailed evaluation is not necessary
☐ No, no nonstructural hazards identified ☐ DNK

***Where information cannot be verified, screener shall note the following: EST = Estimated or unreliable data OR DNK = Do Not Know***

Legend: MRF = Moment-resisting frame; BR = Braced frame; RC = Reinforced concrete; SW = Shear wall; URM INF = Unreinforced masonry infill; TU = Tilt up; MH = Manufactured Housing; LM = Light metal; FD = Flexible diaphragm; RD = Rigid diaphragm

Figure B.9 FEMA p154 data collection form for low seismic regions level 1 (adopted from FEMA p-154 Handbook)

**Rapid Visual Screening of Buildings for Potential Seismic Hazards** **Level 2 (Optional)**

FEMA P-154 Data Collection Form **LOW Seismicity**

Optional Level 2 data collection to be performed by a civil or structural engineering professional, architect, or graduate student with background in seismic evaluation or design of buildings.

| | | | |
|---|---|---|---|
| **Bldg Name:** | **Final Level 1 Score:** | $S_{L1}$ = | *(do not consider $S_{MIN}$)* |
| **Screener:** | **Level 1 Irregularity Modifiers:** | *Vertical Irregularity,* $V_{L1}$ = | *Plan Irregularity,* $P_{L1}$ = |
| **Date/Time:** | **ADJUSTED BASELINE SCORE:** | $S' = (S_{L1} - V_{L1} - P_{L1})$ = | |

**STRUCTURAL MODIFIERS TO ADD TO ADJUSTED BASELINE SCORE**

| Topic | Statement *(If statement is true, circle the "Yes" modifier; otherwise cross out the modifier.)* | | Yes | Subtotals |
|---|---|---|---|---|
| Vertical Irregularity, $V_{L2}$ | Sloping Site | W1 building: There is at least a full story grade change from one side of the building to the other. | -1.5 | |
| | | Non-W1 building: There is at least a full story grade change from one side of the building to the other. | -0.4 | |
| | Weak and/or Soft Story *(circle one maximum)* | W1 building cripple wall: An unbraced cripple wall is visible in the crawl space. | -0.7 | |
| | | W1 house over garage: Underneath an occupied story, there is a garage opening without a steel moment frame, and there is less than 8' of wall on the same line (for multiple occupied floors above, use 16' of wall minimum). | -1.5 | |
| | | W1A building open front: There are openings at the ground story (such as for parking) over at least 50% of the length of the building. | -1.5 | |
| | | Non-W1 building: Length of lateral system at any story is less than 50% of that at story above or height of any story is more than 2.0 times the height of the story above. | -1.3 | |
| | | Non-W1 building: Length of lateral system at any story is between 50% and 75% of that at story above or height of any story is between 1.3 and 2.0 times the height of the story above. | -0.6 | |
| | Setback | Vertical elements of the lateral system at an upper story are outboard of those at the story below causing the diaphragm to cantilever at the offset. | -1.3 | |
| | | Vertical elements of the lateral system at upper stories are inboard of those at lower stories. | -0.6 | |
| | | There is an in-plane offset of the lateral elements that is greater than the length of the elements. | -0.4 | |
| | Short Column/ Pier | C1,C2,C3,PC1,PC2,RM1,RM2: At least 20% of columns (or piers) along a column line in the lateral system have height/depth ratios less than 50% of the nominal height/depth ratio at that level. | -0.6 | |
| | | C1,C2,C3,PC1,PC2,RM1,RM2: The column depth (or pier width) is less than one half of the depth of the spandrel, or there are infill walls or adjacent floors that shorten the column. | -0.6 | |
| | Split Level | There is a split level at one of the floor levels or at the roof. | -0.6 | |
| | Other Irregularity | There is another observable severe vertical irregularity that obviously affects the building's seismic performance. | -1.3 | $V_{L2}$= _______ |
| | | There is another observable moderate vertical irregularity that may affect the building's seismic performance. | -0.6 | *(Cap at -1.5)* |
| Plan Irregularity, $P_{L2}$ | Torsional irregularity: Lateral system does not appear relatively well distributed in plan in either or both directions. *(Do not include the W1A open front irregularity listed above.)* | | -1.1 | |
| | Non-parallel system: There are one or more major vertical elements of the lateral system that are not orthogonal to each other. | | -0.6 | |
| | Reentrant corner: Both projections from an interior corner exceed 25% of the overall plan dimension in that direction. | | -0.6 | |
| | Diaphragm opening: There is an opening in the diaphragm with a width over 50% of the total diaphragm width at that level. | | -0.4 | |
| | C1, C2 building out-of-plane offset: The exterior beams do not align with the columns in plan. | | -0.5 | $P_{L2}$= _______ |
| | Other irregularity: There is another observable plan irregularity that obviously affects the building's seismic performance. | | -1.1 | *(Cap at -1.6)* |
| Redundancy | The building has at least two bays of lateral elements on each side of the building in each direction. | | +0.4 | |
| Pounding | Building is separated from an adjacent structure by less than 0.1% of the height of the shorter of the building and adjacent structure and: | The floors do not align vertically within 2 feet. *(Cap total pounding modifiers at -1.5)* | -1.3 | |
| | | One building is 2 or more stories taller than the other. | -1.3 | |
| | | The building is at the end of the block. | -0.6 | |
| S2 Building | "K" bracing geometry is visible. | | -1.3 | |
| C1 Building | Flat plate serves as the beam in the moment frame. | | -0.6 | |
| PC1/RM1 Bldg | There are roof-to-wall ties that are visible or known from drawings that do not rely on cross-grain bending. *(Do not combine with post-benchmark or retrofit modifier.)* | | +0.4 | |
| PC1/RM1 Bldg | The building has closely spaced, full height interior walls (rather than an interior space with few walls such as in a warehouse). | | +0.4 | |
| URM | Gable walls are present. | | -0.6 | |
| MH | There is a supplemental seismic bracing system provided between the carriage and the ground. | | +1.8 | |
| Retrofit | Comprehensive seismic retrofit is visible or known from drawings. | | +1.6 | *M* = _______ |

**FINAL LEVEL 2 SCORE, $S_{L2} = (S' + V_{L2} + P_{L2} + M) \geq S_{MIN}$:** *(Transfer to Level 1 form)*

There is observable damage or deterioration or another condition that negatively affects the building's seismic performance: ☐ Yes ☐ No

*If yes, describe the condition in the comment box below and indicate on the Level 1 form that detailed evaluation is required independent of the building's score.*

**OBSERVABLE NONSTRUCTURAL HAZARDS**

| Location | Statement *(Check "Yes" or "No")* | Yes | No | Comment |
|---|---|---|---|---|
| Exterior | There is an unbraced unreinforced masonry parapet or unbraced unreinforced masonry chimney. | | | |
| | There is heavy cladding or heavy veneer. | | | |
| | There is a heavy canopy over exit doors or pedestrian walkways that appears inadequately supported. | | | |
| | There is an unreinforced masonry appendage over exit doors or pedestrian walkways. | | | |
| | There is a sign posted on the building that indicates hazardous materials are present. | | | |
| | There is a taller adjacent building with an unanchored URM wall or unbraced URM parapet or chimney. | | | |
| | Other observed exterior nonstructural falling hazard: | | | |
| Interior | There are hollow clay tile or brick partitions at any stair or exit corridor. | | | |
| | Other observed interior nonstructural falling hazard: | | | |

**Estimated Nonstructural Seismic Performance** *(Check appropriate box and transfer to Level 1 form conclusions)*

☐ Potential nonstructural hazards with significant threat to occupant life safety → Detailed Nonstructural Evaluation recommended

☐ Nonstructural hazards identified with significant threat to occupant life safety → But no Detailed Nonstructural Evaluation required

☐ Low or no nonstructural hazard threat to occupant life safety → No Detailed Nonstructural Evaluation required

**Comments:**

Figure B.10 FEMA p154 data collection form for low seismic regions level 2 (adopted from FEMA p-154 Handbook)

# APPENDIX C

# CANADIAN SEISMIC SCREENING METHOD DATA COLLECTION FORMS

| SEISMIC SCREENING FORM | | p. 1 of 2 | ITEM No.: |
|---|---|---|---|
| Address: | Postal Code: | Bldg. Name: | |
| No. of storeys: | Total Floor Area: $m^2$ | Year Built: | Design NBC: |
| Primary use (see list on p. 2): | | Heritage Designation: | |
| Inspector: | Date: | Checked by: | |

*Sketch*

*Photo*

| TYPE OF STRUCTURE (circle appropriate descriptors) see 4.3.2 | | | BM |
|---|---|---|---|
| Wood | WLF<br>WPB | Wood Light Frame<br>Wood, Post and Beam | 90 |
| Steel | SMF<br>SBF<br>SLF<br>SCW<br>SIW | Steel Moment Frame<br>Steel Braced Frame<br>Steel Light Frame<br>Steel Frame with Concrete Shear Walls<br>Steel Frame with Infill Masonry Shear Walls | 90 |
| Concrete | CMF<br>CSW<br>CIW<br>PCF<br>PCW | Concrete Moment Frame<br>Concrete Shear Walls<br>Concrete Frame with Infill Masonry Shear Walls<br>Precast Concrete Frame<br>Precast Concrete Walls | 85 |
| Masonry | RML<br>RMC<br>URM | Reinforced Masonry Bearing Walls with Wood or Metal Deck Floors or Roofs<br>Reinforced Masonry Bearing Walls with Concrete Diaphragms<br>Unreinforced Masonry Bearing Wall Building | 90 |

| BUILDING IRREGULARITIES (circle appropriate descriptors) see 4.3.3 | |
|---|---|
| 1. Vertical Irregularity | Abrupt changes in plan dimensions over height (e.g. setback or building on hill) |
| 2. Horizontal Irregularity (Torsion) | Irregular building shapes such as "L", "V", "E", "T", eccentric stiffness in plan (e.g. shear wall on only one side of building) |
| 3. Short Concrete Columns | Short columns restrained by partial storey height walls (structural or infill) or deep spandrels |
| 4. Soft Storey | Severe reduction of stiffness caused by discontinuous shear walls, openings, etc. |
| 5. Pounding | Separation between buildings less than 20 $Z_v$ x no. of storeys (in mm) |
| 6. Major Modifications | Any change in function, use or addition which results in significant increase in loading or weight |
| 7. Deterioration | Structural elements are damaged, poor condition of building is apparent (corroded reinforcement or steel, rotted wood, poor concrete or masonry) |
| 8. None | None of the irregularities listed above is present. |

NON - STRUCTURAL HAZARDS (Circle appropriate descriptors) see 4.3.4

$F_1$ Falling Hazards to Life:

Exterior: Masonry chimneys, parapets, veneer or stone / precast panels, non-safety glass, or canopies over exits and walkways

Interior: Heavy components; masonry partitions; non-safety glass in egress areas; storage shelves which may collapse onto areas of human occupancy

$F_2$ Hazards to Continuous Operation of Special Buildings: Equipment or lifelines required for continuous operation of special facilities. The owner or authority should provide a list of critical items needed for continuing operations.

From: Manual for Screening of Existing Buildings for Seismic Investigation, IRC / NRC, Canada, Ottawa, September 1992

Figure B.11 Canadian Seismic screening form page 1 (adopted from handbook)

| SEISMIC SCREENING FORM | p. 2 of 2 | ITEM No.: |
|---|---|---|

SEISMIC PRIORITY INDEX: Circle appropriate value and enter each result on right side. Use asterisk (*) with uncertain values

| | | Design NBC | Effective Seismic Zone ($Z_v$ or $Z_v + 1$ if $Z_a > Z_v$) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 2 | 3 | 4 | 5 | 6 | |
| A | Seismicity | Pre - 65<br>65 - 84<br>Post - 85 | 1.0<br>1.0<br>1.0 | 1.5<br>1.0<br>1.0 | 2.0<br>1.3<br>1.0 | 3.0<br>1.5<br>1.0 | 4.0<br>2.0<br>1.0 | A = |

| | | Design NBC | Soil Category | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Rock or Stiff Soil | Stiff Soil > 50 m | Soft Soil > 15 m | Very Soft or Liquefiable Soil | Unknown Soil | |
| B | Soil Conditions | Pre - 65<br>Post - 65 | 1.0<br>1.0 | 1.3<br>1.0 | 1.5<br>1.0 | 2.0<br>1.5 | 1.5<br>1.5 | B = |

| | | Design NBC | Construction Type and Symbol (see p. 1) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Wood | | Steel | | | | Concrete | | Precast | | Masonry Infill | Masonry | | | |
| | | | WLF | WPB | SLF | SMF | SBF | SCW | CMF | CSW | PCF | PCW | SIW, CIW | RML, RMC | URM | | |
| C | Type of Structure (BM = Benchmark year, see p.1) | Pre - 70<br>70 - BM<br>Post - BM | 1.2<br>1.2<br>1.0 | 2.0<br>2.0<br>1.0 | 1.0<br>1.0<br>1.0 | 1.2<br>1.2<br>1.0 | 1.5<br>1.5<br>1.0 | 2.0<br>1.5<br>1.0 | 2.5<br>1.5<br>1.0 | 2.0<br>1.5<br>1.0 | 2.5<br>1.8<br>1.0 | 2.0<br>1.5<br>1.0 | 3.0<br>2.0<br>1.0 | 2.5<br>1.5<br>1.0 | 3.5<br>3.5<br>– | C = | |

| | | Design NBC | 1. Vertical | 2. Horiz. | 3. Short Concrete Columns | 4 .Soft Storey | 5. Pounding | 6. Modifi-cation | 7. Dete-rioration | 8. None | D = product of circled Numbers (Max of 4.0) = |
|---|---|---|---|---|---|---|---|---|---|---|---|
| D | Building Irregularities | Pre - 70 | 1.3 | 1.5 | 1.5 | 2.0 | 1.3 | 1.3 | 1.3 | 1.0 | |
| | | Post - 70 | 1.3 | 1.5 | 1.5 | 1.5 | 1.3 | 1.0 | 1.3 | 1.0 | |

| | | Design NBC | Low Occupancy N < 10 | Normal Occupancy N = 10 - 300 | School, or High Occupancy N = 301 - 3000 | Post Disaster, or Very High Occup. N > 3000 | Special Operational Requirements | |
|---|---|---|---|---|---|---|---|---|
| E | Building Importance | Pre - 70 | 0.7 | 1.0 | 1.5 | 2.0 | 3.0 | E = |
| | | Post - 70 | 0.7 | 1.0 | 1.2 | 1.5 | 2.0 | |

N = Occupied Area x Occupancy Density x Duration Factor* = .......... x .......... x ......... =

| Primary Use: | Occupancy Density Persons / m² | Average Weekly Hours of Human Occupancy |
|---|---|---|
| Assembly | 1 | 5 - 50 |
| Mercantile, Personal service | 0.2 | 50 - 80 |
| Offices, Institutional, Manufacturing | 0.1 | 50 - 60 |
| Residential | 0.05 | 100 |
| Storage | 0.01 - 0.02 | 100 |

* Duration Factor is equal to the average weekly hours of human occupancy divided by 100, not greater than 1.0

| SI | STRUCTURAL INDEX = A · B · C · D · E = → | SI = |
|---|---|---|

| | | NON - STRUCTURAL HAZARDS | Description (see p. 1) | | None | Yes | Yes * | F = max ($F_1$, $F_2$) = |
|---|---|---|---|---|---|---|---|---|
| F | $F_1$ | Falling Hazards to Life | | Pre - 70 NBC<br>Post - 70 NBC | 1.0<br>1.0 | 3.0<br>2.0 | 6.0<br>3.0 | |
| | $F_2$ | Hazards to Vital Operations | | Any Year | 1.0 | 3.0 | 6.0 | |

* applies only if one or more of the following descriptors on page 1 are circled: SMF, CMF, soft storey, torsion

| NSI | NON - STRUCTURAL INDEX = B · E · F = → | NSI = |
|---|---|---|
| SPI | SEISMIC PRIORITY INDEX = SI + NSI = → | SPI = |

Comments:

From: Manual for Screening of Existing Buildings for Seismic Investigation, IRC / NRC, Canada, Ottawa, September 1992

Figure B.12 Canadian Seismic screening form page 2 (adopted from handbook)

| SEISMIC SCREENING INVENTORY FORM Attach asterisks (*) to uncertain values | | | | | | Page No.: |
|---|---|---|---|---|---|---|
| Item No. | Address and/or Name of Building | SI Structural Index | NSI Non-Structural Index | SPI Seismic Priority Index | Priority for Evaluation | Comments |
| | | | | | | |
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From: Manual for Screening of Existing Buildings for Seismic Investigation, IRC / NRC, Canada, Ottawa, September 1992

Figure B.13 Canadian Seismic screening form page 3 (adopted from handbook)