A PRELIMINARY PRIORITIZATION FRAMEWORK OF SEISMIC SAFETY FOR HISTORICAL STRUCTURES IN TÜRKİYE

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ABSTRACT

A PRELIMINARY PRIORITIZATION FRAMEWORK OF SEISMIC SAFETY FOR HISTORICAL STRUCTURES IN TÜRKIYE

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Historical structures have great importance since they form the basis of cultural identity of countries. Among these structures, those located in seismically active regions have been exposed to many earthquakes since they were built. Due to these seismic effects, historical structures are under constant risk of severe damage and collapse.

Historical structures are mainly constructed as masonry structures prior to the development of more advanced and scientific construction methods and seismic resistance provisions. However, masonry construction is still important from the points of sustainability, durability, safety, appearance, and wide range of applications.

There are thousands of historical structures located in Türkiye under considerable seismic hazard. Hence, a practical approach is necessary to receive a rapid and effective evaluation of the seismic safety. The approach selected in this study is the multi-criteria decision analysis methods. In this study, a preliminary seismic safety prioritization framework is proposed which does not require the application of extensive modeling and analysis approaches for assessment of historical structures in terms of seismic safety. Using this simplest framework, prioritization of the structures is aimed to take early precautions and to be more selective for future detailed studies. The framework presented herein evaluates the seismic safety of historical structures considering geological, seismological, structural and social parameters.

In this thesis, a total of 250 different historical structures in Türkiye are selected and evaluated in terms of seismic safety. Almost all the cities of Türkiye are included in the dataset which provides an extensive study of the seismic safety of the historical structures in the country. In this dataset, various types of masonry structures such as churches, mosques, inns, and towers are included. As a case study, the proposed framework is applied to the selected historical structures.

Keywords: Historical structures, masonry structures, seismic safety prioritization, multi-criteria decision analysis, Türkiye

ÖZ

TÜRKİYE'DEKİ TARİHİ YAPILAR İÇİN SİSMİK GÜVENLİĞİN ÖN ÖNCELİKLENDİRME ÇERÇEVESİ OLUŞTURULMASI

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Tarihi yapılar, ülkelerin kültürel kimliğinin temelini oluşturdukları için büyük önem taşımaktadır. Bu yapılar arasından sismik olarak aktif bölgelerde bulunanlar, yapıldıkları tarihten itibaren birçok depreme maruz kalmıştır. Bu sismik etkiler nedeniyle tarihi yapılar sürekli olarak ciddi hasar ve çökme riski altındadır.

Tarihi yapılar, daha gelişmiş bilimsel yapım yöntemlerinin ve sismik dayanım yönetmeliklerinin geliştirilmesinden önce, çoğunlukla yığma yapılar olarak inşa edilmişlerdir. Ancak, yığma yapılar, sürdürülebilirlik, dayanıklılık, güvenlik, görünüm ve geniş uygulama alanları açısından hala önemini korumaktadır.

Türkiye'de büyük deprem tehlikesi altında bulunan binlerce tarihi yapı bulunmaktadır. Bu nedenle, tarihi yapıların sismik güvenliğin hızlı ve etkin bir şekilde değerlendirilmesi için pratik bir yaklaşım gereklidir. Bu çalışmada seçilen yaklaşım, çok kriterli karar analizi yöntemleridir. Bu çalışmada, tarihi yapıların zarar görebilirlik değerlendirmesi için kapsamlı modelleme ve analiz yaklaşımlarının uygulanmasını gerektirmeyen ön bir sismik güvenlik önceliklendirme çerçevesi önerilmiştir. Bu en basit çerçeve kullanılarak yapıların önceliklendirilmesi ile erken önlem alınması ve ileride yapılacak detaylı çalışmalar için daha seçici olunması amaçlanmaktadır. Burada sunulan çerçeve, tarihi yığma yapıların sismik güvenliğinin jeolojik, sismolojik, yapısal ve sosyal parametreleri dikkate alarak değerlendirmektedir.

Bu tezde, Türkiye'de toplam 250 farklı tarihi yapı seçilmiştir ve sismik güvenlik açısından değerlendirilmiştir. Ülkedeki tarihi yapıların sismik güvenliğine ilişkin kapsamlı bir çalışma sağlayan veri setinde Türkiye'nin hemen hemen tüm şehirleri yer almaktadır. Bu veri setinde kilise, cami, han, kule gibi çeşitli yığma yapılar yer almaktadır. Bir vaka çalışması olarak, ileri sürülen çerçeve seçilen bu yapılara uygulanmıştır.

Anahtar Kelimeler: Tarihi yapılar, yığma yapılar, sismik güvenlik önceliklendirmesi, çok kriterli karar analizi, Türkiye

To my advisors and all my loved ones

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ABBREVIATIONS

MCDA:	Multi-criteria decision analysis
AHP:	Analytical hierarchy process
PROMETHEE:	Preference ranking organization method for enrichment evaluations
TOPSIS:	Technique for order preference by similarity to ideal solution
DEMATEL:	Decision-making trial and evaluation laboratory
VIKOR:	VlseKriterijumska Optimizacija I Kompromisno Resenje
CI:	Consistency index
RI:	Random consistency index
CR:	Consistency ratio
AFAD:	Disaster and Emergency Management Presidency
PGA:	Peak ground acceleration

LIST OF SYMBOLS

SYMBOLS

$V_{S_{30}}$:	Time-averaged shear wave velocity to a depth of 30 m
S_s:	Short period map spectral acceleration coefficient

CHAPTER 1

INTRODUCTION

1.1 General

Earthquakes are among the most devastating global natural disasters that cause loss of life and property. Every year, thousands of earthquakes happen all around the world, and at least 10 of them have moment magnitudes larger than 7 (USGS, 2022).

Historical structures are of great importance since they form the basis of cultural identity of countries. These structures in seismically active regions have been exposed to many earthquakes since they were built. Due to these seismic effects, historical structures are under constant risk of severe damage and collapse.

The fact that they are old, monumental and irreplaceable, and they were built a long time ago, in addition to being associated with historical events are the main reasons for classifying buildings and structures as historical. Currently, at least 50–100 year old buildings are called as historical (Gülkan & Wasti, 2009). Cultural, social or symbolic features of these structures make them eligible for conservation.

Historical structures are mainly constructed as masonry structures prior to the development of scientific construction methods and seismic resistance provisions. Masonry is known as one of the oldest building techniques. Masonry construction is still important from the points of sustainability, durability, safety, appearance and wide range of applications. It is frequently used in all types of buildings such as churches, governmental buildings, hospitals, etc.

Türkiye has a lot of historical structures since it has hosted many civilizations since ancient times. These structures in Türkiye have been subjected to seismic loads many times throughout their lifetimes resulting in the loss or severe damages of several invaluable cultural heritage. If a structure has experienced an earthquake in the past, it means it will again experience earthquakes in the future (Gülkan & Wasti, 2009). Thus, evaluation of the physical conditions of the historical structures should be performed regularly and systematically.

Then, restoration and strengthening should be considered as a precaution to ensure structural sustainability. However, seismic assessment procedures for the historical structures are very challenging, time-consuming, and expensive because of the complexities and uncertainties involved with the modeling. Structural plans and properties of the construction materials are also not known in detail in most cases. Obtaining these data to construct detailed and unique structural models requires input from multiple field studies as well as theoretical studies. However, there are thousands of historical structures located in Türkiye under considerable seismic hazard. Hence, a practical approach is necessary to perform a rapid and effective evaluation of the seismic safety condition of the historical structures.

Seismic risk of a structure depends mainly on the vulnerability, hazard, and exposure. The main purpose of the seismic risk assessment is to predict the damage probability of the buildings. Seismic risk assessment for historical structures is, however, a more complex and multidisciplinary task.

In this study, a preliminary seismic safety prioritization framework is proposed which does not require the application of extensive modeling and analysis approaches for vulnerability assessment of historical structures. Using this simple framework, prioritization of the structures is aimed to take early precautions and to be more selective for future detailed studies. The framework presented herein prioritize the structures within the scope of this study according to their seismic safety of historical structures considering geological, seismological, structural and social parameters. The systematic and comprehensive approach is necessary to decide the comparative seismic safety of the structures.

The main approach in this study is to follow multi-criteria decision analysis (MCDA) methods which include the analytic hierarchy process (AHP) and the technique for order preference by similarity to ideal solution (TOPSIS). As a case study, this framework is applied to some selected important historical structures in Türkiye.

1.2 Literature Review

The seismic risk is recognized as the probability of losses during an earthquake. It consists of seismic hazard at the site, exposure and vulnerability of the structures, which is defined as the susceptibility of structures to damage due to earthquakes. In the literature, seismic vulnerability assessments of the masonry structures have been studied for many years in different countries around the world (e.g.: Ramos & Lourenço, 2004; Erberik, 2008; Rota et al., 2010; Ahmad et al., 2012; Singh et al., 2013; Azizi-Bondarabadi et al., 2016; Karimzadeh et al., 2017; Halder et al., 2020).

Well-known studies in literature followed both empirical and analytical seismic vulnerability assessment methods. In empirical assessment approaches, different methods have been applied such as rapid visual screening (Achs & Adam, 2012; FEMA P-154, 2015), vulnerability index with Gruppo Nazionale per la Difesa dai Terremoti (GNDT) approach (Benedetti et al., 1988; Faccioli et al., 1999), European Macro-Seismic (EMS) approach (RISK-UE) (Lagomarsino & Giovinazzi, 2006; Mouroux & le Brun, 2007) and Combined GNDT and macro-seismic approaches (Giovinazzi & Lagomarsino, 2004; Lantada et al., 2010; Athmani et al., 2015).

In the literature, analytical seismic vulnerability assessment approaches are also called as theoretical approaches. The main difference between the empirical and analytical methods is the fact that while the first one is based on observations and expert judgements, the other mainly focuses on simulating the seismic actions and responses of the structures. In literature, different methods such as nonlinear static analysis - pushover analysis (Lagomarsino et al., 2014) and nonlinear time history analysis - incremental dynamic analysis (Marra et al., 2017) have been used within the analytical (theoretical) assessment approach.

Also, it is possible to combine these two approaches in seismic vulnerability assessment, which are called hybrid methods (Lang & Bachmann, 2003; Kappos et al., 2006).

By combining the probability of vulnerability obtained by these methodologies and the probability of occurrence of seismic hazard, seismic risk of structures is obtained (Wisner et al., 2003). In determination of the vulnerability and risk prioritization of historical structures, different methodologies are followed in the literature. Lagomarsino (2006) introduced the framework for the seismic prioritization of cultural heritage assets subjected to structural vulnerability index based on a macroseismic model. Later, D'Ayala et al. (2016) obtained complex structural models and followed the Failure Mechanism Identification and Vulnerability Evaluation (FaMIVE) method (D'ayala, 2005, 2013) in order to propose a multi-hazard vulnerability prioritization index. More recently, Despotaki et al. (2018) followed an approach by (Lagomarsino, 2006) in order to assess the seismic risk of historical structures in Europe using vulnerability indices for prioritization purposes. Furthermore, Sevieri et al. (2020) proposed a multi-hazard risk assessment framework for especially unreinforced masonry building and reinforced concrete frames using rapid-visual-survey form in order to calculate risk prioritization indices. Finally, Özbay & Karapınar (2021) performed a preliminary assessment to define the seismic priority of the masonry structures in Galata, one of the historical regions of Istanbul by using the rapid visual screening method and the score of performance.

The abovementioned vulnerability assessment, risk and safety prioritization studies are complex, and they depend on variety of criteria. Therefore, multi-criteria decision analysis methods have been used on different studies at the literature. Among different techniques, the analytical hierarchy process is one of the most commonly used techniques used in seismic hazard and risk assessment studies. This method developed by Saaty (1980) helps to analyze complex and problematic decisions. Since it ranks the parameters and creates a hierarchy among those, it is one of the most widely used multi criteria decision making models worldwide (Saaty, 1990, 2008). This method is applicable to variety of fields and studies such as engineering, architecture, and urban planning.

Similarly, the technique for order of preference by similarity to ideal solution method developed by Hwang & Yoon (1981) is also among the most widely used multi-criteria decision-making models, which sorts, selects, and prioritizes the alternatives. The best alternative for solution in TOPSIS method is the one which gives the closest distance to ideal solution.

Sarvar et al. (2011) have combined both AHP, TOPSIS and RADIUS methods to evaluate the seismic risk of a region of interest in Tehran, Iran with 8 different criteria including the position of the fault, type of material used in the structures and number of floors.

Zaheri et al. (2015) have used both AHP and TOPSIS methods to evaluate the seismic vulnerability of 74 different regions in Marand Country, Iran.

Banica et al. (2017) have evaluated seismic vulnerability in Iasi City (Romania) by following multi criteria decision analysis of buildings and infrastructures. They have considered 15 different criteria related to physical, social and systemic indicators, and applied AHP method as well as some other standardization and analysis methods. That study constitutes a pre-assessment engineering in order to light the way for effective seismic risk management purposes.

Yavuz Kumlu & Tüdeş (2019) have determined the areas of high seismic risk in Yalova City Center by following AHP and TOPSIS methods with 8 main criteria in the light of GIS-based MCDA within the scope of disaster risk management.

Alam & Haque (2018) have determined the urban seismic vulnerability of the residential neighborhoods of Mymensingh City, Bangladesh by following AHP and TOPSIS methods with 13 different qualitative and quantitative criteria such as average floor height, peak ground acceleration, distance to hospital, percentage of masonry building and etc.

Erdoğan & Terzi (2022) have aimed to assets vulnerability of 57 neighborhoods of Fatih district in Istanbul, Türkiye by using AHP method with 21 different indicators on critical urban services (e.g., accessibility to fire station), infrastructure facilities (e.g., distance to gas station and damage distribution of drinking water line), structures (e.g., building construction type and age of building) and socioeconomics (e.g., education status and population density).

As of now, there are systematic methods few in number for seismic safety prioritization of the historical structures in Türkiye. In this study, as the one of the first systematic attempts to fill this gap in the literature, a preliminary seismic safety prioritization framework is proposed by following multi-criteria decision analysis methods which do not require the application of extensive modeling and analysis approaches for vulnerability assessment of historical structures.

1.3 Objective and Scope

The main objective of this thesis is to propose a preliminary safety prioritization framework since a practical approach is necessary to receive a rapid and effective evaluation of the seismic safety condition of the historical structures.

In order to achieve the main objective, the scope of the study includes multi-criteria decision analysis methods which are employed using a set of selected historical structures considering their geological, seismological, structural and social characteristics. Within the scope, a total of 250 different historical structures are selected in Türkiye, on which the proposed framework is applied as a case study.

1.4 Organization of the Thesis

In this thesis, a preliminary seismic safety prioritization framework is proposed which does not require the application of extensive modeling and detailed analysis approaches for vulnerability assessment of historical structures. The framework presented herein evaluates the seismic safety of historical structures considering geological, seismological, structural and social parameters. The organization of the thesis is as follows:

Chapter 2 introduces the methodology of this thesis. Multi-criteria decision analysis methods which include the AHP and TOPSIS are presented. In addition, theories of these methods are provided.

Chapter 3 includes the database for preliminary prioritization of seismic safety for historical structures in Türkiye. It includes 250 selected historical structures. Major parameters for each structure are also presented in this chapter.

Implementation of the AHP and TOPSIS methods are performed on the database to prioritize the selected structures in relation to their seismic safety in *Chapter 4*.

In *Chapter 5*, a brief summary and the main conclusions of this thesis is provided. Furthermore, the major limitations of the study and future recommendations are addressed.

CHAPTER 2

MULTI-CRITERIA DECISION ANALYSIS

2.1 General

It is difficult to choose, prioritize and sort among a set of alternatives with multi-criteria. When dealing with single criterion situations, decision-making is incredibly intuitive because only the alternative that has the highest preference rating is selected (Tzeng & Huang, 2011). However, when various alternatives are considered using different criteria by the decision maker, many concerns such as weights of criteria, preference dependence, and conflicts across criteria make the decision problem complex, therefore, use of more advanced techniques become necessary. In order to facilitate decision making with a systematic approach, multi-criteria decision analysis methods have been developed. The analytical hierarchy process, the preference ranking organization method for enrichment evaluations (PROMETHEE), the technique for order preference by similarity to ideal solution, the decision-making trial and evaluation laboratory (DEMATEL) method, and the VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR) method are among these MCDA methods in the literature (Belton & Stewart, 2002).

AHP and TOPSIS are among the most widely used MCDA methods in construction, project, safety and risk management fields (Mardani et al., 2015). Thus, in this thesis, they are followed as a selection method to evaluate the seismic risk of the selected historical structures.

2.2 The Analytic Hierarchy Process

The Analytical Hierarchy Process is a multi-decision-making process as a systematic procedure for solving decision-making problems with competitive alternatives. Thomas L. Saaty developed AHP method in the 1970s (Saaty, 1987). It is a method that helps create decision-making models by considering the relationship between criteria and alternatives by analyzing components by both qualitatively and quantitatively: Qualitatively, a hierarchical structure is formed, which starts with the purpose of the problem and continues with alternatives divided into sets or subsets which are usually the criteria, goals, or activities. Quantitatively, it uses pairwise comparisons to assign the weights to sets or subsets. In pairwise comparisons, the importance of the elements relative to each other is determined by expert opinions. The experts' decisions are analytically controlled by calculating the consistency ratio, and objectivity is increased. In AHP method, in the multi-decision problems where multiple criteria play a role, the criteria weights as the contribution of the criteria to the result can be calculated, and the appropriate decision alternative can be preferred.

The procedure of the method of AHP is systematically introduced in Saaty (1980).

The AHP method consists of 3 main stages as shown in Figure 2.1.

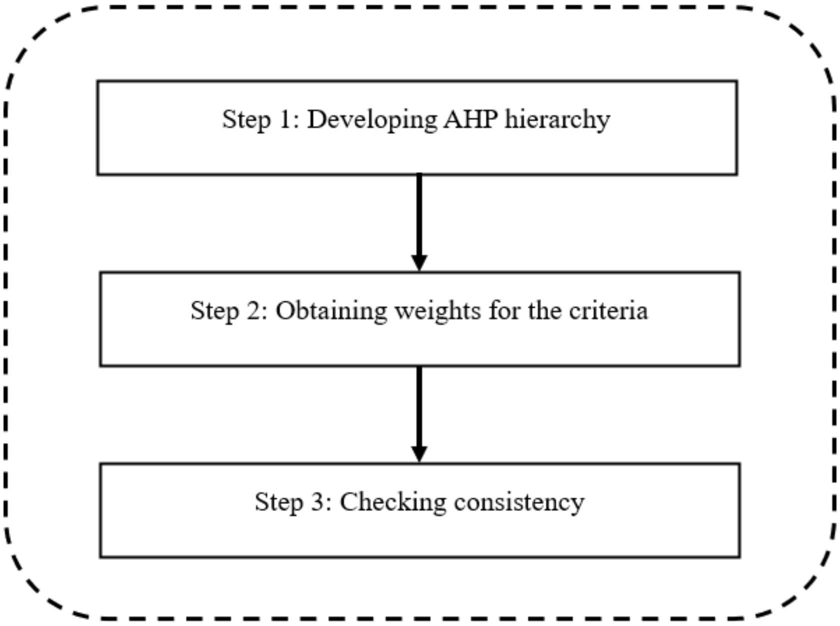

Figure 2.1. Flowchart of AHP method

i) Step 1:

A hierarchical or network structure must be used to model the problem (Saaty, 1987). The decision breaks down into a hierarchy of goals, criteria, and alternatives (Figure 2.2).

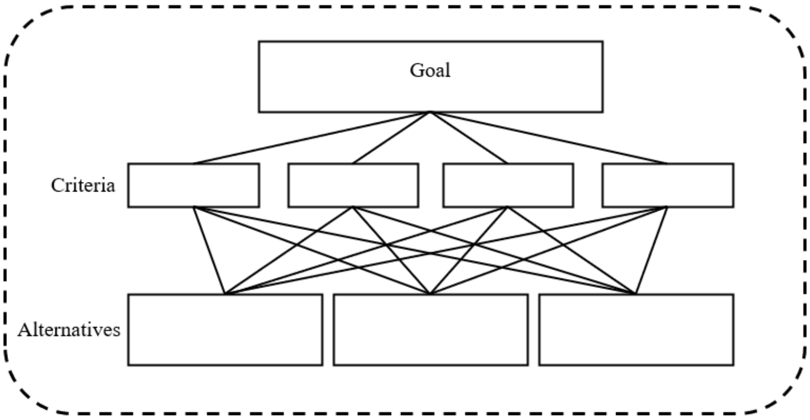

Figure 2.2. A hierarchy model for the decision

ii) Step 2:

The relative importance of each criterion is determined by pairwise comparisons. The numerical scale with 9 levels is used for the importance values of pairwise comparisons in the AHP (Table 2.1). A pairwise comparison matrix is obtained by following the scale with the experts' decision.

Table 2.1. Numerical importance scale (Adopted from Saaty (1987))

Intensity of importance	**Definition**
1	Equal importance
3	Moderate importance of one over another
5	Essential or strong importance
7	Very strong importance
9	Extreme importance
2, 4, 6, 8	Intermediate values between the two adjacent judgements
Reciprocals	If activity i has one of the above numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i

The pairwise comparison matrix $(A)_{nxn}$ is formed in a hierarchy with n decision criteria as in Equations 2.1 and 2.2. In the matrix, i^{th} row and j^{th} column correspond to i^{th} criteria. Each element (a_{ij}) in the matrix is determined by comparing the importance of i^{th} and j^{th} criteria with each other. Diagonal elements in the matrix should be 1.0 since the same criteria has the same importance. The product of two symmetric elements should be 1 as shown in Equation 2.3.

$$A = \left(a_{ij}\right)_{nxn}, \qquad (i, j = 1,2, \dots, n) \qquad (2.1)$$

$$A = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & \vdots \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{bmatrix}_{nxn} \quad (2.2)$$

$$a_{ij} = \frac{1}{a_{ji}} \quad (2.3)$$

Following the proposed eigenvector analysis, the weight matrix is obtained from the pairwise comparison matrix. The eigenvalue problem is defined by Saaty (1980) as follows:

$$Aw = \lambda_{max} w \quad (2.4)$$

where A is defined as a pairwise comparison matrix, w is considered vectors of weights, and λ_{max} is defined as the largest eigenvalue of A.

The division of each cell by the sum of its columnwise entries gives the normalization of the pairwise comparison matrix as follows:

$$a_{ij}^{*} = \frac{a_{ij}}{\sum_{j=1}^{n} a_{ij}} \quad (2.5)$$

From the normalized pairwise matrix, weights are obtained by calculating the average value of each row for each criterion, as follows:

$$w_i = \frac{\sum_{i=1}^{n} a_{ij}^{*}}{n} \quad (2.6)$$

iii) Step 3:

It is necessary to check whether the experts' judgments are consistent or not.

The consistency index (CI) indicates a closeness to consistency (Saaty, 1980). CI is obtained as follows:

$$CI = \frac{\lambda_{max} - n}{n - 1} \qquad (2.7)$$

According to research by Saaty (1980), the random consistency indices (RI) are provided for each n size of the pairwise comparison matrix in Table 2.2.

Table 2.2. The random consistency indices (Adopted from Saaty (1980))

n	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Consistency ratio (CR) is calculated by the ratio of consistency index to the random consistency index as follows:

$$CR = CI/RI \qquad (2.8)$$

If CR is equal or less than 0.10, experts' judgments are acceptable. If the ratio is larger than 0.10, the pairwise comparison matrix is inconsistent, and it should be revised by the experts.

2.3 The Technique for Order Preference by Similarity to Ideal Solution

The technique for order preference by similarity to the ideal solution is a method for multi-decision-making criteria analysis developed by Hwang & Yoon (1981). This technique is based on selecting an alternative that is the closest to the ideal solution and the furthest from the negative ideal solution. The method may be applied by following the 7 steps demonstrated in Figure 2.3.

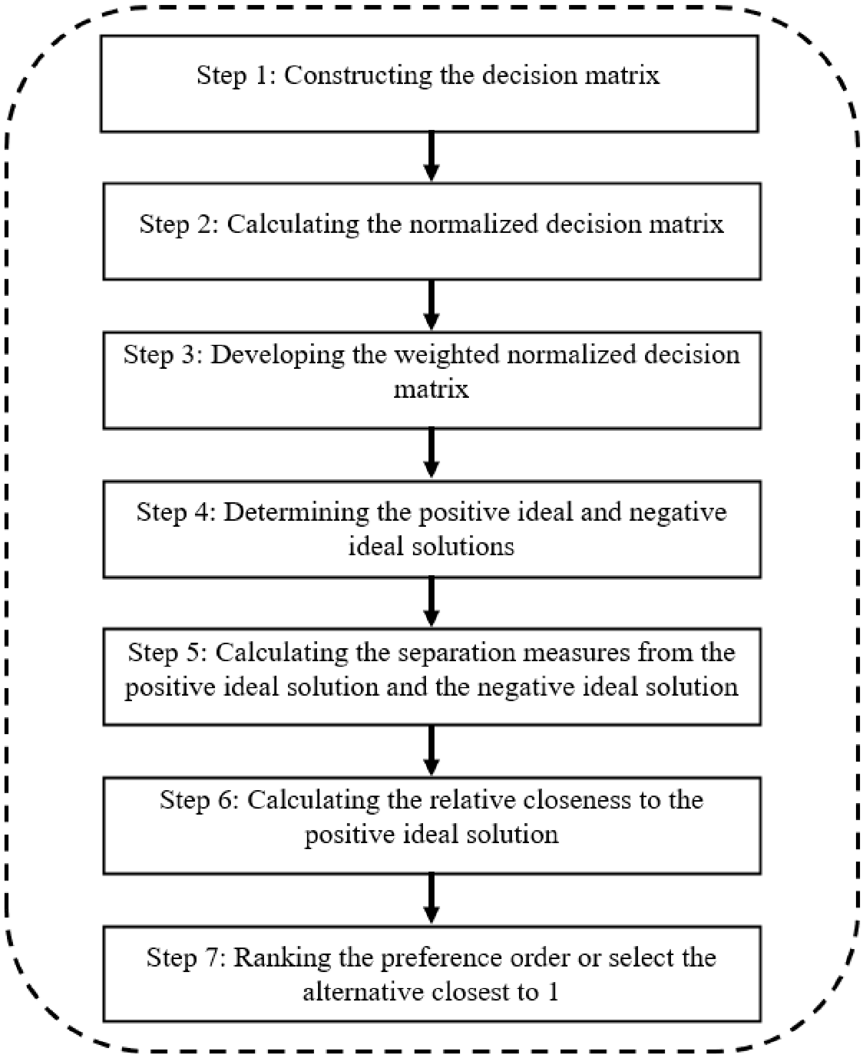

Figure 2.3. Flowchart of TOPSIS method (Adopted from Roszkowska (2011))

i) Step 1:

The decision matrix (D) is constructed by experts considering the alternatives and the criteria. A decision matrix whose size is mxn consists of x_{ij} elements which refers to the evaluation of alternatives according to the criteria, where $i = 1,2,\ldots,m$ and $j = 1,2,\ldots,n$. Its rows and columns are indicated with the alternatives (A_i) and the criteria (C_j), respectively.

The weights of criteria for the goal are obtained by other multi-decision-making analysis or directly experts' judgments. After then, the weight matrix (w_j) is provided with the decision matrix, where $j = 1,2,\ldots,n$. The provided matrices are presented as follows (Roszkowska, 2011):

$$w = [\, w_1 \quad w_2 \quad \cdots \quad w_n \,]_{1xn}$$

$$D = \begin{matrix} \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{matrix} \begin{matrix} \begin{matrix} C_1 & C_2 & \cdots & \mathrm{C_n} \end{matrix} \\ \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & \vdots \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}_{mxn} \end{matrix} \qquad (2.9)$$

ii) Step 2:

Normalization of the decision matrix defined by the decision maker is performed by the division of each cell (x_{ij}) to the square root of the sum of the squares of each cell columnwise as follows:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \qquad (2.10)$$

iii) Step 3:

Each column of normalized decision matrix obtained in step 2 is multiplied by a weight related to its column to produce the weighted normalized decision matrix:

$$V_{ij} = w_j r_{ij} \qquad (2.11)$$

iv) Step 4:

The positive and negative ideal solution in each column of the weighted normalized decision matrix is determined by considering the effect of criteria on the goal. If the criterion is a benefit for the goal, a maximum value from alternatives corresponds to the positive ideal solution. Yet, if the criterion is a disadvantage for the goal, a minimum value from the alternatives corresponds the positive ideal solution. Likewise, the opposite of each of them is valid for the negative ideal solution.

The positive ideal set is obtained for each criterion as follows:

$$A^* = \{max v_{ij}\} = \{v_1^*, v_2^*, \ldots, v_n^*\} \tag{2.12}$$

The negative ideal set is obtained for each criterion as follows:

$$A^- = \{min v_{ij}\} = \{v_1^-, v_2^-, \ldots, v_n^-\} \tag{2.13}$$

v) Step 5:

The separation values of each alternative from the positive (S_i^*) and negative (S_i^-) ideal solution in each criterion are derived using the Euclidean distance, as follows (Tzeng & Huang, 2011):

$$S_i^* = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^*\right)^2} \tag{2.14}$$

$$S_i^- = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^-\right)^2} \tag{2.15}$$

vi) Step 6:

The relative closeness (C_i^*) of each alternative to the positive ideal solution is obtained as follows:

$$C_i^* = \frac{S_i^-}{S_i^- + S_i^*} \tag{2.16}$$

where C_i^* should vary between 0.0 and 1.0.

vii) Step 7:

The alternatives in the decision problem are ranked considering the relative closeness of each alternative. The best alternative according to the goal is an alternative whose relative closeness is closer to 0.0. When the relative closeness of alternative is ranked from 0 to 1, prioritization of the alternatives according to the goal is achieved.

CHAPTER 3

DATABASE FOR PRELIMINARY PRIORITIZATION OF SEISMIC SAFETY FOR THE HISTORICAL STRUCTURES IN TÜRKİYE

3.1 General

The lands of Anatolia have hosted different cultures from ancient times. Since every civilization has built its own structures, Türkiye includes a wide range of historical structures within its borders.

Masonry structures are the structural systems that are based on the principle of transferring loads by placing units such as brick and stone on top of each other and then connecting them mostly with mortar. A masonry structure has no structural frame, instead, the walls carry the loads in the system. Common materials used in masonry structures are brick, stone, adobe, etc. These materials that make up the masonry structure have high compressive strength and low tensile strength. Also, they have limited deformation capacity when exposed to pressure and tensile effects. Most importantly, they are economical and easy to build. Figure 3.1 represents a typical masonry structure.

Figure 3.1. Typical masonry structure (Retrieved from D’Altri et al. (2020))

Masonry is known as the oldest building technique. Masonry construction is still important from the point of their sustainability, durability, safety, appearance, and wide range of applications.

In Türkiye, there exist various types of historical structures such as mosques, governmental buildings, churches, inns, fountains, etc. In this chapter, selected historical structures in Türkiye and the information on these structures will be presented in detail.

3.2 Selected Historical Structures in Türkiye

In this thesis, a total of 250 different historical structures are selected in Türkiye (see Appendix A.1). These structures are taken from the Republic of Türkiye Ministry of Culture and Tourism webpage (https://www.kulturportali.gov.tr). Almost all the cities in Türkiye are included in the dataset in order to investigate the seismic safety of the structures all around the country. In this dataset, various types of historical structures such as churches, mosques, inns, and towers are included. The distribution of the selected structures on Türkiye map is presented in Figure 3.2.

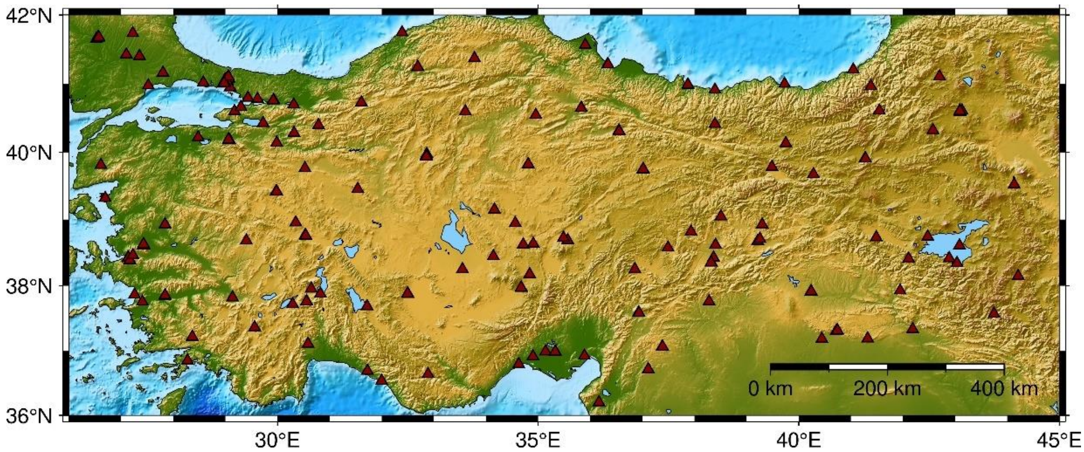

Figure 3.2. Selected historical structures in Türkiye

3.3 Major Parameters about the Selected Historical Structures

Herein, major parameters about the selected historical structures are presented. From the publicly available data and expert opinion, structural, geological, seismological and social parameters of the historical structures are collected. All of the information on the selected structures is provided in Tables B.1 and B.2. These major parameters are type of construction materials, construction year, occupancy class, condition of the restoration, importance in terms of cultural heritage, site class, peak ground acceleration and seismic gap in the region as explained in detail in the following sub-sections.

3.3.1 Type of Construction Materials

The construction materials of the structure are acquired by using the publicly available information and photos of the considered structure taken from different angles. Variety types of materials have been used for the construction of structures over the centuries in Türkiye. The selected historical structures in this thesis had mostly been made of stone units. There is also a group of structures in which stone units had been used together with brick units to construct the masonry walls. The distribution of the type of materials used in the construction of the structures in the dataset is presented in Table 3.1.

Table 3.1. The distribution of the type of materials of the structures in the dataset

Type of Construction Material	**Number in the Dataset**
Stone	173
Stone, Brick	39
Brick	12
Timber	8

Table 3.1. (cont'd)

Type of Construction Material	Number in the Dataset
Stone, Timber, Adobe	1
Stone, Timber	11
Adobe, Timber	2
Stone, Adobe	1
Adobe	1
Stone, Brick, Timber	1
Brick, Timber	1

3.3.2 Construction Year of the Structure

Information on the construction year of the structures is collected by using the publicly available data. Since many ancient civilizations had been located in the Anatolia region, the construction year of some of these historical structures go back to ancient times. Also, there are many historical structures from the republic era of Türkiye close to the present day. Selected historical structures in this thesis cover a wide period of time in terms of the construction year. The distribution of the construction years of the structures in the dataset is presented in Figure 3.3.

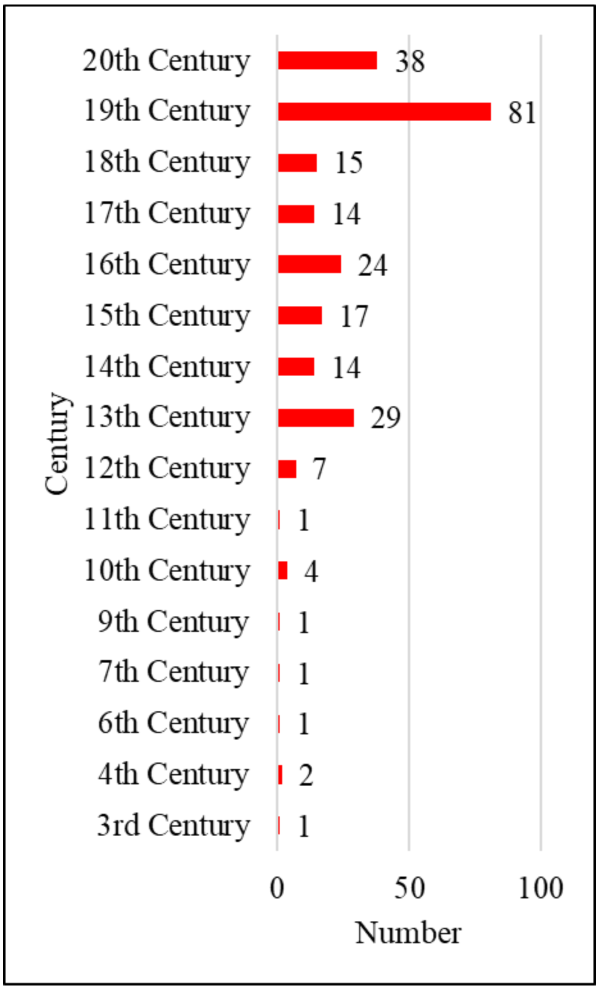

Figure 3.3. The distribution of the construction year of the structures in the dataset

3.3.3 Occupancy Class of the Structure

Historical structures had been built to serve for various functions in the past. In Türkiye, most of the historical structures can be considered in different occupancy classes such as public, commercial, religious or social/cultural. On the other hand, some of them are not used today. The distribution of occupancy classes for the selected historical structures are presented in Figure 3.4.

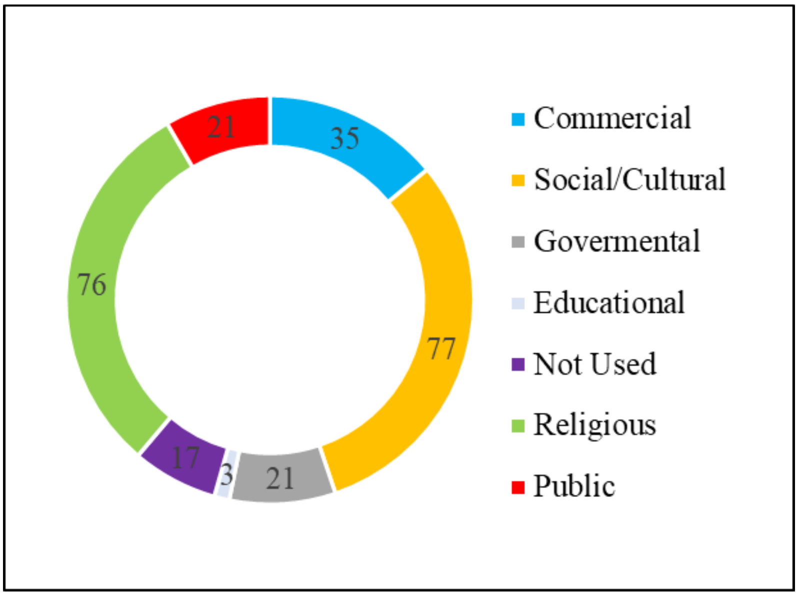

Figure 3.4. The distribution of the occupancy classes of the structures in the dataset

3.3.4 Condition of the Restoration

All structures deteriorate over time due to some internal (for example material fatigue) and external (weathering effect, human-based issues and sustained load effect) factors, and need to be repaired in order to maintain their functions. Among the considered structures within the database, architectural and structural interventions have been applied to 228 structures out of 250, according to the obtained data from different sources.

3.3.5 Importance in terms of Cultural Heritage

The information about importance level is given according to local, national and universal significance of the historical structure under consideration as defined in Ahunbay et al. (2017). The distribution of the structures according to their importance in the dataset are presented in Table 3.2.

Table 3.2. The distribution of the structures in the dataset according to their importance

Importance	Number in the Dataset
Local	194
National	40
Universal	16

3.3.6 Site Class

Site classification plays an important role to properly evaluate the local site effects at any site of interest. By using the time-averaged shear wave velocity to a depth of 30 m (V_{s30}), the site classes of the soils on which the structures are located are assigned. High-resolution velocity models do not exist for each region because they are difficult to obtain. Thus, for simplicity, V_{s30} value of the nearest seismic strong ground motion stations operated by the Disaster and Emergency Management Presidency (AFAD) is assumed as the shear wave velocity of the site of the structure. Also, for the structures located in Istanbul, in case of lack of information about the station, the shear wave velocity map that is available in the recent report by the Istanbul Metropolitan Municipality (2020) is used. At locations without a nearby seismic station or publicly available velocity data, a first-order interpretation has been made by referring to the geological formation and age of the geological formation map prepared by Akbaş et al. (2011). Interpretation of the site classes from geological information is obtained in the light of personal communication with Assoc. Prof. Dr. Mustafa Kerem Koçkar. The site classes that have been employed in this study are based on the site classification system of the National Earthquake Hazards Reduction Program (NEHRP) (2003) as follows:

Table 3.3. Classification of the site class (BSSC, 2003)

NEHRP Site Class	V_{s30} (m/s)	Soil Description
A	>1500	Hard Rock
B	760-1500	Rock
C	360-760	Very dense soil, and soft rock
D	180-360	Stiff soil
E	<180	Soft soil

The site class distribution of the selected historical structures has revealed that most of them have NEHRP C and D site classes, while a small number has NEHRP site class B (Figure 3.5). This observation is consistent with the near surface geology of most urban regions in Türkiye.

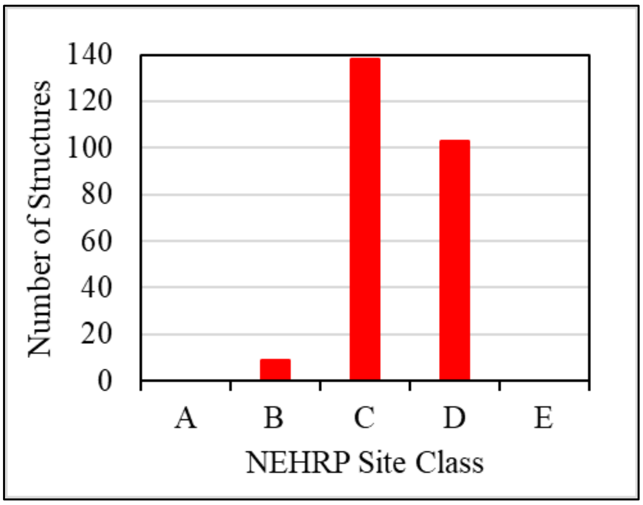

Figure 3.5. The distribution of the structures according to NEHRP site classes

3.3.7 Peak Ground Acceleration

In this study, peak ground acceleration (PGA) is used as a proxy for the seismic hazard level at the site of the considered structure. PGA is determined for each historical structure according to the national seismic hazard map prepared by the AFAD (2018). The map provides expected hazard on rock site conditions as reference for different return periods. Since this study involves historical structures, which are more special and unique when compared to ordinary structures, PGA values for 2475-year return period are employed in this study. Accordingly, PGA values for the considered sites vary between 0.163 g and 1.166 g (see Table B.2).

3.3.8 Seismic Gap in the Region

The historical structures have suffered from many destructive earthquakes since they were constructed. In an active fault, if there is a segment that has the potential to produce large earthquakes but has not ruptured yet, this segment is called to create a seismic gap in the region (Cassidy, 2013). At every segment of the fault, the displacements due to the earthquakes must be equal; therefore, any large gap (unbroken segment) is expected to suffer from the future events. As illustrated in Demirtaş (2020), there are some regions with seismic gaps such as Gökova Bay in Aegean region and Türkoğlu in Maraş region. The locations of the selected historical structures along with the seismic gaps and active faults are presented in Figure 3.6. Among these structures, 63 of them are determined to be located within the seismic gap regions.

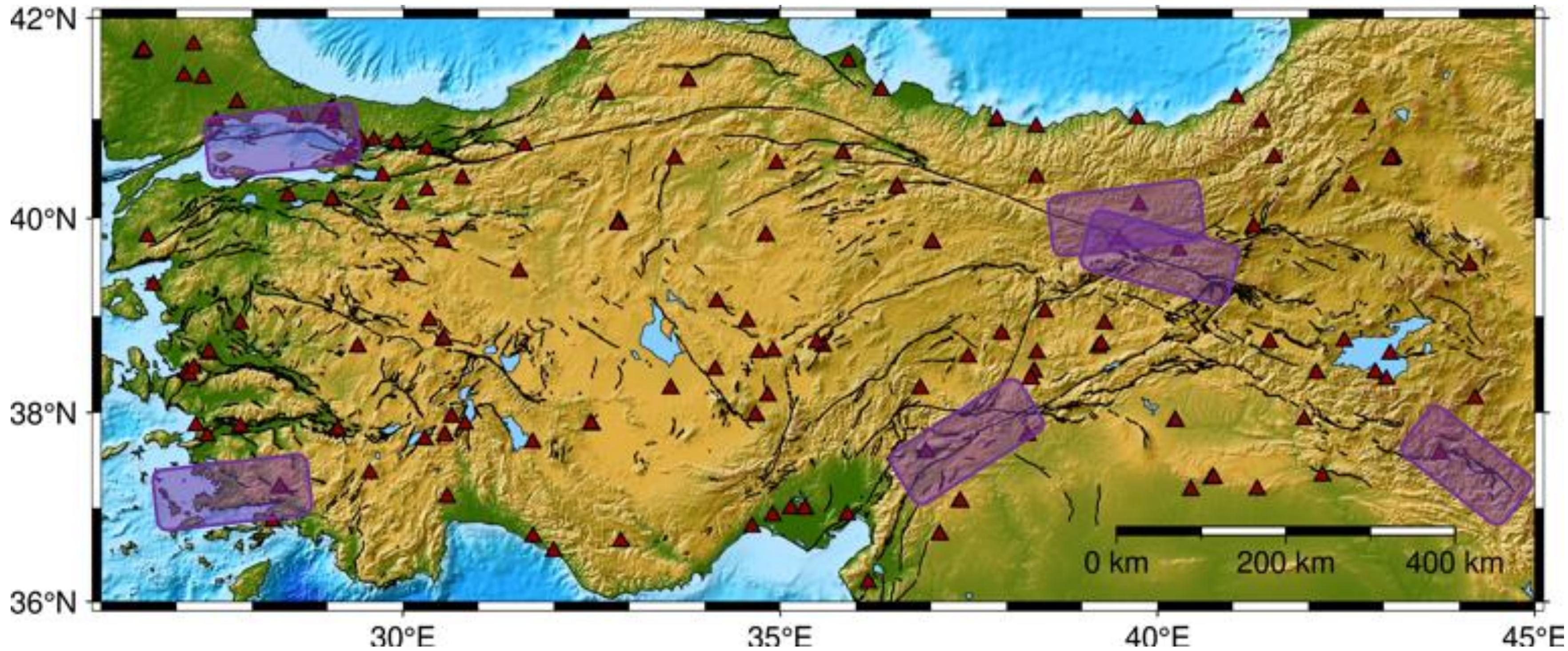

Figure 3.6. Selected historical structures with seismic gap and active faults in Türkiye

CHAPTER 4

IMPLEMENTATION OF THE AHP AND TOPSIS METHODS ON THE HISTORICAL STRUCTURES DATABASE

4.1 General

In this chapter, as a case study, implementation of the AHP and the TOPSIS among the MCDA methods is performed on the database explained in detail in Chapter 3 to obtain a preliminary seismic safety prioritization of the selected historical structures in Türkiye.

Within the concept of the MCDA, there are three basic terminologies such as goal/problem, criteria, and alternatives. In this implementation, the goal of performing MCDA is to obtain a preliminary prioritization of the selected set of historical structures in Türkiye in terms of seismic safety.

The following information on the selected historical structures as explained in Chapter 3.3 are chosen as the criteria:

i) Type of Construction Material (C1)
ii) Construction Year of the Structure (C2)
iii) Occupancy Class of the Structure (C3)
iv) Condition of the Restoration (C4)
v) Importance in terms of Cultural Heritage (C5)
vi) Site Class (C6)
vii) Peak Ground Acceleration (C7)
viii) Seismic Gap in the Region (C8)

In this implementation, alternatives are the 250 selected historical structures in Türkiye given in Appendix A.

As shown in Figure 4.1, the AHP method is initially performed to obtain weights of the criteria on the goal. Then, the TOPSIS method is conducted to prioritize of the alternatives with these weights.

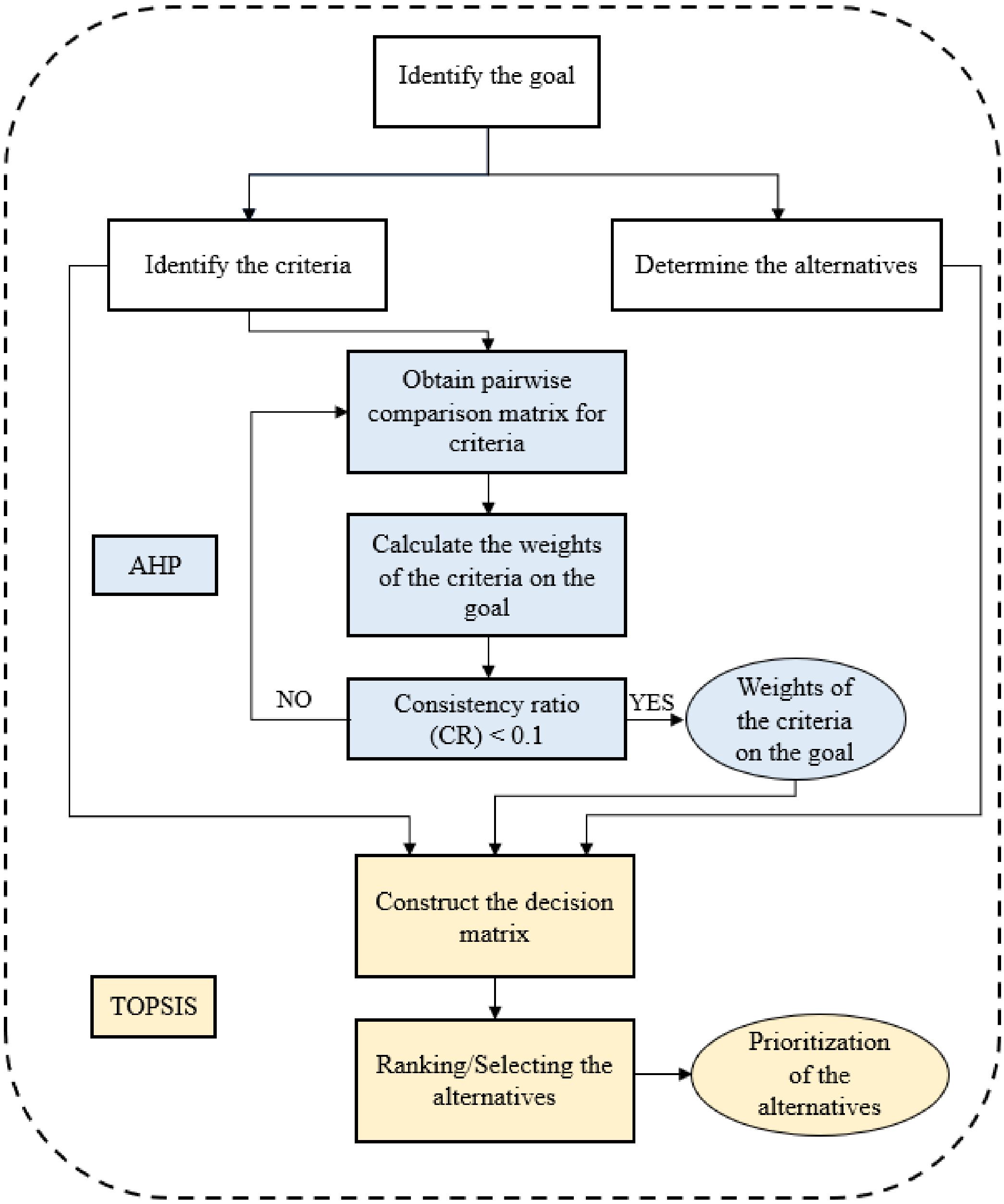

Figure 4.1. Flowchart of the case study

4.2 Implementation of the AHP Method

The purpose of the implementation of the AHP method is to achieve the weights of the criteria affecting the seismic safety of the historical structures within the goal of obtaining preliminary prioritization of the historical structures in terms of seismic safety. While considering the seismic safety of the structure, it is aimed to find out which structures are the most risky. The implementation of the AHP method is performed according to the methodology described in Chapter 2.2.

A hierarchical structure of the case study is developed to form a quantitative decision-making model (Figure 4.2.).

Pairwise comparison of the criteria is conducted in matrix format according to numerical importance scale of Saaty (1980) as given in Table 2.1. In this stage, a survey is conducted within this thesis for obtaining experts' opinion about preferences on the criteria. In the survey, the experts are asked to construct a pairwise comparison matrix. 15 experts consisting of 7 full professors, 1 associate professor, 1 person with a doctorate degree, 2 doctoral and 4 graduate students, who focus on structural and earthquake engineering, city and regional planning research, participated in the survey. Using the geometric mean of the experts' pairwise comparison matrices, the matrix $(A)_{8x8}$ is obtained for the case study (Table 4.1).

Table 4.1. Pairwise comparison matrix for the case study

	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**
C1	1.00	1.73	2.43	1.46	1.75	0.60	0.33	0.83
C2	0.58	1.00	1.61	1.02	1.04	0.42	0.24	0.58
C3	0.41	0.62	1.00	0.54	0.63	0.36	0.22	0.36
C4	0.69	0.98	1.84	1.00	1.20	0.45	0.26	0.54
C5	0.57	0.96	1.59	0.83	1.00	0.49	0.27	0.51
C6	1.67	2.39	2.80	2.22	2.04	1.00	0.43	1.23
C7	2.99	4.15	4.54	3.82	3.65	2.31	1.00	2.23
C8	1.21	1.74	2.80	1.87	1.96	0.81	0.45	1.00

Following the methodology described in Chapter 2.2, the weights of the criteria are calculated as in Table 4.2. It is confirmed that the sum of all weights is 1.0.

Table 4.2. Weights of the criteria

Criteria	Weights	Rank
Type of Construction Material (C1)	0.116	4
Construction Year of the Structure (C2)	0.075	6
Occupancy Class of the Structure (C3)	0.051	8
Condition of the Restoration (C4)	0.080	5
Importance in terms of Cultural Heritage (C5)	0.074	7
Site Class (C6)	0.162	2
Peak Ground Acceleration (C7)	0.304	1
Seismic Gap in the Region (C8)	0.139	3

The largest eigenvalue (λ_{max}), the consistency index (CI), the random consistency index (RI) and the consistency ratio (CR) of the pairwise comparison matrix given in Table 4.1 are obtained as 8.041, 0.006, 1.410, 0.004 respectively.

The consistency ratio which is calculated as 0.004 is less than 0.100. Hence, weights of the criteria shown in Table 4.2 are considered to be appropriate.

When the weights of the criteria are examined, the largest effect on the goal is determined as PGA (C1) while the smallest effect on the goal is determined as occupancy class of the structure (C3). These findings are evaluated to be rational and are anticipated to some extent.

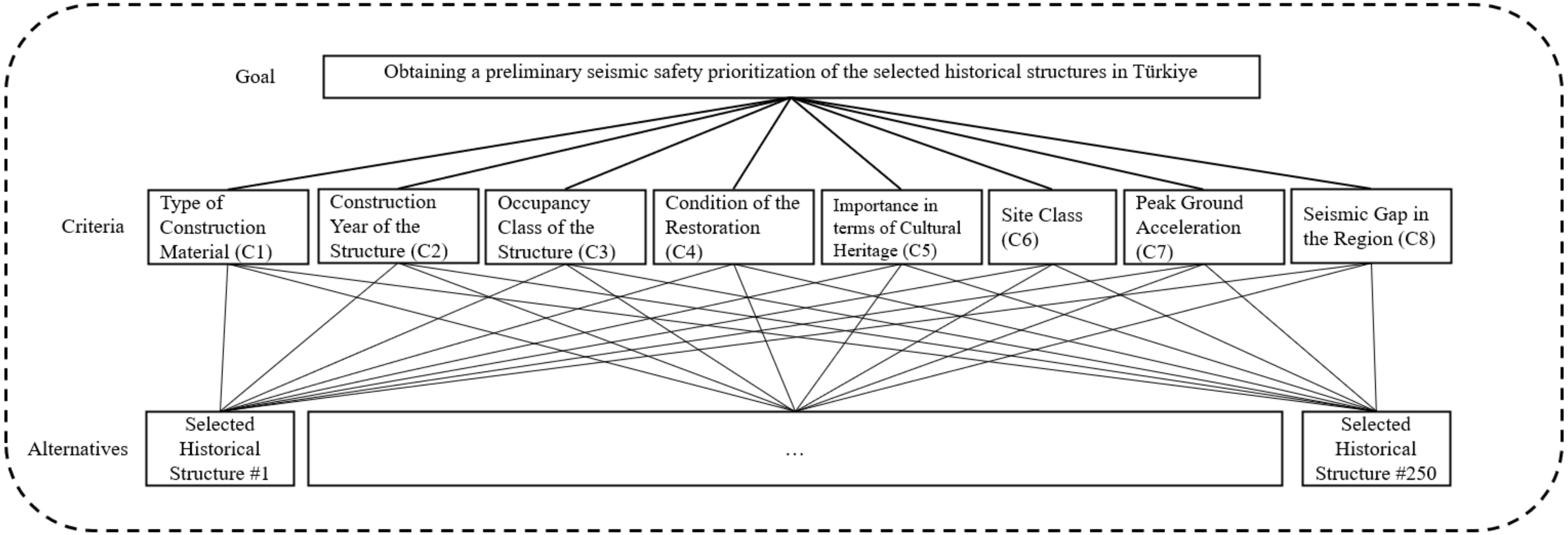

Figure 4.2. A hierarchical structure of the case study

4.3 Implementation of the TOPSIS Method

The purpose for implementing the TOPSIS method in this thesis is to prioritize the selected historical structures in Türkiye in terms of seismic safety by using the weights of 8 criteria as calculated by AHP method. The implementation of the TOPSIS method is performed by following the methodology described in Chapter 2.3.

The score of the intervals, values, and the assigned groups in each criterion was determined for the evaluation of alternatives according to each criterion.

i) Score for the Construction Material (C1):

The strength of the construction material affects the durability of the structure significantly. Hence, a relationship can be constituted between the strength of the construction material and durability of the historical structure under seismic risk. The compressive strength and elastic modulus of some construction materials of masonry structures are assigned according to previous studies (Illampas et al., 2011; Basha & Kaushik, 2015; Isaksson et al., 2016; Gonen & Soyoz, 2021). For structures composed of two or more construction materials, the geometric mean of the values for each material is considered (Table 4.3). In order to obtain a single value, 80% of compressive strength and 20% of elastic modulus are taken and summed up. Then, that value is used to sort the construction materials from largest to smallest. Finally, the largest obtained value is given the least score, and the smallest one is given the highest score, which are from 1 to 10 (Table 4.4).

Table 4.3. Compressive strength and elastic modulus of construction materials of masonry structures

Construction Material	**Compressive Strength (CS) (MPa)**	**Elastic Modulus (EM) (MPa)**	**0.8*CS+0.2*EM (MPa)**
Timber	20.0	7000.0	1416.0
Stone, Timber	15.7	6199.2	1252.4
Stone	12.3	5490.0	1107.9
Stone, Brick, Timber	11.2	5301.8	1069.3
Brick, Timber	10.7	5210.2	1050.6
Stone, Brick	8.4	4614.1	929.5
Brick	5.7	3878.0	780.2
Stone, Timber, Adobe	5.3	1687.3	341.7
Adobe, Timber	3.5	935.4	189.9
Stone, Adobe	2.7	828.4	167.9
Adobe	0.6	125.0	25.5

Table 4.4. Score for the construction material

Criterion	**Construction Material**	**Score**									
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Construction Material (C1)	Timber	●									
	Stone, Timber		●								
	Stone			●							
	Stone, Brick, Timber				●						
	Brick, Timber				●						
	Stone, Brick					●					
	Brick						●				
	Stone, Timber, Adobe							●			

Table 4.4. (cont'd)

Criterion	Construction Material	Score									
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Construction Material (C1)	Adobe, Timber								●		
	Stone, Adobe									●	
	Adobe										●

ii) Score for the Construction Year of the Structure (C2):

The older a historical structure is, the more socially valuable it is. However, the older the technique and building material used, the greater the seismic risk. According to this rationale, old structures are scored higher and comparatively new structures are scored by assigning smaller numbers, which are from 1 to 10 (Table 4.5).

Table 4.5. Score for the construction year of the structures

Criterion	Century	Score									
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Construction Year of the Structure (C2)	1st Century (0-99)										●
	2nd Century (100-199)										●
	3rd Century (200-299)										●
	4th Century (300-399)										●
	5th Century (400-499)										●
	6th Century (500-599)									●	
	7th Century (600-699)									●	
	8th Century (700-799)									●	
	9th Century (800-899)									●	
	10th Century (900-999)								●		
	11th Century (1000-1099)								●		
	12th Century (1100-1199)								●		

Table 4.5. (cont'd)

Criterion	**Century**	**Score**									
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Construction Year of the Structure (C2)	13th Century (1200-1299)							●			
	14th Century (1300-1399)							●			
	15th Century (1400-1499)						●				
	16th Century (1500-1599)					●					
	17th Century (1600-1699)				●						
	18th Century (1700-1799)			●							
	19th Century (1800-1899)		●								
	20th Century (1900-1999)	●									

iii) Score for the Occupancy Class of the Structure (C3):

The occupancy class of the structures refers to the immediate usage of structure after the seismic events, the density of life inside the structure and importance of the function for the society. From this point of view, the occupancy classes used in the database are scored from 1 to 10 (Table 4.6).

Table 4.6. Score for the occupancy class of the structure

Criterion	**Occupancy Class**	**Score**									
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Occupancy Class of the Structure (C3)	Not Used	●									
	Commercial				●						
	Public					●					
	Social/Cultural							●			
	Educational								●		
	Religious								●		
	Governmental										●

iv) Score for the Condition of the Restoration (C4):

The occurrence of any restoration in the historical structure indicates that at least, a simple maintenance has been applied or the structure has been reviewed by an expert. In this respect, it is indicated that a restored historical structure has relatively less seismic risk than the ones that have not been restored. Thus, the condition of the restoration is scored as 0 or 1 (Table 4.7).

Table 4.7. Score for the condition of the restoration

Criterion	**Restoration**	**Score**	
		0	**1**
Condition of the Restoration (C4)	Yes	●	
	No		●

v) Score for the Importance in terms of Cultural Heritage (C5):

One of the factors that influence acceptable damage levels of the structures is importance of the structure (Ahunbay et al., 2017). The seismic vulnerability of a historical structure that has universal importance should be at the lowest level. On the contrary, it can be considered relatively less critical in a historical building that has only local importance. From this point of view, local, national and universal importance of the structures are scored as in Table 4.8.

Table 4.8. Score for the importance in terms of cultural heritage

Criterion	**Restoration**	**Score**									
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Importance of the Structure (C5)	Local			●							
	National							●			
	Universal										●

vi) Score for the Site Class (C6):

Site class is one of the most crucial parameters that represent the local site conditions and thus the potential site amplifications during earthquakes. If there are two structures at the same but on sites with different site classes, the expected seismic hazard for the structure that has the lower site amplification factors is smaller than the one that has larger site amplification factors at critical frequencies of interest.

The regular building type of historical structures are rigid and massive structures; thus, these structures have mostly shorter fundamental periods. This observation applies also for most of the database in the thesis. Additionally, values of short period map spectral acceleration coefficient (S_S) for the sites in the database have wide ranges. For this reason, in order to reflect overall response, values of the site amplification factors in Table 2.1 of Turkish Building Earthquake Code (AFAD, 2018b) for the entire range of S_S are averaged. They are proportioned with each other and scored from 1 to 10 (Table 4.9).

Table 4.9. Score for the site class

Criterion	**Site Class**	**Score**									
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	A						●				
	B							●			
Site Class (C6)	C									●	
	D									●	
	E										●

vii) Score for the Peak Ground Acceleration (C7):

Peak ground acceleration is a natural indicator for the expected seismic hazard. The greater the expected seismic hazard, the more considerable the seismic risk may become since seismic hazard is one of the factors for the seismic risk in addition to exposure and vulnerability. Standard deviation of the values for PGA at the sites where the structures in the database are approximately calculated as 0.2. Also, rather than the exponential relationship between the masonry structure and PGA, it is thought that the historical structures are mostly not a weak structure, showing a linear behavior at PGA values up to 1.0 g. Then, intervals are determined considering the standard deviation value where scores are assigned per intervals of PGA for 2475-year return period (Table 4.10).

Table 4.10. Score for the peak ground acceleration

Criterion	**PGA**	**Score**									
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Peak Ground Acceleration (C7)	0.0 < PGA ≤ 0.2 g	●									
	0.2 g < PGA ≤ 0.4 g		●								
	0.4 g < PGA ≤ 0.6 g				●						
	0.6 g < PGA ≤ 0.8 g						●				
	0.8 g < PGA ≤ 1.0 g								●		
	1.0 g < PGA										●

viii) Score for the Seismic Gap in the Region (C8):

In the regions that have seismic gaps (in cases of very long return periods of destructive events), there is a high probability of occurrence of a large earthquake given any time window. Thus, the structures inside the seismic gap are under serious seismic risk. Therefore, in this implementation, the score of the structures inside the seismic gap is scored as 1, while the ones outside the seismic gap are evaluated as 0 (Table 4.11).

Table 4.11. Score for the seismic gap in the region

Criterion	**PGA**	**Score**	
		0	**1**
Seismic Gap (C8)	Outside	●	
	Inside		●

Each selected historical structure named as alternative is evaluated according to determined scores as presented in this chapter. The resulting decision matrix $(D)_{8x250}$ is given in Table C.1 (Appendix C).

Following the methodology described in Chapter 2.3, the relative closeness (C_i^*) of each selected historical structure is obtained as demonstrated in Table 4.12.

4.4 Summary of the Analysis and Results of the Implementation

Prioritization of historical structures in terms of their seismic safety is considered as a multi-decision problem. In this thesis, a total of 8 criteria are selected along the factors that affect the seismic safety of the historical structures. As the database, 250 historical structures are selected in Türkiye. Then, main parameters related to the selected criteria are collected. Weights of the criteria on the seismic safety of the historical structures are computed by the AHP method as shown in Table 4.2. According to the opinions of 15 experts, the factors that affect the prioritization of the historical structures in terms of seismic safety are determined ranging from the most influential to the least influential one as PGA, site class, seismic gap in the region, construction material, importance in terms of cultural heritage, construction year of the structure, condition of the restoration and occupancy class of the structure. The scores for each criterion are determined to evaluate the structures.

Then, decision matrix is constructed using these scores. The relative closeness of each selected historical structure is obtained by the TOPSIS method as in Table 4.12.

To perform prioritization of selected historical structures in Türkiye, the selected historical structures in this decision-making problem are ranked considering the relative closeness of each structure. The most seismically safety historical structure in the database is the structure whose relative closeness is closer to 0.0. When the relative closeness values of structures are ranked from 0.0 to 1.0, primarily prioritization of the historical structures in the database according to seismic safety is achieved as in Table 4.12. In this table, name of the structures with their orders in the dataset are provided as well as the cities they are located, C_i^* value and their ranks which indicate the result of this implementation. Also, the results are visualized in Figures 4.3-4.10 on the map of Türkiye and each region in Türkiye, respectively.

Table 4.12. Preliminary prioritization of seismic safety for the database

No	City	Name	C_i^*	Rank
35	Erzincan	Abrenk Church	0.64830	1
73	Aydın	Gümrükönü Bath	0.63834	2
196	İstanbul	Abud Efendi Inn	0.61515	3
201	İstanbul	Arnavut Inn	0.61515	3
198	İstanbul	Ali Paşa Inn	0.61480	4
34	Erzincan	Erzincan Train Station	0.61380	5
229	İstanbul	Ragıp Pasha Apartment	0.60353	6
200	İstanbul	Anadolu Inn	0.59636	7
241	Yalova	Walking Mansion	0.59015	8
41	Erzurum	Çifte Minare Madrasah	0.58053	9
72	Aydın	Ahmet Şemsi Pasha Mosque	0.56437	10
222	İstanbul	Tamara Mansion	0.56399	11
40	Erzurum	Atatürk House Museum	0.55135	12
220	İstanbul	Aya İrini Museum	0.53986	13
245	Kocaeli	Pertev Mehmet Pasha Mosque and Complex	0.53867	14
243	Kocaeli	Kasr-i Humayun Palace Museum	0.53800	15
24	Kahramanmaraş	Katip / Cumhuriyet Inn	0.53662	16
240	Yalova	Termal Atatürk Mansion	0.53610	17
250	Sakarya	Rahime Sultan Mosque	0.53111	18
247	Kocaeli	Izmit Old Station Buildings	0.52808	19
246	Kocaeli	İzmit Clock Tower	0.52715	20
153	Bolu	Upper Taşhan	0.52667	21
221	İstanbul	Tiled Kiosk	0.52338	22
242	Kocaeli	Kaiser II. Wilhelm Mansion	0.52293	23
206	İstanbul	Consulate General of Belgium	0.51852	24
208	İstanbul	Defter-i Hakani	0.51829	25
204	İstanbul	Büyük Valide Inn	0.51649	26

Table 4.12. (cont'd)

No	City	Name	C_i^*	Rank
217	İstanbul	Beyoğlu Municipality Building	0.51152	27
197	İstanbul	Ada Inn	0.50986	28
223	İstanbul	Tophane Pavilion	0.50955	29
227	İstanbul	Sirkeci Train Station	0.50820	30
225	İstanbul	Galata Tower	0.50744	31
74	Aydın	İlyas Bey Mosque	0.50668	32
42	Erzurum	Öşvank Church	0.50467	33
216	İstanbul	Surp Krikor Lusavoric Armenian Church	0.50376	34
195	İstanbul	Sixth Foundation Inn	0.49778	35
199	İstanbul	Alyanak Inn	0.49778	35
6	Isparta	Eğirdir Train Station	0.49739	36
82	Manisa	İvaz Pasha Mosque	0.49568	37
75	Muğla	Marmaris Archeology Museum	0.49547	38
194	İstanbul	Second Foundation Inn	0.49456	39
232	İstanbul	Kınacıyan Inn	0.49456	39
65	İzmir	Izmir Ethnography Museum	0.49185	40
228	İstanbul	Bağdat Mansion	0.49183	41
205	İstanbul	Ziraat Bank Karaköy Branch	0.49158	42
21	Kahramanmaraş	Kahramanmaraş Ulu Mosque	0.48961	43
22	Kahramanmaraş	Taş Madrasah	0.48961	43
167	Amasya	Halifet Gazi Tomb	0.48824	44
219	İstanbul	Dolmabahçe Clock Tower	0.48414	45
25	Kahramanmaraş	Grand Bazaar	0.48373	46
213	İstanbul	Kurşunlu Inn	0.48373	46
61	Van	St. Bartholomeus Church	0.48372	47
19	Kahramanmaraş	Taş Inn	0.48053	48
77	Muğla	Kurşunlu Mosque	0.47838	49

Table 4.12. (cont'd)

No	City	Name	C_i^*	Rank
218	İstanbul	Galata Mevlevi Lodge Museum	0.47772	50
18	Hatay	Habibi Neccar Mosque	0.47737	51
81	Manisa	Manisa Mevlevi Lodge	0.47737	51
226	İstanbul	Crimean Memorial Church	0.47702	52
91	Afyonkarahisar	Afyon City (İzmir) Station	0.47698	53
23	Kahramanmaraş	Dedeoğlu Mansion	0.47635	54
230	İstanbul	Fourth Foundation Inn	0.47635	54
76	Muğla	Clock Tower	0.47503	55
83	Denizli	Akhan Caravansary	0.47498	56
210	İstanbul	Zindan Inn	0.47440	57
193	İstanbul	First Foundation Inn	0.47151	58
68	İzmir	Hisar Mosque	0.47145	59
80	Manisa	Sultan Mosque	0.47145	59
244	Kocaeli	Çoban Mustafa Pasha Complex	0.47145	59
66	İzmir	Basmane Train Station	0.46942	60
67	İzmir	Izmir Clock Tower	0.46682	61
71	Aydın	Öküz Mehmet Paşa Caravansary	0.46618	62
26	Kahramanmaraş	Deligönüller Mansion	0.46561	63
70	İzmir	Murat Mansion	0.46079	64
78	Manisa	New Inn	0.46079	64
69	İzmir	Forbes Mansion	0.45674	65
114	Eskişehir	Hafız Ahmet Efendi Mansion	0.43344	66
4	Burdur	Bakibey Mansion	0.42685	67
20	Kahramanmaraş	Eshabı Kehf Complex	0.42621	68
214	İstanbul	Küçüksu Pavilion	0.42615	69
231	İstanbul	Pink Mansion	0.42533	70
224	İstanbul	Ortaköy Mosque	0.42416	71

Table 4.12. (cont'd)

No	City	Name	C_i^*	Rank
202	İstanbul	Military Museum and Cultural Center Command	0.42337	72
215	İstanbul	Malta Mansion	0.42337	72
27	Malatya	Old Malatya Ulu Mosque	0.42185	73
236	Bursa	Green Tomb	0.41800	74
209	İstanbul	İSOV Construction Vocational High School	0.41545	75
211	İstanbul	White Mansion	0.41275	76
36	Elazığ	Harput Ulu Mosque	0.41273	77
37	Elazığ	Mor Ahron Monastery	0.41216	78
238	Bursa	Iznik Hagia Sophia Mosque	0.41213	79
207	İstanbul	Beylerbeyi Palace	0.40988	80
233	Bursa	Issız Inn	0.40540	81
170	Tokat	Gök Madrasah	0.40318	82
178	Bayburt	Pulur (Gökçdere) Madrasah	0.40174	83
62	Van	Çarpanak Church	0.39566	84
64	Hakkari	Meydan Madrasah	0.39479	85
101	Adıyaman	Adıyaman Ulu Mosque	0.39306	86
47	Kars	Katerina Hunting Lodge	0.39212	87
63	Van	St. Thomas Monastery	0.39210	88
96	Balıkesir	Saatli Mosque	0.39147	89
95	Balıkesir	Taksiyarhis Church	0.39056	90
234	Bursa	Hünkar Mansion	0.39056	90
235	Bursa	The Grand Mosque	0.38966	91
165	Amasya	II. Bayezid Complex	0.38874	92
212	İstanbul	Etfal Hospital Clock Tower	0.38851	93
140	Kayseri	Kayseri Clock Tower	0.38770	94
237	Bursa	Koza Inn	0.38642	95

Table 4.12. (cont'd)

No	City	Name	C_i^*	Rank
9	Isparta	Aya Payana Church	0.38595	96
79	Manisa	Ulu Mosque and Complex	0.38477	97
87	Kütahya	Ulu Mosque	0.38477	97
166	Amasya	Burmalı Minaret Mosque and Cumudar Tomb	0.38477	97
93	Afyonkarahisar	Anıtkaya Caravansary	0.38385	98
176	Giresun	Şebinkarahisar Asarcık Church	0.38340	99
203	İstanbul	Atatürk Museum	0.38142	100
88	Kütahya	Tile Museum	0.37965	101
46	Bitlis	Kadı Mahmut Mosque	0.37673	102
187	Tekirdağ	Süleymaniye Mosque	0.37673	102
94	Afyonkarahisar	Afyon High School	0.37658	103
92	Afyonkarahisar	Sultan Divani Mevlevi Lodge	0.37432	104
12	Adana	Kurtkulağı Caravansary	0.37229	105
86	Kütahya	Lajos Kossuth Museum	0.37128	106
189	Tekirdağ	Historical Mansion Bath	0.37061	107
5	Burdur	Stone Room Mansion	0.36990	108
29	Malatya	Silahtar Mustafa Pasha Caravanserai	0.36990	108
38	Elazığ	Elazığ Government House	0.36971	109
89	Kütahya	Kütahya Old Government House	0.36754	110
32	Malatya	New Mosque	0.36753	111
30	Malatya	Ataturk House Museum	0.36656	112
90	Kütahya	Green Mosque	0.36536	113
239	Bursa	Tophane Clock Tower	0.36271	114
181	Çanakkale	Bayramiç Hadımoğlu Mansion	0.35962	115
99	Kilis	Neşet Efendi Mansion	0.35924	116
188	Tekirdağ	Historical Çorlu House	0.35706	117

Table 4.12. (cont'd)

No	City	Name	C_i^*	Rank
84	Denizli	Acıpayam Yazır Mosque	0.35304	118
98	Gaziantep	Boyacı Mosque	0.34224	119
97	Gaziantep	Kurtuluş Mosque	0.32653	120
113	Şırnak	Red Madrasah	0.32184	121
156	Bartın	Small Church	0.31733	122
60	Van	Akdamar Church	0.30758	123
14	Adana	Zeytinli Station Building	0.30691	124
3	Antalya	Kızılkule Ethnography Museum	0.30402	125
162	Samsun	Gazi Museum	0.29920	126
106	Mardin	Mardin Museum	0.29776	127
182	Edirne	Deveci Inn	0.29493	128
183	Edirne	Selimiye Mosque	0.29165	129
186	Edirne	Sweti George Bulgarian Church	0.28324	130
7	Isparta	Ertokuş Madrasah	0.28300	131
43	Muş	Ulu Mosque	0.28300	131
112	Siirt	Siirt Ulu Mosque	0.28300	131
58	Ağrı	Ishak Pasha Palace	0.28218	132
15	Adana	Yeni Bath	0.28216	133
17	Adana	Bebekli Church	0.28087	134
185	Edirne	Old Mosque	0.28034	135
139	Kayseri	American College and Hospital Building	0.27941	136
13	Adana	Seyhan District Governor's Office	0.27892	137
125	Çankırı	Stone Masjid	0.27570	138
168	Tokat	Sümbül Baba Hermitage	0.27570	138
180	Artvin	Barhal Church	0.27570	138
2	Antalya	Kırkgöz Inn	0.27417	139

Table 4.12. (cont'd)

No	City	Name	C_i^*	Rank
45	Bitlis	İhlasiye Madrasah	0.27417	139
248	Bilecik	Mihal Bey Inn	0.27104	140
1	Antalya	Alara Inn	0.27070	141
31	Malatya	Taşhan	0.27070	141
142	Kayseri	Sahabiye Madrasa	0.27070	141
39	Tunceli	Sağman Mosque	0.26308	142
141	Kayseri	Kurşunlu Mosque	0.26308	142
190	Kırklareli	Babaeski Cedid Ali Pasha Mosque	0.26308	142
191	Kırklareli	Lüleburgaz Sokullu Mosque	0.26308	142
184	Edirne	Karaağaç Train Station	0.26112	143
16	Adana	Adana Clock Tower	0.25864	144
155	Karabük	Köprülü Mehmet Pasha Mosque	0.25803	145
8	Isparta	Firdevs Bey Bedesten	0.25769	146
152	Bolu	Göynük Government Office	0.25511	147
157	Kastamonu	Kastamonu Governorship	0.25511	147
158	Kastamonu	Kastamonu Government House	0.25511	147
44	Muş	Alaeddin Bey Mosque	0.25397	148
59	Ardahan	Hamşioğlu Rasim Bey Mansion	0.25328	149
154	Karabük	Cinci Inn	0.25249	150
179	Rize	Işıklı Mosque	0.25100	151
100	Kilis	Tuğlu Bath	0.24941	152
33	Malatya	Çobanlı Mansion	0.24925	153
115	Eskişehir	Surp Yerotutyun Armenian Church	0.24925	153
177	Trabzon	Kostaki Mansion	0.24741	154
159	Çorum	Çorum Clock Tower	0.24639	155
85	Uşak	Paşa Inn	0.24530	156
169	Tokat	Tokat Clock Tower	0.24455	157
122	Ankara	Anatolian Civilizations Museum	0.24309	158

Table 4.12. (cont'd)

No	City	Name	C_i^*	Rank
121	Ankara	Turkish State Meteorological Service Building	0.23394	159
163	Samsun	Samsun City Museum	0.23002	160
249	Bilecik	Bilecik Clock Tower	0.22969	161
105	Diyarbakır	Virgin Mary Church	0.21640	162
104	Diyarbakır	Deliler Inn	0.19737	163
161	Sinop	Ethnography Museum	0.19622	164
55	Kars	Kars Governorate Building	0.19543	165
117	Konya	Beyşehir Eşrefoğlu Mosque	0.19518	166
107	Mardin	Mor Gabriel Monastery	0.19479	167
53	Kars	Kümbet Mosque	0.19189	168
119	Konya	Alâeddin Mosque	0.19189	168
146	Sivas	Sivas Ulu Mosque	0.19189	168
54	Kars	Fethiye Mosque	0.18985	169
102	Diyarbakır	Mesudiye Madrasa	0.18959	170
11	Mersin	St. Paul Memorial Museum	0.18724	171
118	Konya	Şems-i Tebrizi Mosque and Tomb	0.18007	172
131	Niğde	Alaeddin Mosque	0.18007	172
132	Niğde	Sungur Bey Mosque	0.18007	172
192	Kırklareli	Hızırbey Mosque	0.18007	172
116	Konya	Mevlana Museum	0.17753	173
120	Konya	Karatay Madrasah	0.17753	173
126	Aksaray	Sultan Inn	0.17753	173
143	Karaman	Tol Madrasah	0.17753	173
145	Sivas	Gök Madrasah	0.17753	173
147	Sivas	Şifaiye Madrasa (Sivas Hospital)	0.17190	174
109	Mardin	Mardin Ulu Mosque	0.17097	175
135	Nevşehir	Ağzıkaran Caravansary	0.16966	176

Table 4.12. (cont'd)

No	City	Name	C_i^*	Rank
50	Kars	Evliya Mosque	0.15875	177
134	Niğde	Çelebi Hüsamettin Mosque	0.15875	177
149	Sivas	Kale Mosque	0.15875	177
111	Mardin	Şehidiye Madrasa	0.15834	178
127	Kırşehir	Cacabey Madrasa	0.15834	178
51	Kars	Beylerbeyi Palace	0.15567	179
10	Mersin	Mersin Atatürk House and Museum	0.15565	180
48	Kars	The Kafkas Front War History Museum	0.15565	180
137	Nevşehir	Asmali Mansion	0.15565	180
144	Sivas	Sivas Congress Building Ataturk and Ethnography Museum	0.15565	180
123	Ankara	II. Turkish Grand National Assembly Building	0.15380	181
124	Ankara	State Museum of Painting and Sculpture	0.15380	181
148	Sivas	Kurşunlu Turkish Bath	0.15067	182
56	Kars	Provincial Assembly Building	0.14709	183
57	Kars	Revenue Office Building	0.14709	183
150	Sivas	Gendarmerie Building	0.14521	184
173	Ordu	Selimiye Mosque	0.14315	185
52	Kars	Cuma Bath	0.14123	186
130	Yozgat	Yozgat Military Service Branch	0.14053	187
103	Diyarbakır	Surp Giragos Armenian Church	0.13858	188
133	Niğde	Konakli Greek Church	0.13858	188
172	Ordu	Flat Neighborhood Church	0.13858	188
128	Yozgat	Akdağmadeni Ziraat Bank	0.13858	189

Table 4.12. (cont'd)

No	City	Name	C_i^*	Rank
171	Ordu	Paşaoğlu Mansion Ethnography Museum	0.13488	190
174	Ordu	Taşbaşı Cultural Center	0.13488	190
28	Malatya	Somuncu Baba Mosque and Tomb	0.13344	191
108	Mardin	Kasımiye Madrasa	0.13159	192
151	Sivas	Sivas Government House	0.13034	193
175	Giresun	Giresun Children's Library	0.12881	194
160	Sinop	Pervane Madrasah	0.12444	195
49	Kars	Gazi Ahmet Muhtar Pasha Mansion	0.12339	196
110	Mardin	Former Post Office Building	0.12232	197
129	Yozgat	Yozgat Clock Tower	0.11862	198
136	Nevşehir	Damat Ibrahim Pasha Mosque	0.11750	199
138	Nevşehir	Atatürk House	0.10790	200
164	Samsun	Bafra Archeology Museum	0.10773	201

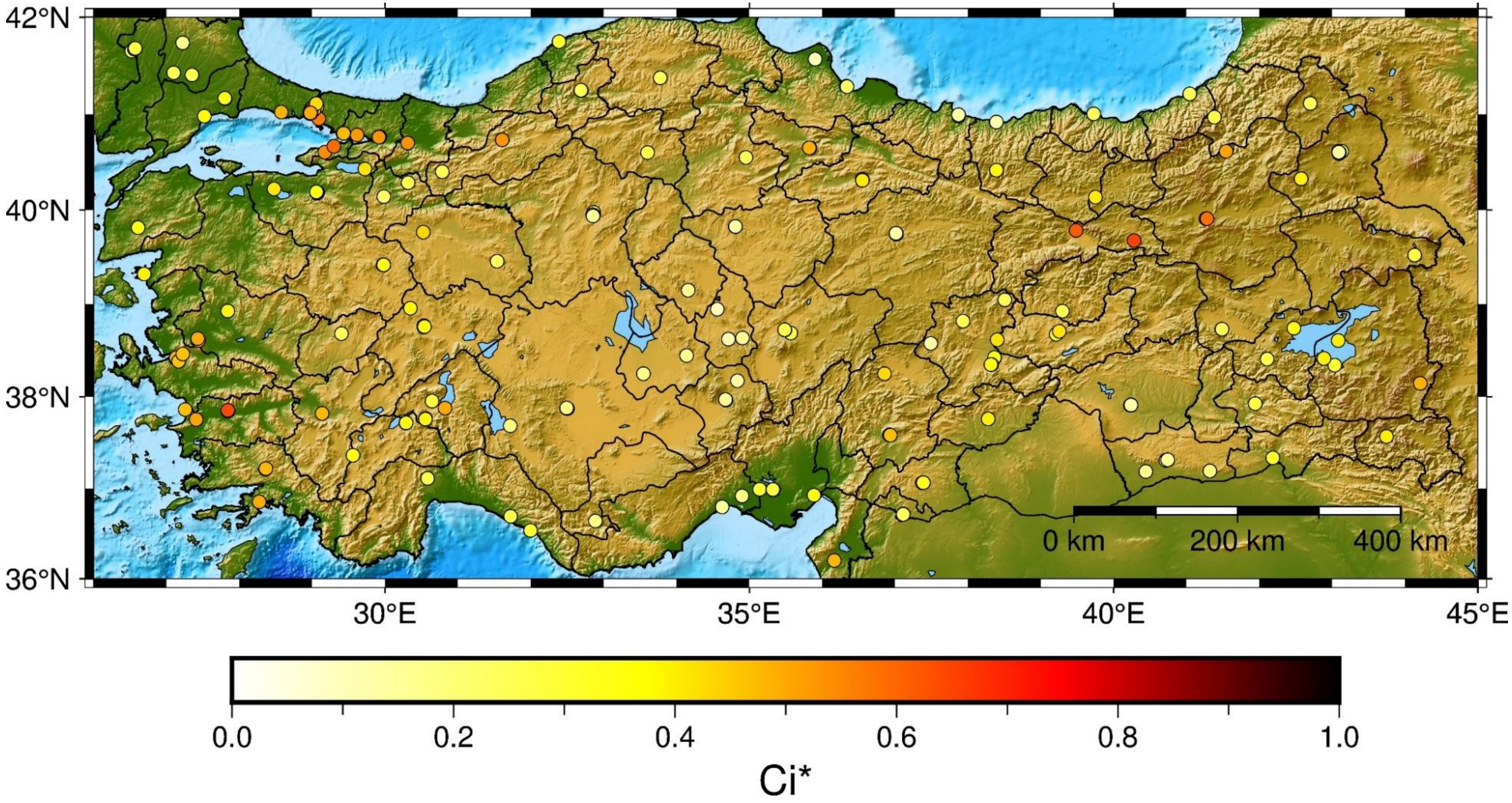

Figure 4.3. Distribution of the preliminary prioritization of selected historical structures on the map of Türkiye

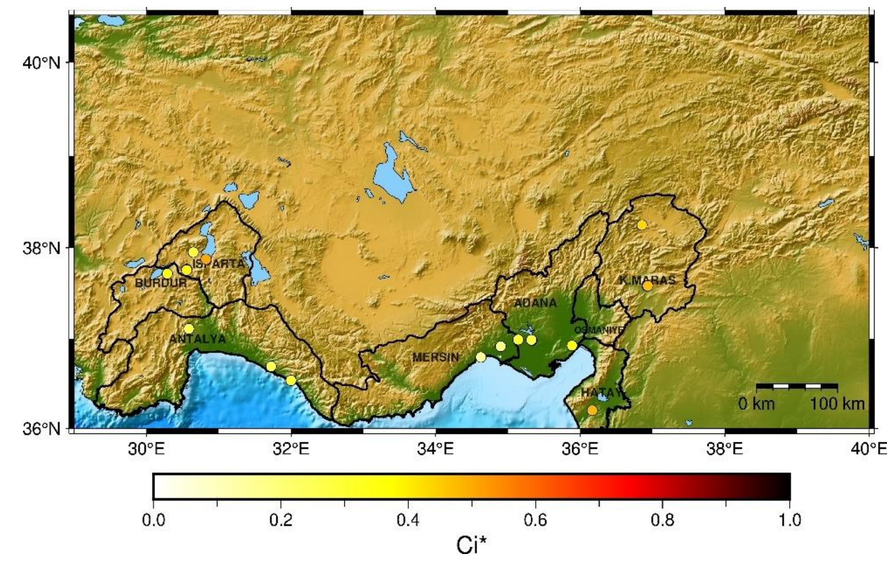

Figure 4.4. Distribution of the preliminary prioritization of the selected historical structures on the map of Mediterranean region in Türkiye

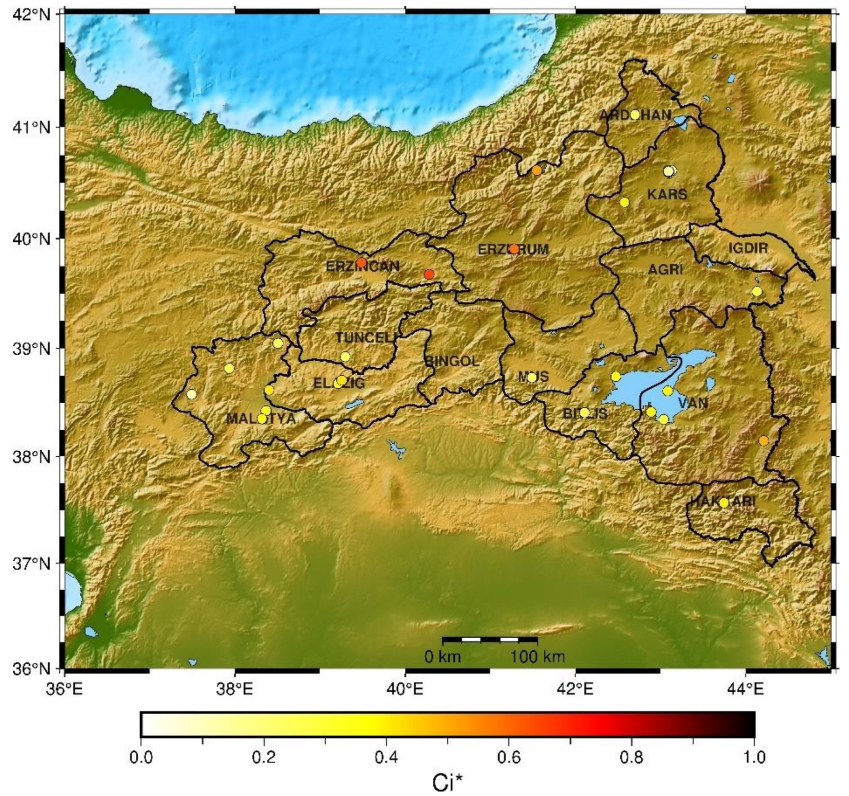

Figure 4.5. Distribution of the preliminary prioritization of the selected historical structures on the map of Eastern Anatolian region in Türkiye

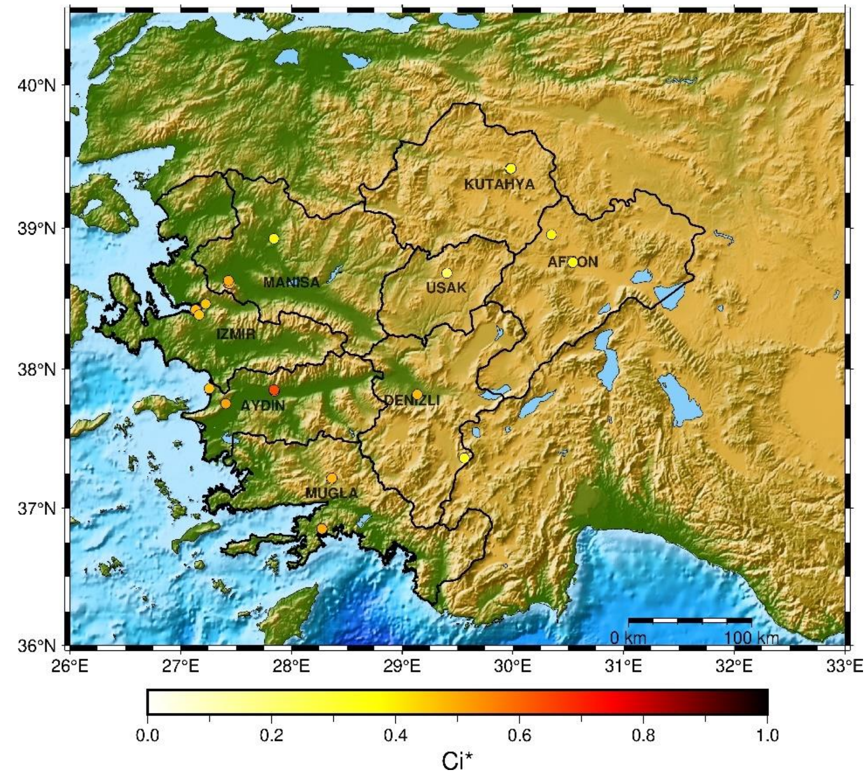

Figure 4.6. Distribution of the preliminary prioritization of the selected historical structures on the map of Aegean region in Türkiye

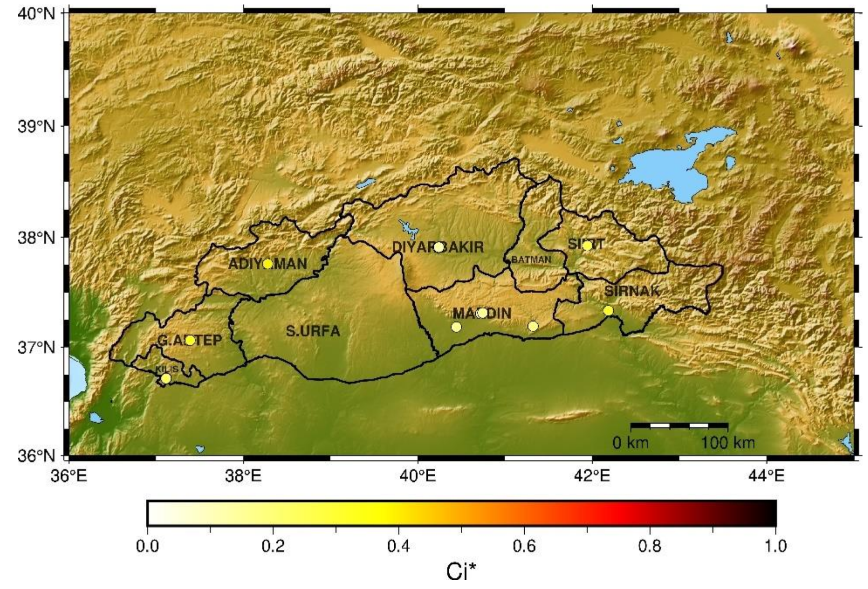

Figure 4.7. Distribution of the preliminary prioritization of the selected historical structures on the map of Southeastern Anatolia region in Türkiye

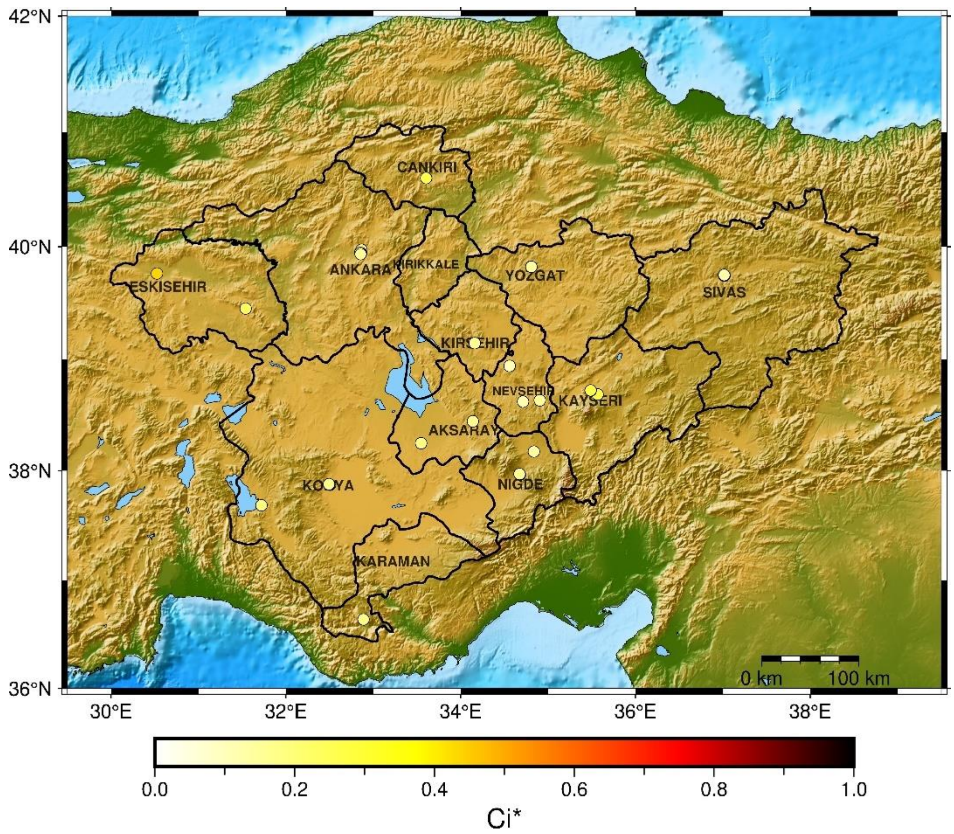

Figure 4.8. Distribution of the preliminary prioritization of the selected historical structures on the map of Central Anatolia region in Türkiye

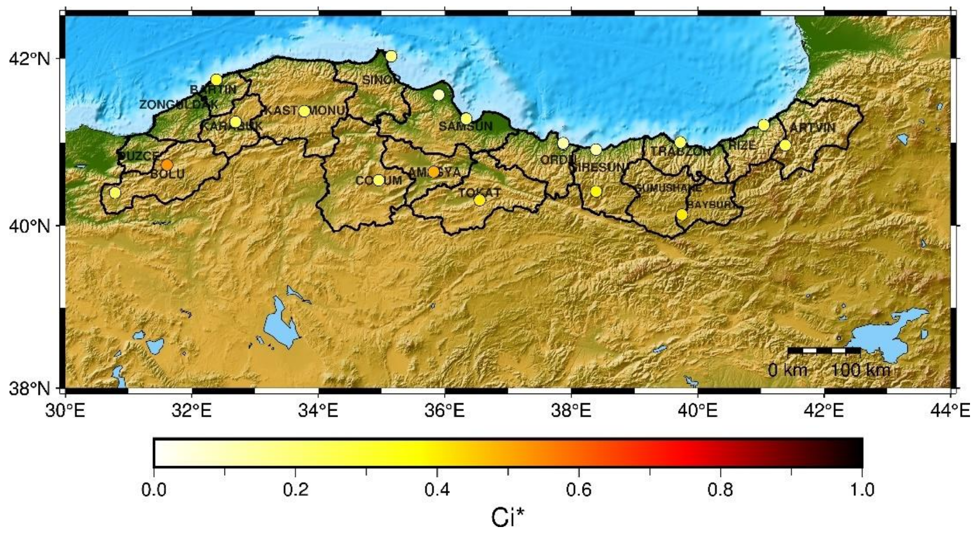

Figure 4.9. Distribution of the preliminary prioritization of the selected historical structures on the map of Black Sea region in Türkiye

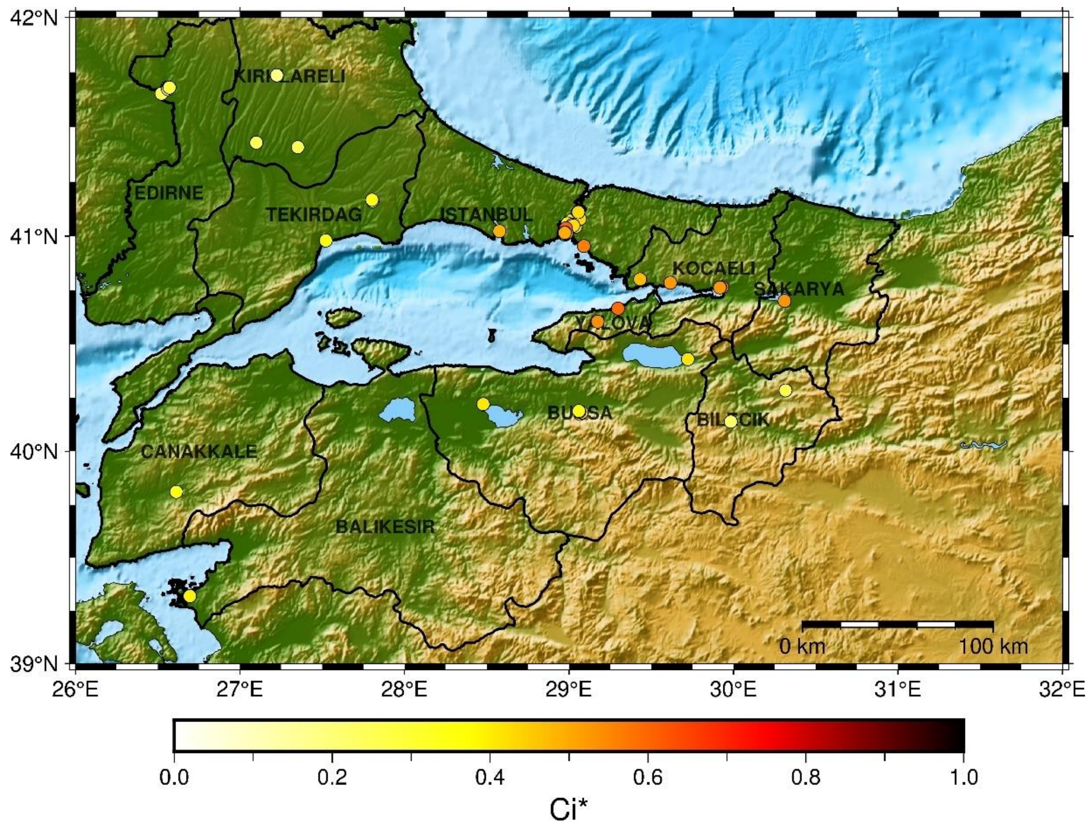

Figure 4.10. Distribution of the preliminary prioritization of the selected historical structures on the map of Marmara region in Türkiye

The structures of lowest and highest seismic safety in the database are determined as Abrenk Church in Erzincan and Bafra Archeology Museum in Samsun with relative closeness values of 0.64830 and 0.10773, respectively. The values correspond to an almost 6 times difference between the most safe and the least safe structures in the database. These proportions are certainly specific to the dataset formed in this study.

The numerical results of the analyses indicate that most of the historical structures with lower seismic safety in the database are located on the North Anatolian Fault and in the Aegean region. In contrary, the historical structures located in the Central Anatolia region are resulted to have comparatively higher seismic safety in the database. Even though this finding is somewhat anticipated considering the relative hazard values in these regions, geographical location is not found to be the only indicator: It is observed that there are historical structures with different seismic safety rankings in very close locations. For example, there are structures from Istanbul both in the first 3 rankings and the last 100 rankings.

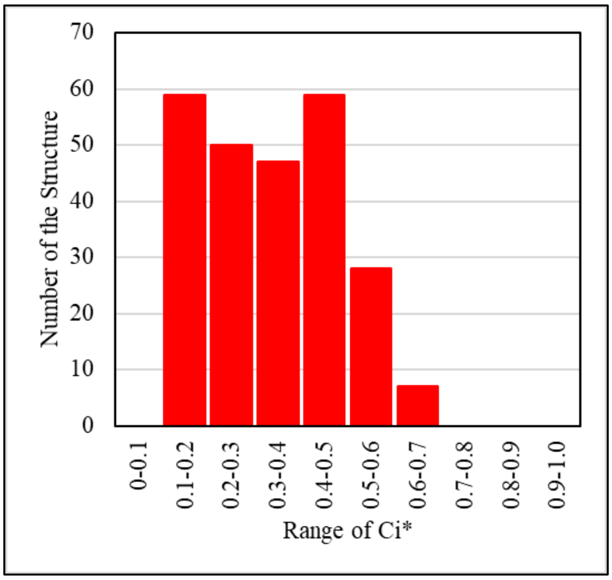

Figure 4.11. Distribution of the number of the structures with their relative closeness values

Through the numerical results of the analyses, it is observed that the relative closeness values of the structures between 0.1 and 0.5 exhibited a nearly uniform distribution and the majority of the structures are found within this range (Figure 4.11). Only 14% of the structures take place in the range of 0.5 and 1.0. Since there is a threshold at the value of 0.5, the structures with relative closeness values bigger than 0.5 can be considered to have comparatively lower seismic safety in this dataset.

In this study, none of the structures have had the maximum score in the dataset for all the criteria at the same time, and similarly, no structures exist with the minimum score for all the criteria at the same time in decision matrix (Table C.1). Thus, the lower and upper bounds of C_i^* values (0 and 1) have not been achieved.

CHAPTER 5

CONCLUSIONS

5.1 Summary and Conclusions

Historical structures are of great importance since they form the basis of cultural identity of countries. These structures in seismically active regions have been exposed to many earthquakes since they were built. Due to these seismic effects, historical structures are under constant risk of severe damage and collapse.

There are thousands of historical structures located in Türkiye which are under considerable seismic hazard. Hence, a practical approach is necessary to receive a rapid and effective evaluation of the seismic safety condition of the historical structures.

In this study, a preliminary seismic safety prioritization framework is proposed which does not require the application of extensive modeling and analysis approaches for vulnerability assessment of historical structures. Using this simplest framework, prioritization of the structures is aimed to take early precautions and to be more selective for future detailed studies.

The approach proposed in this thesis is to follow AHP and TOPSIS methods through multi-criteria decision analysis methods.

In this thesis, a total of 250 different historical structures are selected in Türkiye and information on them are collected. As a case study, the proposed risk estimation framework is applied to these selected historical structures. In this thesis, a total of 8 criteria are selected among the factors that affect the seismic safety of the historical structures. Weights of the criteria on the seismic safety of the historical structures are obtained by the AHP method with opinions of 15 experts. The scores for each criterion are determined to evaluate the safety of structures. Finally, preliminary prioritization of the selected historical structures regarding their seismic safety are performed by ranking the relative closeness of each selected historical structure obtained by TOPSIS method.

The main conclusions of this thesis are as follows:

- This study proposes a framework for preliminary prioritization of the historical structures regarding their seismic safety using multi criteria decision analysis without the application of extensive modeling and analysis of the structures.
- This study constitutes the one of the first systematic attempt for preliminary prioritization of historical structures regarding seismic safety in Türkiye by using multi criteria decision analysis. This framework can be used by governments, institutions, organizations and researchers to obtain a rapid and effective evaluation of the seismic safety condition of the historical structures. Initially, this framework can be applied to an extensive number of historical structures. Then, detailed seismic risk analysis can be performed on the structures that are considered risky according to the preliminary prioritization. Thus, early precautions can be taken, and the initial results can be used for future detailed studies. In fact, this framework can help save time and budget in risk management efforts.
- The established inventory of the historical structures consisting of 250 structures in Türkiye and the information of them are informative and useful for researchers from multiple fields.
- For any goal of interest, it is difficult to choose, prioritize and sort among multi-alternatives with multi-criteria. As demonstrated in this study, when evaluating more than one alternative according to many criteria, multi-criteria decision analysis facilitates the problem’s complexity in a systematic way.
- The factors that affect the prioritization of the historical structures in terms of seismic safety are determined from the most to the least effective ones as

PGA, site class, existing of a seismic gap in the region, types of construction material, condition of restoration, construction year of the structure, importance in terms of cultural heritage and occupancy class of the structure according to the opinions of 15 experts using AHP method.

- Most of the seismically unsafety structures in the database are found to be located on the North Anatolian Fault and in the Aegean region. In contrary, the structures located in the Central Anatolia region are resulted to have comparatively higher seismic safety in the database. The low seismic safety of structures in the regions where the expected hazard is largest in Türkiye is due to the fact that the most impact on the criteria weights is in the criteria related to expected hazard such as PGA and seismic gap.
- However, location is not the only influential parameter on seismic safety. It is also observed that there are structures with different ranks at very close locations. It reveals that the study does not prioritize according to the expected hazard alone, but also considers other criteria in accordance with the purpose of the study.
- It should be taken into account that this study makes a relative prioritization by obtaining relative closeness values. The structures obtained as risky in datasets may not actually be risky due to the relative evaluation when looking at the real situation of the structures.
- It is observed that evaluation of the structures is independent from the return periods in PGA since the PGA value of each structure changes in different return periods at approximately the same rate and the TOPSIS method performs a relative analysis.
- Since most of the historical structures are located on NEHRP C and D site classes in the study and the same score is suggested for these two site classes in evaluation of the structures, the effect of the site class on seismic safety has not been truly observed in the study.

5.2 Limitations of this Study and Future Recommendations

Herein, limitations of this study and related future recommendations are stated.

- In this study, the AHP and TOPSIS methods are selected among the MCDA methods for simplicity and due to the frequent use of these methods in the literature. In future studies, more advance MCDA methods such as those which rely on fuzzy systems could be performed.
- For this initial study, only 250 historical structures in Türkiye are selected randomly to form the database. A wider set of structures could be included in the future studies in order to obtain more consistent prioritization.
- In this study, only 8 factors are selected among all of the potential factors which affect the seismic safety of historical structures. In between these parameters, a few of them are specific to historical structure (e.g., condition of the restoration, construction year of the structure). This subset of factors is selected mostly due to lack of publicly available information on the structures. In future studies, other factors especially specific to historical structures could also be included to perform more reliable analyses.
- Some information on the structures such as construction materials and condition of the restoration are obtained by engineering judgement by interpretation of structure photo to make a rapid decision, which brings considerable uncertainty. In future studies, in order to obtain more reliable information about the structures of interest, information could be collected by site investigation or collaborating extensively with the corresponding authorities.
- In this study, probabilistic parameters related to the seismology such as peak ground acceleration are used. In order to investigate from another aspect, deterministic parameters such as distance of the structure to the fault line could be collected in the future studies.
- While determining the site classes, for simplicity, $V_{s_{30}}$ parameter of the nearest seismic strong ground motion stations operated by AFAD is assumed

as the shear wave velocity of the soils near the structure. Such an approach is employed mostly due to lack of high-resolution velocity models for each region because they are difficult to obtain. Also, for the structures in Istanbul, in case of lack of information about the station, the shear wave velocity map in the report by the Istanbul Metropolitan Municipality (2020) is used. At locations without a nearby seismic station and publicly available shear wave velocity data, a first-order interpretation for the site classes can be made by looking at the geological formation and age of the geological formation, which may result in inadequate judgement of site classes. In further studies, to obtain more reliable and accurate site classes, site characterization studies in the field could be conducted nearby sites of the historical structures.

- In AHP method, a total of 15 experts participates in the survey as the decision makers in obtaining pair-wise comparison matrix to determine weights of the criteria. In future studies, this survey could be conducted with a higher number of participants to make more effective decisions.

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APPENDICES

A. Selected Historical Structures

The selected historical structures in Türkiye are tabulated in Table A.1.

Table A.1. Selected historical structures in Türkiye

No	Name	Region	City	District	Latitude	Longitude
1	Alara Inn	Mediterranean	Antalya	Alanya	36.692789	31.724040
2	Kırkgöz Inn	Mediterranean	Antalya	Döşemealtı	37.110563	30.585310
3	Kızılkule Ethnography Museum	Mediterranean	Antalya	Alanya	36.536612	31.998453
4	Bakibey Mansion	Mediterranean	Burdur	Merkez	37.715780	30.287556
5	Stone Room Mansion	Mediterranean	Burdur	Merkez	37.717419	30.288811
6	Eğirdir Train Station	Mediterranean	Isparta	Eğirdir	37.876486	30.823454
7	Ertokuş Madrasah	Mediterranean	Isparta	Atabey	37.951969	30.646576
8	Firdevs Bey Bedesten	Mediterranean	Isparta	Merkez	37.764207	30.556856
9	Aya Payana Church	Mediterranean	Isparta	Merkez	37.757155	30.555254
10	Mersin Atatürk House and Museum	Mediterranean	Mersin	Akdeniz	36.796050	34.626889
11	St. Paul Memorial Museum	Mediterranean	Mersin	Tarsus	36.915256	34.899999
12	Kurtkulağı Caravansary	Mediterranean	Adana	Ceyhan	36.924337	35.887917
13	Seyhan District Governor's Office	Mediterranean	Adana	Seyhan	36.984033	35.332714
14	Zeytinli Station Building	Mediterranean	Adana	Seyhan	36.989797	35.142240
15	Yeni Bath	Mediterranean	Adana	Seyhan	36.981975	35.330277

Table A.1. (cont'd)

No	Name	Region	City	District	Latitude	Longitude
16	Adana Clock Tower	Mediterranean	Adana	Seyhan	36.984925	35.332885
17	Bebekli Church	Mediterranean	Adana	Seyhan	36.987877	35.325876
18	Habibi Neccar Mosque	Mediterranean	Hatay	Antakya	36.202164	36.167036
19	Taş Inn	Mediterranean	Kahramanmaraş	Dulkadiroğlu	37.583574	36.927543
20	Eshabı Kehf Complex	Mediterranean	Kahramanmaraş	Afşin	38.249288	36.854857
21	Kahramanmaraş Ulu Mosque	Mediterranean	Kahramanmaraş	Dulkadiroğlu	37.584781	36.926782
22	Taş Madrasah	Mediterranean	Kahramanmaraş	Dulkadiroğlu	37.586319	36.925835
23	Dedeoğlu Mansion	Mediterranean	Kahramanmaraş	Dulkadiroğlu	37.585414	36.928232
24	Katip / Cumhuriyet Inn	Mediterranean	Kahramanmaraş	Dulkadiroğlu	37.584671	36.926768
25	Grand Bazaar	Mediterranean	Kahramanmaraş	Dulkadiroğlu	37.582738	36.926963
26	Deligönüller Mansion	Mediterranean	Kahramanmaraş	Dulkadiroğlu	37.583589	36.935198
27	Old Malatya Ulu Mosque	Eastern Anatolia	Malatya	Battalgazi	38.420758	38.366801
28	Somuncu Baba Mosque and Tomb	Eastern Anatolia	Malatya	Darende	38.577017	37.491923
29	Silahtar Mustafa Pasha Caravanserai	Eastern Anatolia	Malatya	Battalgazi	38.424705	38.364715
30	Ataturk House Museum	Eastern Anatolia	Malatya	Battalgazi	38.348537	38.325329

Table A.1. (cont'd)

No	Name	Region	City	District	Latitude	Longitude
31	Taşhan	Eastern Anatolia	Malatya	Hekimhan	38.815691	37.933920
32	New Mosque	Eastern Anatolia	Malatya	Battalgazi	38.349952	38.317994
33	Çobanlı Mansion	Eastern Anatolia	Malatya	Arapgir	39.044918	38.506401
34	Erzincan Train Station	Eastern Anatolia	Erzincan	Merkez	39.782991	39.486515
35	Abrenk Church	Eastern Anatolia	Erzincan	Tercan	39.674545	40.282786
36	Harput Ulu Mosque	Eastern Anatolia	Elazığ	Merkez	38.706859	39.256159
37	Mor Ahron Monastery	Eastern Anatolia	Elazığ	Baskil	38.615822	38.401721
38	Elazığ Government House	Eastern Anatolia	Elazığ	Merkez	38.675182	39.212373
39	Sağman Mosque	Eastern Anatolia	Tunceli	Pertek	38.922894	39.297452
40	Atatürk House Museum	Eastern Anatolia	Erzurum	Yakutiye	39.907300	41.268897
41	Çifte Minare Madrasah	Eastern Anatolia	Erzurum	Yakutiye	39.906266	41.281318
42	Öşvank Church	Eastern Anatolia	Erzurum	Uzundere	40.614054	41.545819
43	Ulu Mosque	Eastern Anatolia	Muş	Merkez	38.730579	41.487336
44	Alaeddin Bey Mosque	Eastern Anatolia	Muş	Merkez	38.730169	41.488792
45	İhlasiye Madrasah	Eastern Anatolia	Bitlis	Merkez	38.407082	42.107192

Table A.1. (cont'd)

No	Name	Region	City	District	Latitude	Longitude
46	Kadı Mahmut Mosque	Eastern Anatolia	Bitlis	Ahlat	38.741232	42.476212
47	Katerina Hunting Lodge	Eastern Anatolia	Kars	Sarıkamış	40.326969	42.575597
48	The Kafkas Front War History Museum	Eastern Anatolia	Kars	Merkez	40.591521	43.095503
49	Gazi Ahmet Muhtar Pasha Mansion	Eastern Anatolia	Kars	Merkez	40.604970	43.097560
50	Evliya Mosque	Eastern Anatolia	Kars	Merkez	40.611370	43.092030
51	Beylerbeyi Palace	Eastern Anatolia	Kars	Merkez	40.612900	43.091824
52	Cuma Bath	Eastern Anatolia	Kars	Merkez	40.612136	43.088176
53	Kümbet Mosque	Eastern Anatolia	Kars	Merkez	40.613398	43.131850
54	Fethiye Mosque	Eastern Anatolia	Kars	Merkez	40.602042	43.099704
55	Kars Governorate Building	Eastern Anatolia	Kars	Merkez	40.600455	43.095638
56	Provincial Assembly Building	Eastern Anatolia	Kars	Merkez	40.601923	43.097539
57	Revenue Office Building	Eastern Anatolia	Kars	Merkez	40.605623	43.092765
58	Ishak Pasha Palace	Eastern Anatolia	Ağrı	Doğubeyazıt	39.520947	44.132635
59	Hamşioğlu Rasim Bey Mansion	Eastern Anatolia	Ardahan	Merkez	41.111418	42.700425
60	Akdamar Church	Eastern Anatolia	Van	Gevaş	38.342773	43.035266

Table A.1. (cont'd)

No	Name	Region	City	District	Latitude	Longitude
61	St. Bartholomeus Church	Eastern Anatolia	Van	Başkale	38.145462	44.210143
62	Çarpanak Church	Eastern Anatolia	Van	Tuşba	38.608288	43.084851
63	St. Thomas Monastery	Eastern Anatolia	Van	Gevaş	38.413569	42.889271
64	Meydan Madrasah	Eastern Anatolia	Hakkari	Merkez	37.568222	43.745287
65	Izmir Ethnography Museum	Aegean	İzmir	Konak	38.414452	27.128524
66	Basmane Train Station	Aegean	İzmir	Konak	38.422874	27.144623
67	Izmir Clock Tower	Aegean	İzmir	Konak	38.419034	27.129097
68	Hisar Mosque	Aegean	İzmir	Konak	38.421836	27.134659
69	Forbes Mansion	Aegean	İzmir	Buca	38.385327	27.165914
70	Murat Mansion	Aegean	İzmir	Bornova	38.463682	27.225233
71	Öküz Mehmet Paşa Caravansary	Aegean	Aydın	Kuşadası	37.860925	27.257248
72	Ahmet Şemsi Pasha Mosque	Aegean	Aydın	Efeler	37.842765	27.845544
73	Gümrükönü Bath	Aegean	Aydın	Efeler	37.852397	27.842448
74	İlyas Bey Mosque	Aegean	Aydın	Didim	37.752929	27.406281
75	Marmaris Archeology Museum	Aegean	Muğla	Marmaris	36.850719	28.274387

Table A.1. (cont'd)

No	Name	Region	City	District	Latitude	Longitude
76	Clock Tower	Aegean	Muğla	Menteşe	37.210161	28.359414
77	Kurşunlu Mosque	Aegean	Muğla	Menteşe	37.217769	28.365910
78	New Inn	Aegean	Manisa	Şehzadeler	38.612817	27.431628
79	Ulu Mosque and Complex	Aegean	Manisa	Akhisar	38.924892	27.841114
80	Sultan Mosque	Aegean	Manisa	Şehzadeler	38.610653	27.427362
81	Manisa Mevlevi Lodge	Aegean	Manisa	Şehzadeler	38.608388	27.440290
82	İvaz Pasha Mosque	Aegean	Manisa	Şehzadeler	38.628885	27.430303
83	Akhan Caravansary	Aegean	Denizli	Pamukkale	37.818641	29.136587
84	Acıpayam Yazır Mosque	Aegean	Denizli	Acıpayam	37.362328	29.560697
85	Paşa Inn	Aegean	Uşak	Merkez	38.681557	29.403474
86	Lajos Kossuth Museum	Aegean	Kütahya	Merkez	39.417204	29.974460
87	Ulu Mosque	Aegean	Kütahya	Merkez	39.418124	29.975920
88	Tile Museum	Aegean	Kütahya	Merkez	39.417971	29.975525
89	Kütahya Old Government House	Aegean	Kütahya	Merkez	39.417574	29.984044
90	Green Mosque	Aegean	Kütahya	Merkez	39.417715	29.982642

Table A.1. (cont’d)

No	Name	Region	City	District	Latitude	Longitude
91	Afyon City (İzmir) Station	Aegean	Afyonkarahisar	Merkez	38.767122	30.534917
92	Sultan Divani Mevlevi Lodge	Aegean	Afyonkarahisar	Merkez	38.754170	30.535084
93	Anıtkaya Caravansary	Aegean	Afyonkarahisar	Merkez	38.953860	30.347789
94	Afyon High School	Aegean	Afyonkarahisar	Merkez	38.758172	30.541823
95	Taksiyarhis Church	Aegean	Balıkesir	Ayvalık	39.320126	26.694716
96	Saatli Mosque	Aegean	Balıkesir	Ayvalık	39.319368	26.695058
97	Kurtuluş Mosque	Southeastern Anatolia	Gaziantep	Şahinbey	37.060730	37.377242
98	Boyacı Mosque	Southeastern Anatolia	Gaziantep	Şahinbey	37.062750	37.389210
99	Neşet Efendi Mansion	Southeastern Anatolia	Kilis	Merkez	36.717563	37.112714
100	Tuğlu Bath	Southeastern Anatolia	Kilis	Merkez	36.712944	37.114287
101	Adıyaman Ulu Mosque	Southeastern Anatolia	Adıyaman	Merkez	37.759767	38.278822
102	Mesudiye Madrasa	Southeastern Anatolia	Diyarbakır	Sur	37.913182	40.238310
103	Surp Giragos Armenian Church	Southeastern Anatolia	Diyarbakır	Sur	37.911156	40.240076
104	Deliler Inn	Southeastern Anatolia	Diyarbakır	Sur	37.907333	40.237597
105	Virgin Mary Church	Southeastern Anatolia	Diyarbakır	Sur	37.908984	40.230638

Table A.1. (cont'd)

No	Name	Region	City	District	Latitude	Longitude
106	Mardin Museum	Southeastern Anatolia	Mardin	Artuklu	37.314056	40.734811
107	Mor Gabriel Monastery	Southeastern Anatolia	Mardin	Midyat	37.191972	41.321912
108	Kasımiye Madrasa	Southeastern Anatolia	Mardin	Artuklu	37.307613	40.719977
109	Mardin Ulu Mosque	Southeastern Anatolia	Mardin	Artuklu	37.184640	40.442157
110	Former Post Office Building	Southeastern Anatolia	Mardin	Artuklu	37.314342	40.743347
111	Şehidiye Madrasa	Southeastern Anatolia	Mardin	Artuklu	37.314268	40.743479
112	Siirt Ulu Mosque	Southeastern Anatolia	Siirt	Merkez	37.925230	41.945395
113	Red Madrasah	Southeastern Anatolia	Şırnak	Cizre	37.333810	42.184583
114	Hafız Ahmet Efendi Mansion	Central Anatolia	Eskişehir	Odunpazarı	39.764331	30.525125
115	Surp Yerotutyun Armenian Church	Central Anatolia	Eskişehir	Sivrihisar	39.454649	31.539499
116	Mevlana Museum	Central Anatolia	Konya	Karatay	37.872794	32.505004
117	Beyşehir Eşrefoğlu Mosque	Central Anatolia	Konya	Beyşehir	37.684746	31.719420
118	Şems-i Tebrizi Mosque and Tomb	Central Anatolia	Konya	Karatay	37.874467	32.497698
119	Alâeddin Mosque	Central Anatolia	Konya	Selçuklu	37.874149	32.492841
120	Karatay Madrasah	Central Anatolia	Konya	Selçuklu	37.877895	32.492809

Table A.1. (cont'd)

No	Name	Region	City	District	Latitude	Longitude
121	Turkish State Meteorological Service Building	Central Anatolia	Ankara	Keçiören	39.973328	32.863517
122	Anatolian Civilizations Museum	Central Anatolia	Ankara	Altındağ	39.943616	32.860727
123	II. Turkish Grand National Assembly Building	Central Anatolia	Ankara	Altındağ	39.947195	32.851459
124	State Museum of Painting and Sculpture	Central Anatolia	Ankara	Altındağ	39.935319	32.855463
125	Stone Masjid	Central Anatolia	Çankırı	Merkez	40.601569	33.604333
126	Sultan Inn	Central Anatolia	Aksaray	Merkez	38.248704	33.546974
127	Cacabey Madrasa	Central Anatolia	Kırşehir	Merkez	39.145841	34.161272
128	Akdağmadeni Ziraat Bank	Central Anatolia	Yozgat	Merkez	39.822249	34.809263
129	Yozgat Clock Tower	Central Anatolia	Yozgat	Merkez	39.823034	34.808245
130	Yozgat Military Service Branch	Central Anatolia	Yozgat	Merkez	39.823168	34.809234
131	Alaeddin Mosque	Central Anatolia	Niğde	Merkez	37.966435	34.678971
132	Sungur Bey Mosque	Central Anatolia	Niğde	Merkez	37.965550	34.677740
133	Konakli Greek Church	Central Anatolia	Niğde	Merkez	38.172651	34.837711
134	Çelebi Hüsamettin Mosque	Central Anatolia	Niğde	Merkez	37.969104	34.674163
135	Ağzıkaran Caravansary	Central Anatolia	Nevşehir	Aksaray	38.445626	34.140428

Table A.1. (cont'd)

No	Name	Region	City	District	Latitude	Longitude
136	Damat Ibrahim Pasha Mosque	Central Anatolia	Nevşehir	Merkez	38.622313	34.714531
137	Asmali Mansion	Central Anatolia	Nevşehir	Ürgüp	38.634903	34.905490
138	Atatürk House	Central Anatolia	Nevşehir	Hacıbektaş	38.942936	34.560746
139	American College and Hospital Building	Central Anatolia	Kayseri	Talas	38.687446	35.568299
140	Kayseri Clock Tower	Central Anatolia	Kayseri	Melikgazi	38.722556	35.488171
141	Kurşunlu Mosque	Central Anatolia	Kayseri	Kocasinan	38.722785	35.485314
142	Sahabiye Madrasa	Central Anatolia	Kayseri	Kocasinan	38.723887	35.486652
143	Tol Madrasah	Central Anatolia	Karaman	Ermenek	36.640130	32.888200
144	Sivas Congress Building Ataturk and Ethnography Museum	Central Anatolia	Sivas	Merkez	39.750131	37.013423
145	Gök Madrasah	Central Anatolia	Sivas	Merkez	39.744364	37.016712
146	Sivas Ulu Mosque	Central Anatolia	Sivas	Merkez	39.747114	37.017681
147	Şifaiye Madrasa (Sivas Hospital)	Central Anatolia	Sivas	Merkez	39.748458	37.014870
148	Kurşunlu Turkish Bath	Central Anatolia	Sivas	Merkez	39.746945	37.020447
149	Kale Mosque	Central Anatolia	Sivas	Merkez	39.749172	37.014383

Table A.1. (cont'd)

No	Name	Region	City	District	Latitude	Longitude
150	Gendarmerie Building	Central Anatolia	Sivas	Merkez	39.751105	37.015023
151	Sivas Government House	Central Anatolia	Sivas	Merkez	39.751025	37.015197
152	Göynük Government Office	Black Sea	Bolu	Göynük	40.399610	30.786287
153	Upper Taşhan	Black Sea	Bolu	Merkez	40.733746	31.608788
154	Cinci Inn	Black Sea	Karabük	Safranbolu	41.245299	32.695923
155	Köprülü Mehmet Pasha Mosque	Black Sea	Karabük	Safranbolu	41.248746	32.690110
156	Small Church	Black Sea	Bartın	Amasra	41.749579	32.388201
157	Kastamonu Governorship	Black Sea	Kastamonu	Merkez	41.376279	33.778221
158	Kastamonu Government House	Black Sea	Kastamonu	Merkez	41.376457	33.778860
159	Çorum Clock Tower	Black Sea	Çorum	Merkez	40.550432	34.955435
160	Pervane Madrasah	Black Sea	Sinop	Merkez	42.026928	35.148236
161	Ethnography Museum	Black Sea	Sinop	Merkez	42.026392	35.153115
162	Gazi Museum	Black Sea	Samsun	İlkadım	41.290282	36.332414
163	Samsun City Museum	Black Sea	Samsun	İlkadım	41.286434	36.339789
164	Bafra Archeology Museum	Black Sea	Samsun	Bafra	41.570034	35.904995

Table A.1. (cont’d)

No	Name	Region	City	District	Latitude	Longitude
165	II. Bayezid Complex	Black Sea	Amasya	Merkez	40.650917	35.827329
166	Burmalı Minaret Mosque and Cumudar Tomb	Black Sea	Amasya	Merkez	40.650773	35.832185
167	Halifet Gazi Tomb	Black Sea	Amasya	Merkez	40.650209	35.823219
168	Sümbül Baba Hermitage	Black Sea	Tokat	Merkez	40.321332	36.551207
169	Tokat Clock Tower	Black Sea	Tokat	Merkez	40.310777	36.553542
170	Gök Madrasah	Black Sea	Tokat	Merkez	40.310416	36.552669
171	Paşaoğlu Mansion Ethnography Museum	Black Sea	Ordu	Altınordu	40.982928	37.875242
172	Flat Neighborhood Church	Black Sea	Ordu	Altınordu	40.992103	37.875160
173	Selimiye Mosque	Black Sea	Ordu	Altınordu	40.981675	37.875463
174	Taşbaşı Cultural Center	Black Sea	Ordu	Altınordu	40.994180	37.872249
175	Giresun Children's Library	Black Sea	Giresun	Merlez	40.918369	38.392792
176	Şebinkarahisar Asarcık Church	Black Sea	Giresun	Şebinkarahisar	40.416410	38.391996
177	Kostaki Mansion	Black Sea	Trabzon	Ortahisar	41.004985	39.726635
178	Pulur (Gökçdere) Madrasah	Black Sea	Bayburt	Demirözü	40.133969	39.750731
179	Işıklı Mosque	Black Sea	Rize	Ardeşen	41.210633	41.045530

Table A.1. (cont’d)

No	Name	Region	City	District	Latitude	Longitude
180	Barhal Church	Black Sea	Artvin	Yusufeli	40.970674	41.385095
181	Bayramiç Hadımoğlu Mansion	Marmara	Çanakkale	Bayramiç	39.810797	26.612350
182	Deveci Inn	Marmara	Edirne	Merkez	41.680176	26.556562
183	Selimiye Mosque	Marmara	Edirne	Merkez	41.678591	26.560915
184	Karaağaç Train Station	Marmara	Edirne	Merkez	41.652750	26.521940
185	Old Mosque	Marmara	Edirne	Merkez	41.674121	26.560994
186	Sweti George Bulgarian Church	Marmara	Edirne	Merkez	41.680817	26.570777
187	Süleymaniye Mosque	Marmara	Tekirdağ	Çorlu	41.160604	27.805155
188	Historical Çorlu House	Marmara	Tekirdağ	Çorlu	41.166509	27.802849
189	Historical Mansion Bath	Marmara	Tekirdağ	Süleymanpaşa	40.979320	27.521100
190	Babaeski Cedid Ali Pasha Mosque	Marmara	Kırklareli	Babaeski	41.429025	27.099185
191	Lüleburgaz Sokullu Mosque	Marmara	Kırklareli	Lüleburgaz	41.408029	27.351180
192	Hızırbey Mosque	Marmara	Kırklareli	Merkez	41.736706	27.223611
193	First Foundation Inn	Marmara	İstanbul	Fatih	41.015444	28.972496
194	Second Foundation Inn	Marmara	İstanbul	Fatih	41.015079	28.971278

Table A.1. (cont'd)

No	Name	Region	City	District	Latitude	Longitude
195	Sixth Foundation Inn	Marmara	İstanbul	Beyoğlu	41.024111	28.979150
196	Abud Efendi Inn	Marmara	İstanbul	Fatih	41.016366	28.970415
197	Ada Inn	Marmara	İstanbul	Beyoğlu	41.026703	28.979518
198	Ali Paşa Inn	Marmara	İstanbul	Fatih	41.010539	28.966193
199	Alyanak Inn	Marmara	İstanbul	Fatih	41.015022	28.973288
200	Anadolu Inn	Marmara	İstanbul	Fatih	41.016576	28.973429
201	Arnavut Inn	Marmara	İstanbul	Fatih	41.009894	28.969586
202	Military Museum and Cultural Center Command	Marmara	İstanbul	Şişli	41.048578	28.987832
203	Atatürk Museum	Marmara	İstanbul	Şişli	41.056977	28.987554
204	Büyük Valide Inn	Marmara	İstanbul	Fatih	41.013798	28.971957
205	Ziraat Bank Karaköy Branch	Marmara	İstanbul	Beyoğlu	41.022465	28.974993
206	Consulate General of Belgium	Marmara	İstanbul	Beyoğlu	41.035581	28.984750
207	Beylerbeyi Palace	Marmara	İstanbul	Beykoz	41.043062	29.040080
208	Defter-i Hakani	Marmara	İstanbul	Fatih	41.007086	28.976523
209	İSOV Construction Vocational Hisgh School	Marmara	İstanbul	Şişli	41.072499	29.014247

Table A.1. (cont'd)

No	Name	Region	City	District	Latitude	Longitude
210	Zindan Inn	Marmara	İstanbul	Fatih	41.019270	28.968909
211	White Mansion	Marmara	İstanbul	Sarıyer	41.109790	29.052895
212	Etfal Hospital Clock Tower	Marmara	İstanbul	Şişli	41.057970	28.990126
213	Kurşunlu Inn	Marmara	İstanbul	Büyükçekmece	41.022431	28.577131
214	Küçüksu Pavilion	Marmara	İstanbul	Beykoz	41.079065	29.066596
215	Malta Mansion	Marmara	İstanbul	Beşiktaş	41.051968	29.019378
216	Surp Krikor Lusavoric Armenian Church	Marmara	İstanbul	Beyoğlu	41.026444	28.979961
217	Beyoğlu Municipality Building	Marmara	İstanbul	Beyoğlu	41.028403	28.973735
218	Galata Mevlevi Lodge Museum	Marmara	İstanbul	Beyoğlu	41.029295	28.974665
219	Dolmabahçe Clock Tower	Marmara	İstanbul	Beşiktaş	41.038631	28.998854
220	Aya İrini Museum	Marmara	İstanbul	Fatih	41.010581	28.982857
221	Tiled Kiosk	Marmara	İstanbul	Fatih	41.012492	28.981950
222	Tamara Mansion	Marmara	İstanbul	Kadıköy	40.953787	29.090599
223	Tophane Pavillion	Marmara	İstanbul	Beyoğlu	41.027785	28.983541
224	Ortaköy Mosque	Marmara	İstanbul	Beşiktaş	41.047960	29.026776

Table A.1. (cont’d)

No	**Name**	**Region**	**City**	**District**	**Latitude**	**Longitude**
225	Galata Tower	Marmara	İstanbul	Beyoğlu	41.025949	28.975207
226	Crimean Memorial Church	Marmara	İstanbul	Beyoğlu	41.028453	28.977624
227	Sirkeci Train Station	Marmara	İstanbul	Fatih	41.015452	28.977074
228	Bağdat Mansion	Marmara	İstanbul	Fatih	41.014834	28.986123
229	Ragıp Pasha Apartment	Marmara	İstanbul	Beyoğlu	41.035999	28.981358
230	Fourth Foundation Inn	Marmara	İstanbul	Fatih	41.016628	28.973993
231	Pink Mansion	Marmara	İstanbul	Sarıyer	41.109715	29.056887
232	Kınacıyan Inn	Marmara	İstanbul	Fatih	41.014622	28.974735
233	Issız Inn	Marmara	Bursa	Karacabey	40.220715	28.478451
234	Hünkar Mansion	Marmara	Bursa	Yıldırım	40.175362	29.067074
235	The Grand Mosque	Marmara	Bursa	Osmangazi	40.184077	29.063040
236	Green Tomb	Marmara	Bursa	Yıldırım	40.181973	29.076871
237	Koza Inn	Marmara	Bursa	Osmangazi	40.185356	29.063544
238	Iznik Hagia Sophia Mosque	Marmara	Bursa	İznik	40.430040	29.722798
239	Tophane Clock Tower	Marmara	Bursa	Osmangazi	40.188578	29.059442

Table A.1. (cont’d)

No	Name	Region	City	District	Latitude	Longitude
240	Termal Atatürk Mansion	Marmara	Yalova	Termal	40.604242	29.173978
241	Walking Mansion	Marmara	Yalova	Merkez	40.665331	29.297463
242	Kaiser II. Wilhelm Mansion	Marmara	Kocaeli	Körfez	40.783981	29.616442
243	Kasr-i Humayun Palace Museum	Marmara	Kocaeli	İzmit	40.763605	29.920429
244	Çoban Mustafa Pasha Complex	Marmara	Kocaeli	Gebze	40.800227	29.432280
245	Pertev Mehmet Pasha Mosque and Complex	Marmara	Kocaeli	İzmit	40.764243	29.931384
246	İzmit Clock Tower	Marmara	Kocaeli	İzmit	40.763353	29.919404
247	Izmit Old Station Buildings	Marmara	Kocaeli	İzmit	40.762592	29.917601
248	Mihal Bey Inn	Marmara	Bilecik	Gölpazarı	40.284626	30.316313
249	Bilecik Clock Tower	Marmara	Bilecik	Merkez	40.138567	29.983978
250	Rahime Sultan Mosque	Marmara	Sakarya	Sapanca	40.700777	30.310175

B. Information about Selected Historical Structures

The information on the selected historical structures in Türkiye are tabulated in Tables B.1 and B.2.

Table B.1. Information on the selected historical structures in Türkiye

No	Material	Year	Occupancy Class	Restoration	Importance	V_{s30} (m/s)	NEHRP Site Class
1	Stone	1231	Commercial	Yes	Local	607	C
2	Stone	1232	Social/Cultural	Yes	Local	724	C
3	Stone, Brick	1226	Social/Cultural	Yes	Local	540	C
4	Stone, Timber, Adobe	17^{th} Century	Governmental	Yes	Local	335	D
5	Stone	17^{th} Century	Commercial	Yes	Local	335	D
6	Stone, Brick	1907	Not Used	No	National	NA	D
7	Stone	1124	Religious	Yes	Local	NA	C
8	Stone	1521	Commercial	Yes	Local	NA	D
9	Stone	1750	Not Used	No	Local	NA	D
10	Stone	1807	Social/Cultural	Yes	National	366	C
11	Stone	1850	Social/Cultural	Yes	Universal	NA	D
12	Stone	1659	Social/Cultural	Yes	Local	264	D
13	Stone, Brick, Timber	1901	Governmental	Yes	National	461	C
14	Stone, Timber	1910	Not Used	No	Local	461	C
15	Stone, Brick	1720	Public	Yes	Local	461	C

Table B.1. (cont'd)

No	Material	Year	Occupancy Class	Restoration	Importance	V_{s30} (m/s)	NEHRP Site Class
16	Stone	1882	Public	Yes	National	461	C
17	Stone	1880	Religious	Yes	Universal	461	C
18	Stone	1275	Religious	Yes	Local	377	C
19	Stone	1650	Commercial	Yes	Local	440	C
20	Stone	1234	Religious	Yes	Universal	186	D
21	Stone	1454	Religious	Yes	Local	440	C
22	Stone	Late 15^{th} Century	Religious	Yes	Local	440	C
23	Stone	19^{th} Century	Social/Cultural	Yes	Local	440	C
24	Adobe, Timber	1780	Commercial	Yes	Local	440	C
25	Stone	16^{th} Century	Commercial	Yes	Local	440	C
26	Stone, Timber	19^{th} Century	Social/Cultural	Yes	Local	440	C
27	Brick	1224	Religious	Yes	Local	508	C
28	Stone, Timber	1686	Religious	Yes	Local	508	C
29	Stone	1637	Commercial	Yes	Local	508	C
30	Stone	19^{th} Century	Social/Cultural	Yes	Local	508	C

Table B.1. (cont'd)

No	Material	Year	Occupancy Class	Restoration	Importance	V_{s30} (m/s)	NEHRP Site Class
31	Stone	1218	Commercial	Yes	Local	508	C
32	Stone	1893	Religious	Yes	Local	508	C
33	Stone	1890	Social/Cultural	Yes	Local	508	C
34	Stone	1938	Public	Yes	National	541	C
35	Stone	1854	Not Used	No	Local	320	D
36	Stone, Brick	1157	Religious	Yes	Local	407	C
37	Stone	329	Not Used	No	Local	NA	C
38	Stone	1896	Governmental	Yes	Local	407	C
39	Stone	1555	Religious	Yes	Local	NA	C
40	Stone, Timber	Late 19th Century	Social/Cultural	Yes	National	375	C
41	Stone	Late 13th Century	Social/Cultural	Yes	National	375	C
42	Stone	973	Not Used	No	Local	NA	C
43	Stone	979	Religious	Yes	Local	315	D
44	Stone	18th Century	Religious	Yes	Local	315	D
45	Stone	1216	Social/Cultural	Yes	Local	273	D

Table B.1. (cont'd)

No	Material	Year	Occupancy Class	Restoration	Importance	V_{s30} (m/s)	NEHRP Site Class
46	Stone	1584	Religious	Yes	Local	NA	C
47	Stone, Timber	1896	Not Used	No	Universal	641	C
48	Stone	19^{th} Century	Social/Cultural	Yes	National	270	D
49	Stone	19^{th} Century	Not Used	Yes	Local	270	D
50	Stone	1579	Religious	Yes	Local	270	D
51	Stone	16^{th} Century	Social/Cultural	Yes	Local	270	D
52	Stone	Late 17^{th} Century	Public	Yes	Local	270	D
53	Stone	937	Religious	Yes	Local	270	D
54	Stone, Brick	Late 19^{th} Century	Religious	Yes	Local	270	D
55	Stone, Brick	1883	Governmental	Yes	Local	270	D
56	Stone	Late 19^{th} Century	Governmental	Yes	Local	270	D
57	Stone	19^{th} Century	Governmental	Yes	Local	270	D
58	Stone	1784	Social/Cultural	Yes	Universal	271	D
59	Stone	1911	Governmental	Yes	Local	555	C

Table B.1. (cont'd)

No	Material	Year	Occupancy Class	Restoration	Importance	V_{s30} (m/s)	NEHRP Site Class
60	Stone	921	Social/Cultural	Yes	Universal	NA	C
61	Stone	Early 14^{th} Century	Not Used	No	Local	NA	D
62	Stone	15^{th} Century	Not Used	No	Local	NA	C
63	Stone	1581	Not Used	No	Local	NA	C
64	Stone	1701	Social/Cultural	Yes	Local	NA	C
65	Stone, Brick	1831	Social/Cultural	Yes	National	298	D
66	Stone	1856	Public	Yes	National	298	D
67	Stone	1901	Public	Yes	National	298	D
68	Stone	1592	Religious	Yes	Local	298	D
69	Stone	1910	Not Used	Yes	Local	695	C
70	Stone	1880	Commercial	Yes	Local	270	D
71	Stone	1618	Commercial	Yes	Local	369	C
72	Brick	1659	Religious	Yes	Local	311	D
73	Stone, Brick	Late 15^{th} Century	Not Used	No	Local	311	D
74	Brick	1404	Religious	Yes	Local	630	C

Table B.1. (cont'd)

No	Material	Year	Occupancy Class	Restoration	Importance	V_{s30} (m/s)	NEHRP Site Class
75	Stone	1044	Social/Cultural	Yes	Local	393	C
76	Stone	1895	Public	Yes	Local	466	C
77	Stone, Timber	1493	Religious	Yes	Local	466	C
78	Stone	1830	Commercial	Yes	Local	NA	D
79	Stone	1366	Religious	Yes	Local	292	D
80	Stone	1522	Religious	Yes	Local	NA	D
81	Stone	1379	Religious	Yes	Local	NA	C
82	Stone, Brick	1484	Religious	Yes	Local	NA	D
83	Stone	1254	Commercial	Yes	Local	346	D
84	Timber	1797	Religious	Yes	Local	303	D
85	Stone	1898	Commercial	Yes	Local	285	D
86	Timber	18^{th} Century	Social/Cultural	Yes	Universal	267	D
87	Stone	1384	Religious	Yes	Local	267	D
88	Stone	1429	Social/Cultural	Yes	Local	267	D
89	Stone	1905	Governmental	Yes	Local	267	D

Table B.1. (cont'd)

No	Material	Year	Occupancy Class	Restoration	Importance	V_{s30} (m/s)	NEHRP Site Class
90	Stone	1905	Religious	Yes	Local	267	D
91	Stone	1890	Not Used	No	National	226	D
92	Stone	1908	Religious	Yes	National	226	D
93	Stone	14^{th} Century	Social/Cultural	Yes	Local	226	D
94	Stone	1894	Educational	Yes	National	226	D
95	Stone, Brick	1873	Social/Cultural	Yes	Local	387	C
96	Stone, Brick	Late 19^{th} Century	Religious	Yes	Local	387	C
97	Stone	1892	Religious	Yes	Local	758	C
98	Stone	1357	Religious	Yes	Local	758	C
99	Stone, Adobe	1927	Social/Cultural	Yes	Local	463	C
100	Stone	1785	Public	Yes	Local	463	C
101	Stone	1863	Religious	Yes	Local	391	C
102	Stone	1198	Social/Cultural	Yes	Local	NA	C
103	Stone	1883	Religious	Yes	Local	NA	C
104	Stone, Brick	1528	Commercial	Yes	Local	519	C

Table B.1. (cont'd)

No	Material	Year	Occupancy Class	Restoration	Importance	V_{s30} (m/s)	NEHRP Site Class
105	Stone	3rd Century	Religious	Yes	Local	NA	C
106	Adobe	1895	Social/Cultural	Yes	Local	709	C
107	Stone	397	Social/Cultural	Yes	Local	NA	C
108	Stone	1502	Social/Cultural	Yes	Local	709	C
109	Stone	1176	Religious	Yes	Local	709	C
110	Stone	1890	Governmental	Yes	Local	709	C
111	Stone	13^{th} Century	Religious	Yes	Local	709	C
112	Stone	1129	Religious	Yes	Local	NA	C
113	Brick	14^{th} Century	Social/Cultural	Yes	Local	NA	D
114	Adobe, Timber	1717	Commercial	Yes	Local	348	D
115	Stone	1881	Social/Cultural	Yes	Local	480	C
116	stone	1273	Social/Cultural	Yes	Local	321	D
117	Stone	1299	Religious	Yes	National	286	D
118	Stone	13^{th} Century	Religious	Yes	Local	321	D
119	Stone	1156	Religious	Yes	Local	NA	C

Table B.1. (cont'd)

No	Material	Year	Occupancy Class	Restoration	Importance	V_{s30} (m/s)	NEHRP Site Class
120	Stone	1251	Social/Cultural	Yes	Local	NA	C
121	Brick	19th Century	Governmental	Yes	National	195	D
122	Stone, Brick	1471	Social/Cultural	Yes	Universal	728	C
123	Stone	1923	Social/Cultural	Yes	National	728	C
124	Stone	1930	Social/Cultural	Yes	National	728	C
125	Stone	1235	Religious	Yes	Local	510	C
126	Stone	1229	Social/Cultural	Yes	Local	214	D
127	Stone	1272	Religious	Yes	Local	460	C
128	Stone	Early 20th Century	Governmental	Yes	Local	906	B
129	Stone	1908	Public	Yes	Local	906	B
130	Stone	1896	Governmental	Yes	Local	906	B
131	Stone	1223	Religious	Yes	Local	678	C
132	Stone	1335	Religious	Yes	Local	678	C
133	Stone	1844	Religious	Yes	Local	678	C
134	Stone	16th Century	Religious	Yes	Local	678	C

Table B.1. (cont'd)

No	**Material**	**Year**	**Occupancy Class**	**Restoration**	**Importance**	**V_{s30} (m/s)**	**NEHRP Site Class**
135	Stone	13^{th} Century	Not Used	Yes	Local	369	C
136	Stone	1727	Religious	Yes	Local	369	C
137	Stone	1887	Social/Cultural	Yes	National	NA	C
138	Stone	19^{th} Century	Social/Cultural	Yes	Local	NA	C
139	Stone	1871	Social/Cultural	Yes	Universal	407	C
140	Stone	1906	Governmental	No	Local	407	C
141	Stone	1585	Religious	Yes	Local	NA	D
142	Stone	1267	Commercial	Yes	Local	NA	D
143	Stone	1339	Social/Cultural	Yes	Local	404	C
144	Stone	1892	Social/Cultural	Yes	National	659	C
145	Stone	1271	Social/Cultural	Yes	Local	659	C
146	Stone	1178	Religious	Yes	Local	659	C
147	Stone	1218	Commercial	Yes	Local	659	C
148	Stone	1576	Public	Yes	Local	659	C
149	Stone	1580	Religious	Yes	Local	659	C

Table B.1. (cont'd)

No	Material	Year	Occupancy Class	Restoration	Importance	V_{s30} (m/s)	NEHRP Site Class
150	Stone	1908	Governmental	Yes	Local	659	C
151	Stone, Timber	1884	Governmental	Yes	Local	659	C
152	Stone	1898	Governmental	Yes	Local	472	C
153	Stone	1904	Commercial	Yes	Local	294	D
154	Stone	1645	Commercial	Yes	Local	530	C
155	Stone	1661	Religious	Yes	Local	530	C
156	Stone, Brick	9^{th} Century	Social/Cultural	Yes	Local	NA	C
157	Stone	1898	Governmental	Yes	Local	514	C
158	Stone	19^{th} Century	Governmental	Yes	Local	514	C
159	Stone	1894	Public	Yes	Local	193	D
160	Stone	1262	Commercial	Yes	Local	328	D
161	Brick, Timber	1214	Social/Cultural	Yes	Local	328	D
162	Brick	1902	Social/Cultural	Yes	Local	420	C
163	Timber	1928	Social/Cultural	Yes	Local	420	C
164	Timber	1858	Social/Cultural	Yes	Local	420	C

Table B.1. (cont'd)

No	Material	Year	Occupancy Class	Restoration	Importance	V_{s30} (m/s)	NEHRP Site Class
165	Stone	1486	Social/Cultural	Yes	National	443	C
166	Stone	1242	Religious	Yes	Local	443	C
167	Stone	1210	Religious	No	Local	443	C
168	Stone	1292	Religious	Yes	Local	447	C
169	Stone	1902	Public	Yes	Local	447	C
170	Stone	1277	Social/Cultural	No	Local	447	C
171	Stone	1896	Social/Cultural	Yes	Local	199	D
172	Stone	19^{th} Century	Religious	Yes	Local	199	D
173	Stone	18^{th} Century	Religious	Yes	Local	NA	C
174	Stone	1853	Social/Cultural	Yes	Local	199	D
175	Stone	19^{th} Century	Public	Yes	Local	NA	D
176	Stone	1890	Not Used	No	Local	425	C
177	Stone	1900	Social/Cultural	Yes	Local	574	C
178	Stone	1517	Religious	Yes	Local	519	C
179	Stone	1887	Religious	Yes	Local	NA	D

Table B.1. (cont'd)

No	Material	Year	Occupancy Class	Restoration	Importance	V_{s30} (m/s)	NEHRP Site Class
180	Stone	14th Century	Religious	Yes	Local	350	D
181	Stone, Timber	1796	Social/Cultural	Yes	Local	403	C
182	Stone, Brick	15th century	Commercial	Yes	Local	322	D
183	Stone	1575	Religious	Yes	Universal	NA	D
184	Stone	1914	Educational	Yes	National	322	D
185	Stone	1414	Religious	Yes	National	322	D
186	Stone, Brick	1880	Religious	Yes	Local	322	D
187	Stone	1521	Religious	Yes	Local	313	D
188	Stone, Timber	Late 19th Century	Social/Cultural	Yes	Local	313	D
189	Stone	1600	Public	Yes	Local	409	C
190	stone	1555	Religious	Yes	Local	NA	D
191	Stone	1569	Religious	Yes	Local	317	D
192	Stone	1383	Religious	Yes	Local	500	C
193	Stone	1918	Commercial	Yes	Local	323	D
194	Stone, Brick	Early 20th Century	Commercial	Yes	Local	323	D

Table B.1. (cont'd)

No	Material	Year	Occupancy Class	Restoration	Importance	V_{s30} (m/s)	NEHRP Site Class
195	Stone, Brick	Late 19th Century	Commercial	Yes	Local	595	C
196	Brick	1895	Commercial	No	Local	323	D
197	Brick	19th-20th Century	Commercial	Yes	Local	595	C
198	Stone, Brick	16th Century	Commercial	No	Local	323	D
199	Stone, Brick	Late 19th Century	Commercial	Yes	Local	323	D
200	Stone, Brick	Early 20th Century	Commercial	No	Local	323	D
201	Brick	1882	Commercial	No	Local	323	D
202	Stone, Brick	1862	Social/Cultural	Yes	National	595	C
203	Timber	1908	Social/Cultural	Yes	National	595	C
204	Stone, Brick	17th Century	Social/Cultural	Yes	National	323	D
205	Stone	1912	Governmental	Yes	Universal	595	C
206	Stone, Brick	Late 19th Century	Governmental	Yes	Universal	595	C
207	Stone	1865	Social/Cultural	Yes	Universal	415	C
208	Brick	1908	Social/Cultural	Yes	National	323	D
209	Stone, Brick	1884	Educational	Yes	Local	595	C

Table B.1. (cont'd)

No	Material	Year	Occupancy Class	Restoration	Importance	V_{s30} (m/s)	NEHRP Site Class
210	Stone	19th Century	Commercial	Yes	Local	323	D
211	Stone, Brick	19th Century	Social/Cultural	Yes	Local	1000	B
212	Stone	1907	Public	Yes	Local	595	C
213	Stone	1566	Commercial	Yes	Local	247	D
214	Stone, Brick	1752	Social/Cultural	Yes	National	415	C
215	Stone, Brick	1871	Social/Cultural	Yes	National	595	C
216	Stone, Brick	1799	Religious	Yes	Local	595	C
217	Stone, Brick	1857	Governmental	Yes	National	595	C
218	Stone, Timber	1491	Social/Cultural	Yes	Local	595	C
219	Stone	1894	Public	Yes	National	595	C
220	Stone, Brick	538	Social/Cultural	Yes	Universal	323	D
221	Stone, Brick	1472	Social/Cultural	Yes	National	323	D
222	Stone	1903	Not Used	No	Local	800	B
223	Stone, Brick	1852	Social/Cultural	Yes	National	595	C
224	Stone, Brick	1854	Religious	Yes	National	595	C

Table B.1. (cont'd)

No	Material	Year	Occupancy Class	Restoration	Importance	V_{s30} (m/s)	NEHRP Site Class
225	Stone	1349	Public	Yes	Universal	595	C
226	Stone	1868	Religious	Yes	Local	595	C
227	Stone, Brick	1890	Public	Yes	National	323	D
228	Stone	1639	Social/Cultural	Yes	National	323	D
229	Stone, Brick	19^{th} Century	Social/Cultural	No	Local	595	C
230	Stone	19^{th} Century	Social/Cultural	Yes	Local	323	D
231	Brick	19^{th} Century	Social/Cultural	Yes	Local	1000	B
232	Stone, Brick	1907	Commercial	Yes	Local	323	D
233	Stone, Brick	1395	Commercial	Yes	Local	375	C
234	Stone, Brick	1844	Social/Cultural	Yes	Local	459	C
235	Stone	1400	Religious	Yes	National	272	D
236	Brick	1421	Religious	Yes	Local	459	C
237	Stone	1451	Commercial	Yes	National	272	D
238	Stone	7^{th} Century	Religious	Yes	Universal	251	D

Table B.1. (cont'd)

No	Material	Year	Occupancy Class	Restoration	Importance	V_{s30} (m/s)	NEHRP Site Class
239	Stone	1905	Public	Yes	Local	272	D
240	Timber	1929	Social/Cultural	Yes	National	312	D
241	Timber	1929	Social/Cultural	Yes	National	196	D
242	Timber	1884	Social/Cultural	Yes	Universal	906	B
243	Stone	19^{th} Century	Social/Cultural	Yes	National	188	D
244	Stone	1523	Religious	Yes	Local	701	C
245	Stone	1579	Religious	Yes	Local	305	D
246	Stone	1902	Public	Yes	Local	188	D
247	Stone	1910	Social/Cultural	Yes	Local	188	D
248	Stone	1318	Social/Cultural	Yes	Local	901	B
249	Stone, Timber	1907	Public	Yes	Local	901	B
250	Stone	1892	Religious	Yes	Local	215	D

Table B.2. Information on the selected structures in Türkiye

No	**PGA 2475 (g)**	**Geological Formation**	**Geological Age**	**Seismic Gap**
1	0.445	Neritic limestone	Miocene	Outside
2	0.494	Non graded quaternary	Quaternary	Outside
3	0.420	Marble	Permian	Outside
4	0.787	Alluvial fan, debris, moraine	Quaternary	Outside
5	0.787	Alluvial fan, debris, moraine	Quaternary	Outside
6	0.657	Non graded quaternary	Quaternary	Outside
7	0.499	Non graded terrigenous clastics	Pleistocene	Outside
8	0.582	Non graded quaternary	Quaternary	Outside
9	0.582	Non graded quaternary	Quaternary	Outside
10	0.288	Clastics	Miocene	Outside
11	0.320	Non graded quaternary	Quaternary	Outside
12	0.607	Clastics and carbonates	Miocene	Outside
13	0.447	Non graded quaternary	Quaternary	Outside
14	0.380	Non graded quaternary	Quaternary	Outside
15	0.447	Non graded quaternary	Quaternary	Outside

Table B.2. (cont'd)

No	PGA 2475 (g)	Geological Formation	Geological Age	Seismic Gap
16	0.447	Non graded quaternary	Quaternary	Outside
17	0.446	Non graded quaternary	Quaternary	Outside
18	0.875	Clastics and carbonates	Miocene	Outside
19	0.685	Clastics and carbonates	Miocene	Inside
20	0.471	Shists	Upper Paleozoic	Inside
21	0.683	Clastics and carbonates	Miocene	Inside
22	0.680	Clastics and carbonates	Miocene	Inside
23	0.683	Clastics and carbonates	Miocene	Inside
24	0.683	Clastics and carbonates	Miocene	Inside
25	0.686	Clastics and carbonates	Miocene	Inside
26	0.693	Clastics and carbonates	Miocene	Inside
27	0.624	Non graded quaternary	Quaternary	Outside
28	0.323	Clastics and carbonates	Eocene	Outside
29	0.621	Non graded quaternary	Quaternary	Outside
30	0.655	Non graded quaternary	Quaternary	Outside

Table B.2. (cont'd)

No	PGA 2475 (g)	Geological Formation	Geological Age	Seismic Gap
31	0.402	Clastics and carbonates	Upper Cretaceous - Eocene	Outside
32	0.650	Non graded quaternary	Quaternary	Outside
33	0.568	Basalt	Pliocene	Outside
34	1.118	Alluvial fan, debris, moraine	Quaternary	Inside
35	0.818	Evaporite sedimentary rocks	Lower Miocene	Inside
36	0.697	Basalt, spilite	Upper Cretaceous	Outside
37	0.537	Clastics and carbonates	Eocene	Outside
38	0.714	Non graded terrigenous clastics	Pleistocene	Outside
39	0.566	Terrigenous clastics	Miocene	Outside
40	0.826	Non graded terrigenous clastics	Pleistocene	Inside
41	0.858	Non graded terrigenous clastics	Pleistocene	Inside
42	0.413	Clastics and carbonates	Middle Jura - Cretaceous	Inside
43	0.581	Shists	Upper Paleozoic	Outside
44	0.581	Shists	Upper Paleozoic	Outside
45	0.490	Pyroclastic rocks	Quaternary	Outside

Table B.2. (cont'd)

No	PGA 2475 (g)	Geological Formation	Geological Age	Seismic Gap
46	0.619	Terrigenous clastics	Miocene	Outside
47	0.455	Pyroclastic rocks	Upper Miocene - Pliocene	Outside
48	0.377	Terrigenous clastics	Upper Miocene	Outside
49	0.379	Terrigenous clastics	Upper Miocene	Outside
50	0.381	Terrigenous clastics	Upper Miocene	Outside
51	0.381	Terrigenous clastics	Upper Miocene	Outside
52	0.382	Terrigenous clastics	Upper Miocene	Outside
53	0.372	Terrigenous clastics	Upper Miocene	Outside
54	0.378	Terrigenous clastics	Upper Miocene	Outside
55	0.378	Terrigenous clastics	Upper Miocene	Outside
56	0.378	Terrigenous clastics	Upper Miocene	Outside
57	0.380	Terrigenous clastics	Upper Miocene	Outside
58	0.585	Ophiolitic melange	Upper Cretaceous	Outside
59	0.519	Non graded volcanites	Upper Miocene - Pliocene	Outside

Table B.2. (cont'd)

No	PGA 2475 (g)	Geological Formation	Geological Age	Seismic Gap
60	0.519	Marble	Paleozoic - Mesozoic	Outside
61	0.630	Non graded quaternary	Quaternary	Outside
62	0.581	Limestone	Upper Paleocene - Eocene	Outside
63	0.505	Non graded terrigenous clastics	Pleistocene	Outside
64	0.593	Clastics and carbonates	Eocene	Inside
65	0.852	Pyroclastic	Lower - Middle Miocene	Outside
66	0.854	Non graded quaternary	Quaternary	Outside
67	0.853	Non graded quaternary	Quaternary	Outside
68	0.854	Non graded quaternary	Quaternary	Outside
69	0.832	Non graded quaternary	Quaternary	Outside
70	0.832	Non graded quaternary	Quaternary	Outside
71	0.801	Lacustrine carbonates	Miocene	Outside
72	1.095	Alluvial fan, debris, moraine	Quaternary	Outside
73	1.088	Alluvial fan, debris, moraine	Quaternary	Outside
74	0.924	Alluvial fan, debris, moraine	Quaternary	Outside

Table B.2. (cont'd)

No	PGA 2475 (g)	Geological Formation	Geological Age	Seismic Gap
75	0.786	Non graded quaternary	Quaternary	Inside
76	0.688	Non graded quaternary	Quaternary	Inside
77	0.687	Non graded quaternary	Quaternary	Inside
78	0.875	Alluvial fan, debris, moraine	Quaternary	Outside
79	0.741	Non graded quaternary	Quaternary	Outside
80	0.873	Alluvial fan, debris, moraine	Quaternary	Outside
81	0.872	Terrigenous clastics	Miocene	Outside
82	0.888	Alluvial fan, debris, moraine	Quaternary	Outside
83	0.918	Non graded quaternary	Quaternary	Outside
84	0.735	Ophiolitic melange	Upper Cretaceous	Outside
85	0.482	Non graded quaternary	Quaternary	Outside
86	0.768	Terrigenous clastics	Miocene	Outside
87	0.770	Terrigenous clastics	Miocene	Outside
88	0.770	Terrigenous clastics	Miocene	Outside
89	0.772	Terrigenous clastics	Miocene	Outside

Table B.2. (cont'd)

No	PGA 2475 (g)	Geological Formation	Geological Age	Seismic Gap
90	0.772	Terrigenous clastics	Miocene	Outside
91	0.637	Non graded quaternary	Quaternary	Outside
92	0.633	Non graded quaternary	Quaternary	Outside
93	0.659	Terrigenous clastics	Miocene	Outside
94	0.634	Non graded quaternary	Quaternary	Outside
95	0.676	Non graded volcanites	Lower - Middle Miocene	Outside
96	0.675	Non graded volcanites	Lower - Middle Miocene	Outside
97	0.326	Non graded quaternary	Quaternary	Inside
98	0.321	Non graded quaternary	Quaternary	Inside
99	0.428	Non graded quaternary	Quaternary	Outside
100	0.425	Non graded quaternary	Quaternary	Outside
101	0.422	Non graded terrigenous clastics	Pliocene - Quaternary	Inside
102	0.245	Basalt	Pliocene	Outside
103	0.245	Terrigenous clastics	Miocene	Outside
104	0.244	Terrigenous clastics	Miocene	Outside

Table B.2. (cont'd)

No	PGA 2475 (g)	Geological Formation	Geological Age	Seismic Gap
105	0.244	Basalt	Pliocene	Outside
106	0.174	Terrigenous clastics	Eocene	Outside
107	0.199	Neritic limestone	Eocene	Outside
108	0.174	Neritic limestone	Cretaceous	Outside
109	0.163	Basalt	Pliocene	Outside
110	0.175	Terrigenous clastics	Eocene	Outside
111	0.175	Terrigenous clastics	Eocene	Outside
112	0.456	Neritic limestone	Eocene	Outside
113	0.563	Non graded quaternary	Quaternary	Outside
114	0.622	Terrigenous clastics	Pliocene	Outside
115	0.433	Granitoid	Paleocene	Outside
116	0.291	Non graded terrigenous clastics	Pleistocene	Outside
117	0.342	Non graded quaternary	Quaternary	Outside
118	0.293	Non graded terrigenous clastics	Pleistocene	Outside
119	0.293	Non graded terrigenous clastics	Pleistocene	Outside

Table B.2. (cont’d)

No	PGA 2475 (g)	Geological Formation	Geological Age	Seismic Gap
120	0.294	Non graded terrigenous clastics	Pleistocene	Outside
121	0.297	Non graded volcanites	Lower - Middle Miocene	Outside
122	0.297	Non graded volcanites	Lower - Middle Miocene	Outside
123	0.296	Non graded quaternary	Quaternary	Outside
124	0.296	Non graded volcanites	Lower - Middle Miocene	Outside
125	0.586	Non graded quaternary	Quaternary	Outside
126	0.238	Non graded terrigenous clastics	Pleistocene	Outside
127	0.185	Terrigenous clastics	Upper Miocene	Outside
128	0.253	Neritic limestone	Eocene	Outside
129	0.254	Neritic limestone	Eocene	Outside
130	0.254	Neritic limestone	Eocene	Outside
131	0.283	Non graded terrigenous clastics	Pleistocene	Outside
132	0.284	Non graded terrigenous clastics	Pleistocene	Outside
133	0.254	Pyroclastic rocks	Upper Miocene	Outside
134	0.283	Pyroclastic rocks	Miocene	Outside

Table B.2. (cont'd)

No	PGA 2475 (g)	Geological Formation	Geological Age	Seismic Gap
135	0.284	Pyroclastic rocks	Upper Miocene	Outside
136	0.192	Pyroclastic rocks	Quaternary	Outside
137	0.231	Pyroclastic rocks	Upper Miocene - Pliocene	Outside
138	0.175	Terrigenous clastics	Upper Miocene	Outside
139	0.430	Pyroclastic rocks	Pliocene	Outside
140	0.419	Non graded quaternary	Quaternary	Outside
141	0.419	Non graded quaternary	Quaternary	Outside
142	0.419	Non graded quaternary	Quaternary	Outside
143	0.268	Neritic limestone	Miocene	Outside
144	0.340	Terrigenous clastics	Upper Miocene	Outside
145	0.338	Terrigenous clastics	Upper Miocene	Outside
146	0.339	Terrigenous clastics	Upper Miocene	Outside
147	0.339	Terrigenous clastics	Upper Miocene	Outside
148	0.338	Non graded quaternary	Quaternary	Outside
149	0.340	Terrigenous clastics	Upper Miocene	Outside

Table B.2. (cont'd)

No	PGA 2475 (g)	Geological Formation	Geological Age	Seismic Gap
150	0.340	Terrigenous clastics	Upper Miocene	Outside
151	0.340	Terrigenous clastics	Upper Miocene	Outside
152	0.576	Clastics, carbonates in places	Cretaceous	Outside
153	1.075	Terrigenous clastics	Pliocene	Outside
154	0.566	Neritic limestone	Eocene	Outside
155	0.570	Neritic limestone	Eocene	Outside
156	0.454	Neritic limestone	Middle Jura - Cretaceous	Outside
157	0.523	Non graded quaternary	Quaternary	Outside
158	0.523	Non graded quaternary	Quaternary	Outside
159	0.515	Non graded quaternary	Quaternary	Outside
160	0.313	Non graded quaternary	Quaternary	Outside
161	0.313	Non graded quaternary	Quaternary	Outside
162	0.408	Clastics and carbonates	Eocene	Outside
163	0.409	Clastics and carbonates	Eocene	Outside
164	0.353	Non graded quaternary	Quaternary	Outside

Table B.2. (cont'd)

No	PGA 2475 (g)	Geological Formation	Geological Age	Seismic Gap
165	0.789	Non graded quaternary	Quaternary	Outside
166	0.791	Non graded quaternary	Quaternary	Outside
167	0.787	Shist, phyllite, marble, metabasite	Upper Paleozoic - Triassic	Outside
168	0.587	Marble	Permian	Outside
169	0.578	Shist, phyllite, marble, metabasite	Upper Paleozoic - Triassic	Outside
170	0.578	Shist, phyllite, marble, metabasite	Upper Paleozoic - Triassic	Outside
171	0.278	Clastics and carbonates	Upper Cretaceous - Eocene	Outside
172	0.278	Non graded andesite, pyroclastic	Upper Cretaceous	Outside
173	0.278	Clastics and carbonates	Upper Cretaceous - Eocene	Outside
174	0.278	Non graded andesite, pyroclastic	Upper Cretaceous	Outside
175	0.330	Non graded andesite, pyroclastic	Upper Cretaceous	Outside
176	0.509	Granitoid	Paleocene - Eocene	Outside
177	0.422	Terrigenous clastics	Pliocene	Outside
178	0.444	Non graded quaternary	Quaternary	Inside
179	0.470	Volcanites and sedimentary rocks	Upper Cretaceous	Outside

Table B.2. (cont'd)

No	PGA 2475 (g)	Geological Formation	Geological Age	Seismic Gap
180	0.421	Granitoid	Paleocene - Eocene	Outside
181	0.635	Terrigenous clastics	Miocene	Outside
182	0.410	Clastics	Oligocene - Lower Miocene	Outside
183	0.410	Clastics	Oligocene - Lower Miocene	Outside
184	0.420	Non graded quaternary	Quaternary	Outside
185	0.411	Terrigenous clastics	Miocene	Outside
186	0.409	Clastics	Oligocene - Lower Miocene	Outside
187	0.665	Terrigenous clastics	Miocene	Outside
188	0.665	Terrigenous clastics	Miocene	Outside
189	0.725	Clastics	Oligocene - Lower Miocene	Outside
190	0.420	Non graded quaternary	Quaternary	Outside
191	0.478	Non graded quaternary	Quaternary	Outside
192	0.369	Terrigenous clastics	Upper Miocene	Outside
193	0.658	Terrigenous clastics	Miocene	Inside
194	0.659	Clastics and carbonates	Miocene	Inside

Table B.2. (cont'd)

No	PGA 2475 (g)	Geological Formation	Geological Age	Seismic Gap
195	0.638	Flysch	Permo - Carboniferous	Inside
196	0.657	Clastics and carbonates	Miocene	Inside
197	0.633	Flysch	Permo - Carboniferous	Inside
198	0.671	Terrigenous clastics	Miocene	Inside
199	0.659	Clastics and carbonates	Miocene	Inside
200	0.655	Flysch	Permo - Carboniferous	Inside
201	0.671	Terrigenous clastics	Miocene	Inside
202	0.593	Flysch	Permo - Carboniferous	Inside
203	0.581	Flysch	Permo - Carboniferous	Inside
204	0.662	Clastics and carbonates	Miocene	Inside
205	0.643	Flysch	Permo - Carboniferous	Inside
206	0.615	Flysch	Permo - Carboniferous	Inside
207	0.587	Flysch	Permo - Carboniferous	Inside
208	0.673	Terrigenous clastics	Miocene	Inside
209	0.556	Flysch	Permo - Carboniferous	Inside

Table B.2. (cont'd)

No	PGA 2475 (g)	Geological Formation	Geological Age	Seismic Gap
210	0.652	Flysch	Permo - Carboniferous	Inside
211	0.514	Clastics and carbonates	Upper Devonian - Lower Carboniferous	Inside
212	0.579	Flysch	Permo - Carboniferous	Inside
213	0.742	Non graded quaternary	Quaternary	Inside
214	0.539	Clastics and carbonates	Upper Devonian - Lower Carboniferous	Inside
215	0.580	Flysch	Permo - Carboniferous	Inside
216	0.633	Flysch	Permo - Carboniferous	Inside
217	0.632	Flysch	Permo - Carboniferous	Inside
218	0.632	Flysch	Permo - Carboniferous	Inside
219	0.606	Flysch	Permo - Carboniferous	Inside
220	0.663	Clastics and carbonates	Miocene	Inside
221	0.660	Clastics and carbonates	Miocene	Inside
222	0.729	Non graded quaternary	Quaternary	Inside
223	0.630	Flysch	Permo - Carboniferous	Inside
224	0.584	Flysch	Permo - Carboniferous	Inside

Table B.2. (cont'd)

No	PGA 2475 (g)	Geological Formation	Geological Age	Seismic Gap
225	0.636	Flysch	Permo - Carboniferous	Inside
226	0.631	Flysch	Permo - Carboniferous	Inside
227	0.656	Flysch	Permo - Carboniferous	Inside
228	0.653	Flysch	Permo - Carboniferous	Inside
229	0.616	Flysch	Permo - Carboniferous	Inside
230	0.655	Flysch	Permo - Carboniferous	Inside
231	0.513	Clastics and carbonates	Upper Devonian - Lower Carboniferous	Inside
232	0.659	Clastics and carbonates	Miocene	Inside
233	0.700	Non graded quaternary	Quaternary	Outside
234	0.660	Gneiss	Precambrian and/or Paleozoic	Outside
235	0.668	Non graded quaternary	Quaternary	Outside
236	0.662	Non graded quaternary	Quaternary	Outside
237	0.668	Non graded quaternary	Quaternary	Outside
238	0.709	Non graded quaternary	Quaternary	Outside

Table B.2. (cont'd)

No	PGA 2475 (g)	Geological Formation	Geological Age	Seismic Gap
239	0.672	Non graded quaternary	Quaternary	Outside
240	0.893	Non graded volcanites	Eocene	Inside
241	1.057	Non graded quaternary	Quaternary	Inside
242	1.051	Clastics and carbonates	Upper Paleocene - Eocene	Outside
243	1.145	Non graded quaternary	Quaternary	Outside
244	0.935	Clastics	Oligocene - Lower Miocene	Outside
245	1.145	Non graded quaternary	Quaternary	Outside
246	1.146	Non graded quaternary	Quaternary	Outside
247	1.148	Non graded quaternary	Quaternary	Outside
248	0.419	Clastics, carbonates in places	Cretaceous	Outside
249	0.460	Clastics and carbonates	Jura	Outside
250	1.166	Terrigenous clastics	Pliocene	Outside

C. Decision Matrix in Implementation of TOPSIS Method

The decision matrix in implementation of TOPSIS method is tabulated in Table C.1.

Table C.1. Decision matrix in implementation of TOPSIS method

Alternatives/Criteria	C1	C2	C3	C4	C5	C6	C7	C8
1	3	7	4	0	3	9	4	0
2	3	7	7	0	3	9	4	0
3	5	7	7	0	3	9	4	0
4	7	4	10	0	3	9	6	0
5	3	4	4	0	3	9	6	0
6	5	1	1	1	7	9	6	0
7	3	8	8	0	3	9	4	0
8	3	5	4	0	3	9	4	0
9	3	3	1	1	3	9	4	0
10	3	2	7	0	7	9	2	0
11	3	2	7	0	10	9	2	0
12	3	4	7	0	3	9	6	0
13	4	1	10	0	7	9	4	0
14	2	1	1	1	3	9	2	0
15	5	3	5	0	3	9	4	0
16	3	2	5	0	7	9	4	0
17	3	2	8	0	10	9	4	0
18	3	7	8	0	3	9	8	0
19	3	4	4	0	3	9	6	1
20	3	7	8	0	10	9	4	1
21	3	6	8	0	3	9	6	1

Table C.1. (cont'd)

Alternatives/Criteria	C1	C2	C3	C4	C5	C6	C7	C8
22	3	6	8	0	3	9	6	1
23	3	2	7	0	3	9	6	1
24	8	3	4	0	3	9	6	1
25	3	5	4	0	3	9	6	1
26	2	2	7	0	3	9	6	1
27	6	7	8	0	3	9	6	0
28	2	4	8	0	3	9	2	0
29	3	4	4	0	3	9	6	0
30	3	2	7	0	3	9	6	0
31	3	7	4	0	3	9	4	0
32	3	2	8	0	3	9	6	0
33	3	2	7	0	3	9	4	0
34	3	1	5	0	7	9	10	1
35	3	2	1	1	3	9	8	1
36	5	8	8	0	3	9	6	0
37	3	10	1	1	3	9	4	0
38	3	2	10	0	3	9	6	0
39	3	5	8	0	3	9	4	0
40	2	2	7	0	7	9	8	1
41	3	7	7	0	7	9	8	1
42	3	8	1	1	3	9	4	1
43	3	8	8	0	3	9	4	0
44	3	3	8	0	3	9	4	0
45	3	7	7	0	3	9	4	0
46	3	5	8	0	3	9	6	0
47	2	2	1	1	10	9	4	0
48	3	2	7	0	7	9	2	0
49	3	2	1	0	3	9	2	0

Table C.1. (cont'd)

Alternatives/Criteria	C1	C2	C3	C4	C5	C6	C7	C8
50	3	5	8	0	3	9	2	0
51	3	5	7	0	3	9	2	0
52	3	4	5	0	3	9	2	0
53	3	8	8	0	3	9	2	0
54	5	2	8	0	3	9	2	0
55	5	2	10	0	3	9	2	0
56	3	2	10	0	3	9	2	0
57	3	2	10	0	3	9	2	0
58	3	3	7	0	10	9	4	0
59	3	1	10	0	3	9	4	0
60	3	8	7	0	10	9	4	0
61	3	7	1	1	3	9	6	0
62	3	6	1	1	3	9	4	0
63	3	5	1	1	3	9	4	0
64	3	3	7	0	3	9	4	1
65	5	2	7	0	7	9	8	0
66	3	2	5	0	7	9	8	0
67	3	1	5	0	7	9	8	0
68	3	5	8	0	3	9	8	0
69	3	1	1	0	3	9	8	0
70	3	2	4	0	3	9	8	0
71	3	4	4	0	3	9	8	0
72	6	4	8	0	3	9	10	0
73	5	6	1	1	3	9	10	0
74	6	6	8	0	3	9	8	0
75	3	8	7	0	3	9	6	1
76	3	2	5	0	3	9	6	1
77	2	6	8	0	3	9	6	1

Table C.1. (cont'd)

Alternatives/Criteria	C1	C2	C3	C4	C5	C6	C7	C8
78	3	2	4	0	3	9	8	0
79	3	7	8	0	3	9	6	0
80	3	5	8	0	3	9	8	0
81	3	7	8	0	3	9	8	0
82	5	6	8	0	3	9	8	0
83	3	7	4	0	3	9	8	0
84	1	3	8	0	3	9	6	0
85	3	2	4	0	3	9	4	0
86	1	3	7	0	10	9	6	0
87	3	7	8	0	3	9	6	0
88	3	6	7	0	3	9	6	0
89	3	1	10	0	3	9	6	0
90	3	1	8	0	3	9	6	0
91	3	2	1	1	7	9	6	0
92	3	1	8	0	7	9	6	0
93	3	7	7	0	3	9	6	0
94	3	2	8	0	7	9	6	0
95	5	2	7	0	3	9	6	0
96	5	2	8	0	3	9	6	0
97	3	2	8	0	3	9	2	1
98	3	7	8	0	3	9	2	1
99	9	1	7	0	3	9	4	0
100	3	3	5	0	3	9	4	0
101	3	2	8	0	3	9	4	1
102	3	8	7	0	3	9	2	0
103	3	2	8	0	3	9	2	0
104	5	5	4	0	3	9	2	0
105	3	10	8	0	3	9	2	0

Table C.1. (cont'd)

Alternatives/Criteria	C1	C2	C3	C4	C5	C6	C7	C8
106	10	2	7	0	3	9	1	0
107	3	10	7	0	3	9	1	0
108	3	5	7	0	3	9	1	0
109	3	8	8	0	3	9	1	0
110	3	2	10	0	3	9	1	0
111	3	7	8	0	3	9	1	0
112	3	8	8	0	3	9	4	0
113	6	7	7	0	3	9	4	0
114	8	3	4	0	3	9	6	0
115	3	2	7	0	3	9	4	0
116	3	7	7	0	3	9	2	0
117	3	7	8	0	7	9	2	0
118	3	7	8	0	3	9	2	0
119	3	8	8	0	3	9	2	0
120	3	7	7	0	3	9	2	0
121	6	2	10	0	7	9	2	0
122	5	6	7	0	10	9	2	0
123	3	1	7	0	7	9	2	0
124	3	1	7	0	7	9	2	0
125	3	7	8	0	3	9	4	0
126	3	7	7	0	3	9	2	0
127	3	7	8	0	3	9	1	0
128	3	1	10	0	3	7	2	0
129	3	1	5	0	3	7	2	0
130	3	2	10	0	3	7	2	0
131	3	7	8	0	3	9	2	0
132	3	7	8	0	3	9	2	0
133	3	2	8	0	3	9	2	0

Table C.1. (cont'd)

Alternatives/Criteria	C1	C2	C3	C4	C5	C6	C7	C8
134	3	5	8	0	3	9	2	0
135	3	7	1	0	3	9	2	0
136	3	3	8	0	3	9	1	0
137	3	2	7	0	7	9	2	0
138	3	2	7	0	3	9	1	0
139	3	2	7	0	10	9	4	0
140	3	1	10	1	3	9	4	0
141	3	5	8	0	3	9	4	0
142	3	7	4	0	3	9	4	0
143	3	7	7	0	3	9	2	0
144	3	2	7	0	7	9	2	0
145	3	7	7	0	3	9	2	0
146	3	8	8	0	3	9	2	0
147	3	7	4	0	3	9	2	0
148	3	5	5	0	3	9	2	0
149	3	5	8	0	3	9	2	0
150	3	1	10	0	3	9	2	0
151	2	2	10	0	3	9	2	0
152	3	2	10	0	3	9	4	0
153	3	1	4	0	3	9	10	0
154	3	4	4	0	3	9	4	0
155	3	4	8	0	3	9	4	0
156	5	9	7	0	3	9	4	0
157	3	2	10	0	3	9	4	0
158	3	2	10	0	3	9	4	0
159	3	2	5	0	3	9	4	0
160	3	1	4	0	3	9	2	0
161	4	7	7	0	3	9	2	0

Table C.1. (cont'd)

Alternatives/Criteria	C1	C2	C3	C4	C5	C6	C7	C8
162	6	1	7	0	3	9	4	0
163	1	1	7	0	3	9	4	0
164	1	2	7	0	3	9	2	0
165	3	6	7	0	7	9	6	0
166	3	7	8	0	3	9	6	0
167	3	7	8	1	3	9	6	0
168	3	7	8	0	3	9	4	0
169	3	1	5	0	3	9	4	0
170	3	7	7	1	3	9	4	0
171	3	2	7	0	3	9	2	0
172	3	2	8	0	3	9	2	0
173	3	3	8	0	3	9	2	0
174	3	2	7	0	3	9	2	0
175	3	2	5	0	3	9	2	0
176	3	2	1	1	3	9	4	0
177	3	1	7	0	3	9	4	0
178	3	5	8	0	3	9	4	1
179	3	2	8	0	3	9	4	0
180	3	7	8	0	3	9	4	0
181	2	3	7	0	3	9	6	0
182	5	6	4	0	3	9	4	0
183	3	5	8	0	10	9	4	0
184	3	1	8	0	7	9	4	0
185	3	6	8	0	7	9	4	0
186	5	2	8	0	3	9	4	0
187	3	5	8	0	3	9	6	0
188	2	2	7	0	3	9	6	0
189	3	4	5	0	3	9	6	0

Table C.1. (cont'd)

Alternatives/Criteria	C1	C2	C3	C4	C5	C6	C7	C8
190	3	5	8	0	3	9	4	0
191	3	5	8	0	3	9	4	0
192	3	7	8	0	3	9	2	0
193	3	1	4	0	3	9	6	1
194	5	1	4	0	3	9	6	1
195	5	2	4	0	3	9	6	1
196	6	2	4	1	3	9	6	1
197	6	2	4	0	3	9	6	1
198	5	5	4	1	3	9	6	1
199	5	2	4	0	3	9	6	1
200	5	1	4	1	3	9	6	1
201	6	2	4	1	3	9	6	1
202	5	2	7	0	7	9	4	1
203	1	1	7	0	7	9	4	1
204	5	4	7	0	7	9	6	1
205	3	1	10	0	10	9	6	1
206	5	2	10	0	10	9	6	1
207	3	2	7	0	10	9	4	1
208	6	1	7	0	7	9	6	1
209	5	2	8	0	3	9	4	1
210	3	2	4	0	3	9	6	1
211	5	2	7	0	3	7	4	1
212	3	1	5	0	3	9	4	1
213	3	5	4	0	3	9	6	1
214	5	3	7	0	7	9	4	1
215	5	2	7	0	7	9	4	1
216	5	3	8	0	3	9	6	1
217	5	2	10	0	7	9	6	1

Table C.1. (cont'd)

Alternatives/Criteria	C1	C2	C3	C4	C5	C6	C7	C8
218	2	6	7	0	3	9	6	1
219	3	2	5	0	7	9	6	1
220	5	9	7	0	10	9	6	1
221	5	6	7	0	7	9	6	1
222	3	1	1	1	3	7	6	1
223	5	2	7	0	7	9	6	1
224	5	2	8	0	7	9	4	1
225	3	7	5	0	10	9	6	1
226	3	2	8	0	3	9	6	1
227	5	2	5	0	7	9	6	1
228	3	4	7	0	7	9	6	1
229	5	2	7	1	3	9	6	1
230	3	2	7	0	3	9	6	1
231	6	2	7	0	3	7	4	1
232	5	1	4	0	3	9	6	1
233	5	7	4	0	3	9	6	0
234	5	2	7	0	3	9	6	0
235	3	6	8	0	7	9	6	0
236	6	6	8	0	3	9	6	0
237	3	6	4	0	7	9	6	0
238	3	9	8	0	10	9	6	0
239	3	1	5	0	3	9	6	0
240	1	1	7	0	7	9	8	1
241	1	1	7	0	7	9	10	1
242	1	2	7	0	10	7	10	0
243	3	2	7	0	7	9	10	0
244	3	5	8	0	3	9	8	0
245	3	5	8	0	3	9	10	0

Table C.1. (cont'd)

Alternatives/Criteria	C1	C2	C3	C4	C5	C6	C7	C8
246	3	1	5	0	3	9	10	0
247	3	1	7	0	3	9	10	0
248	3	7	7	0	3	7	4	0
249	2	1	5	0	3	7	4	0
250	3	2	8	0	3	9	10	0