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A New Approximate Method for Earthquake Behaviour of Worship Buildings

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Abstract

Turkey is in seismically active region, so many earthquakes occur in this country in the last decades. Ancient worship buildings are vulnerable to seismic activity, as many historical buildings. So, it is important to understand that building's behavior under seismic actions. In this paper, fifteen masonry worship building has been selected which are located and built-in different region in Antalya. The main reason for the paper is to assess the seismic vulnerability of worship building by using a new approximate method. The method which is proposed in this paper aims at a simple and fast procedure based on a simplified geometric approach for immediate screening of masonry buildings at risk.

Keywords: Worship Buildings; Seismic Risk Assessment; Simplified Approximate Method.

1. Introduction

Historical structures have a very important role to carry cultural inherit of the country and they are one of the most valuable pieces of cultural accumulation [1]. There are many historical buildings, religious monuments and ruins of our ancestors [2]. Many historical buildings are quite vulnerable because they were built with low resistance materials. However, these buildings have insufficient connections between the various construction parts; masonry walls, floors, etc. [3]. These problems of historical masonry buildings lead to an overturning collapse of the perimeter walls under seismic horizontal acceleration. For this reason, seismic vulnerability assessments are very important and essential to care for historic masonry structures [4].

Turkey is located on one of the most active several tectonic plates that name is he Alpine–Himalayan earthquake belt. This plate is still active, and many earthquakes occur each month. The city center of Antalya, lying in the second seismic zone of Turkey. When the province is considered in general, the western part of Antalya located in the 1st and 2nd-degree seismic zone, the eastern part of located within the 3rd and 4th-degree seismic zone [5-6]. Antalya is the fifth biggest city in Turkey according to the population. The population of Antalya is approximately 1.2 million. Besides, Antalya is the first rank according to the population growth rate in Turkey. So it is very important to know seismicity of Antalya [7, 8]. Turkey Earthquake Regions Map and Seismic zones map of Antalya is shown in Figure 1.

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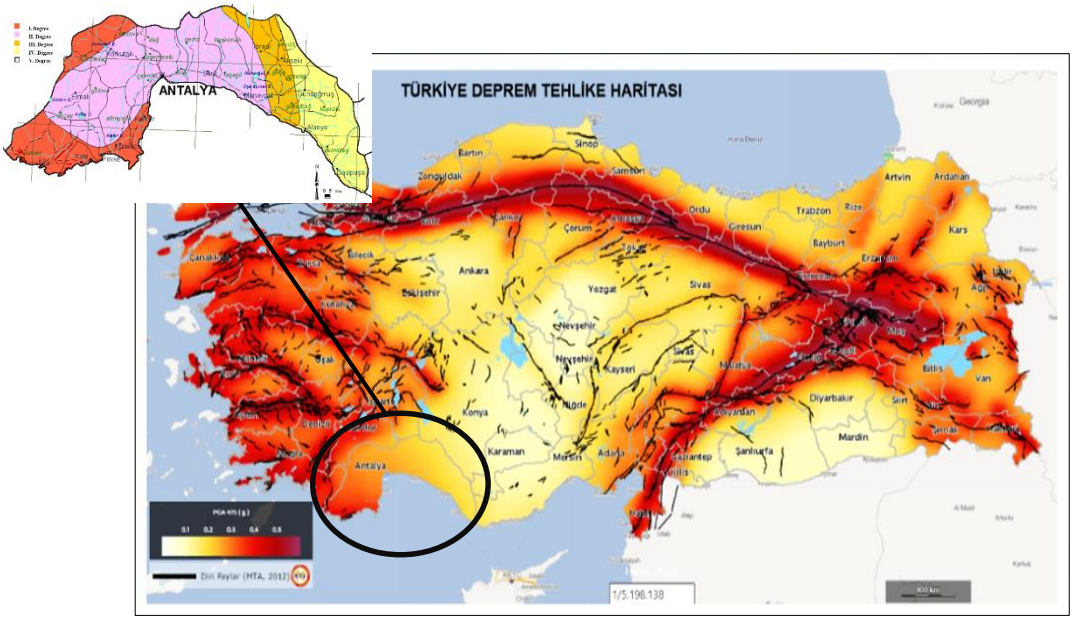

Figure 1. Turkey Earthquake Regions Map and Seismic zones map of Antalya [9]

The approach followed by Lourenço et al. (2013) [10] suggested here is simple and fast being based on a simplified geometric approach for immediate screening of a large number of historical buildings at seismic risk. The aim of the approximate method is to evaluate historical buildings at possible seismic risk, using structural characterization and screening of a large number of historical worship buildings under risk, immediately. The approximate method is applied for historical worship buildings in Antalya, providing lower bound formulas for 10 different simplified geometrical indexes. In this paper, six worship buildings from Antalya have been selected and analyzed considering ten indexes of the approximate method.

2. Approximate Method of Worship Buildings

The approximate method, which is based on the study of Lourenço and Roque (2006), proposed in aims at much more fast and simple procedure for immediate screening of the worship buildings [11]. The analysis and preservation of historical worship buildings are complex phenomena which include many studies. Because of lack of various information such as geometry data and formation about the inner core of the structural elements, existing damage, regulations, and codes about masonry buildings. Moreover, materials that are used in the construction of masonry buildings, that exhibit large variability due to workmanship and that use of natural materials. Therefore, more reliable and better results achieved are not related to more complex and accurate methods [4, 12, 13].

This approximate method is based on a simplified analysis of the structural characteristics of the worship buildings. Each building is inspected individually by its geometry and data is collected which can use for analysis. The usage of the approximate method usually requires that the worship building is regular and symmetric, that the floors act as rigid diaphragms, and that the dominant collapse mode is an in-plane shear failure of the walls. Generally, these last two conditions are not verified by ancient masonry structures [4]. The proposed method consists of ten parameters, and every index has a limit value. Besides ten parameters, defined a total parameter value in this proposed method. Parameters of the approximate method are given below.

- **Parameter 1 (γ_1)- In-plan area ratio**

This parameter relates to (being associated with) the area of the earthquake-resistant walls in each main direction (transversal y and longitudinal x, with respect to the central axis of the worship building) and the total in-plan area of the building. Parameter 1 is non-dimensional and the simplest one among the other parameters. The formula of the first parameter, (γ_1), is as follows:

$$\gamma_1 . i = \frac{\left(\frac{Awi}{S}\right)}{0} / 0.1 \quad (1)$$

Where A_{wi} is the in-plan area of earthquake-resistant walls in direction "i" and S is the total in-plan area of the building.

- **Parameter 2 (γ_2)- Area to weight ratio**

This parameter is defined as the ratio between the in-plan area of earthquake-resistant walls in each main direction (again, Y and X) and the total weight of the construction. The formula of the second parameter, (γ_2), is as follows:

$$\gamma_2.i = \left(\frac{Awi}{G}\right)/3.25 \quad (2)$$

Where Awi is the in-plan area of earthquake-resistant walls in direction "i" and G is the quasi-permanent vertical action.

- **Parameter 3 (γ_3)- Base shear ratio**

The total design base shear for rigid structures in a given direction shall be determined from the formula is as follows:

$$F_E = V_{sdbase} = 0.5ZIW \quad (3)$$

Where Z is the seismic zone for the building site, I is structure importance coefficient, w is the total seismic dead load.

The total base shear for seismic loading (VSd, base = FE) can be obtained from an analysis with horizontal static loading equivalent to the seismic action (FE = βG), where β is an equivalent seismic static coefficient related to the peak ground acceleration. The shear strength of the structure (VRd, base = FRd) can be obtained from the contribution of all earthquake-resistant walls FRd,i = Σ Awi fvk, fvk = fvk0 + 0.4σd. Here, fvk0 is the cohesion, which can be assumed equal to a low value or zero in the absence of more information, σd is the design value of the normal stress, and 0.4 describes the tangent of a constant friction angle φ, equal to 22º.

The index, γ_3, is as follows:

$$\gamma_3.i = \left(\frac{FRd.i}{FE}\right) \quad (5)$$

If a zero cohesion is assumed (fvk0 = 0), γ_3,i is as follows:

$$\gamma_3.i = \left(\frac{VRdi}{VSd}\right) = \left(\frac{Awi}{Aw} \times \frac{tan\theta}{\beta}\right) \quad (6)$$

For a non-zero cohesion, which is most relevant for low height buildings, γ_3,i is as follows:

$$\gamma_3.\mathrm{i} = \frac{\mathrm{VRdi}}{\mathrm{VSd}} = \frac{\mathrm{Awi}}{\mathrm{Aw}} \times \left[\tan\theta + \frac{\mathrm{fvk0}}{(\gamma \mathrm{Xh})}\right]/\beta \quad (7)$$

Where Awi is the in-plan area of earthquake-resistant walls in direction "i," Aw is the total in-plan area of earthquake-resistant walls, h is the (average) height of the building, γ is the volumetric masonry weight, φ is the friction angle of masonry walls, and β is an equivalent static seismic coefficient.

Here, it is assumed that the normal stress in the walls is only due to their self-weight, i.e. σd = γ × h, which is on the safe side and is a very reasonable approximation for historical masonry buildings, usually made of very thick walls. Here, it was assumed that all the masonry materials were similar, the volumetric weight of masonry was 20 kN/m^3.

- **Parameter 4 (γ_4)- Slenderness ratio of columns**

Parameter 4 is related to the geometric ratio of columns and main wall. γ_4,i is as follows:

$$\gamma_4 = \left(\frac{hcol}{\left(\frac{I}{A}\right)^{1/2}}\right)/70 \quad (8)$$

Where h_{col} is the free height of the columns, I and A are the inertia and the cross-section area of the columns.

- **Parameter 5 (γ_5)- Thickness to height ratio of columns**

Parameter 5 is related to Thickness to height ratio of columns. γ_5,i presented:

$$\gamma_5 = \left(\frac{dcol}{hcol}\right)/0.05 \quad or \quad \gamma 5 = \left(\frac{tcol}{hcol}\right)/0.05 \quad (9)$$

Where d_{col} and t_{col} are the (equivalent) diameter and thickness of the columns, respectively.

- **Parameter 6 (γ_6)- Thickness to height ratio of perimeter walls**

Parameter 6 is related to Thickness to height ratio of perimeter walls. γ_6,i is as follows:

$$\gamma_6 = \left(\frac{twall}{hwall}\right)/0.02 \quad (10)$$

Where t_{wall} and h_{wall} are the thickness and the (average) height of the perimeter walls, respectively.

- **Parameter 7 (γ_7)- dome area to structure area**

Parameter 7 is related to the dome area to structure area. γ_7,i is as follows:

$$\gamma_7 = \left(\frac{Ka}{S}\right)/0.03 \quad (11)$$

Where K_a is an area of dome, S is an area of worship building.

- **Parameter 8 (γ_8)- Dome diameter to dome height**

Parameter 8 is related to dome diameter to dome height. γ_8,i is as follows:

$$\gamma_8 = \left(\frac{kc}{hk}\right)/1.3 \quad (12)$$

Where K_c is the diameter of the dome, h_k is height of dome.

- **Parameter 9 (γ_9)- Cavity wall area to full wall area**

Parameter 9 is related to Cavity wall area to full wall area. γ_9,i is as follows:

$$\gamma_9 = \left(\frac{Awi}{Awidolu}\right)/1.65 \quad (13)$$

Where A_{wi} is the in-plan area of earthquake-resistant walls in direction, $A_{wi,full}$ is the in-plan area of earthquake-resistant cavity walls in direction

- **Parameter 10 (γ_{10})- The ratio of external load base shear force capacity building (dynamic analysis)**

Parameter 10 is related to the ratio of external load base shear force capacity building (dynamic analysis). γ_{10},i is as follows:

$$\gamma_{10} = \left(\frac{Vrd}{Vsd}\right)/1.2 \quad (14)$$

Where $VS_{d,\,base}$ (F_E) is the total base shear for seismic loading, $VR_{d,\,base}$ (F_{Rd}) is the shear strength of the structure.

- **Total Parameter**

The total parameter is used in determining whether historical building risky or not. Total parameter is as follows:

$$\sum \text{parametre2} = \frac{\gamma_1}{0.1} + \frac{\gamma_2}{3.25} + \frac{\gamma_3}{1.0} + \frac{\gamma_7}{0.03} + \frac{\gamma_8}{1.3} + \frac{\gamma_{10}}{1.2} \quad (15)$$

Where γ_1 is parameter 1, γ_2 is parameter 2, γ_3 is parameter 3, γ_7 is parameter 7, γ_8 is parameter 8, γ_{10} is parameter 10.

According to the total parameter formulate, which are given above, was used to calculate the risk levels of the worship building. The risk levels are classified as “no risk” and “risk”.

3. Worship Buildings in Antalya, Turkey

In this paper, six historical worship buildings have been selected which are located in Antalya. The worship buildings were explained below.

3.1. Suleymaniye Mosque

The Suleymaniye Mosque is located in Alanya, Antalya. The mosque is also called as Alâeddin, Alaüddin, Kale, Orta Hisar, and Sultan Suleyman Mosque. The mosque had been restored by the General Directorate of Foundations in 1960, 1964, 1973 and 1989. Suleymaniye Mosque consists of octagonal platform and has one main dome. There is a minaret on the northwest corner of the mosque and a five-eyed last community place on the north [14]. Photo and plan of Suleymaniye Mosque shown in Figure 2.

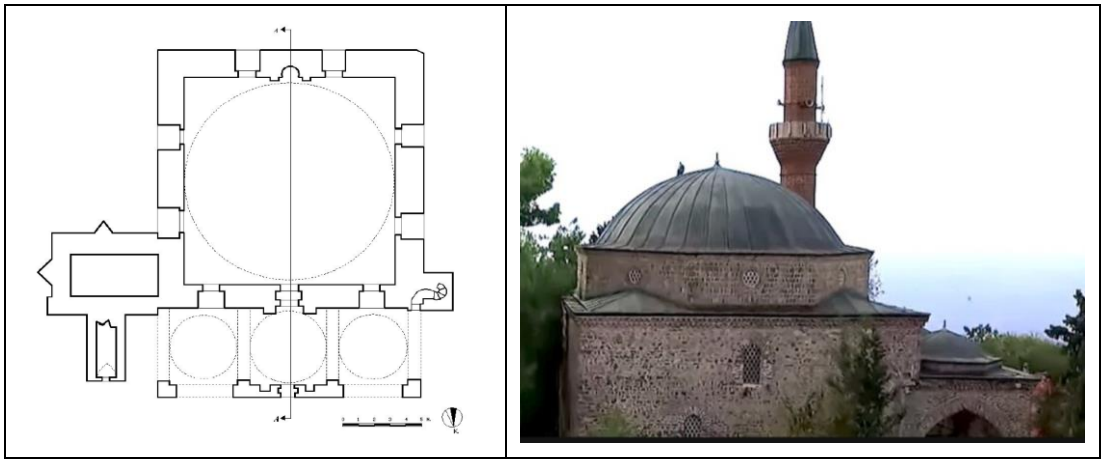

Figure 2. Photo and plan of Suleymaniye Mosque

3.2. Bali Bey Mosque

Bali Bey Mosque located in Muratpasa, Antalya. The Mosque is constructed by Bali Bey according to some resources, but the construction date of the mosque is unknown. The mosque had been restored by the General Directorate of Foundations in 1905, 1963 and 1980. Bali Bey mosque has a rectangular plan, which is close to square, covered with a single dome. And there is the last community room that extending along the northern frontier of mosque. Photo and plan of Bali Bey Mosque shown in Figure 3.

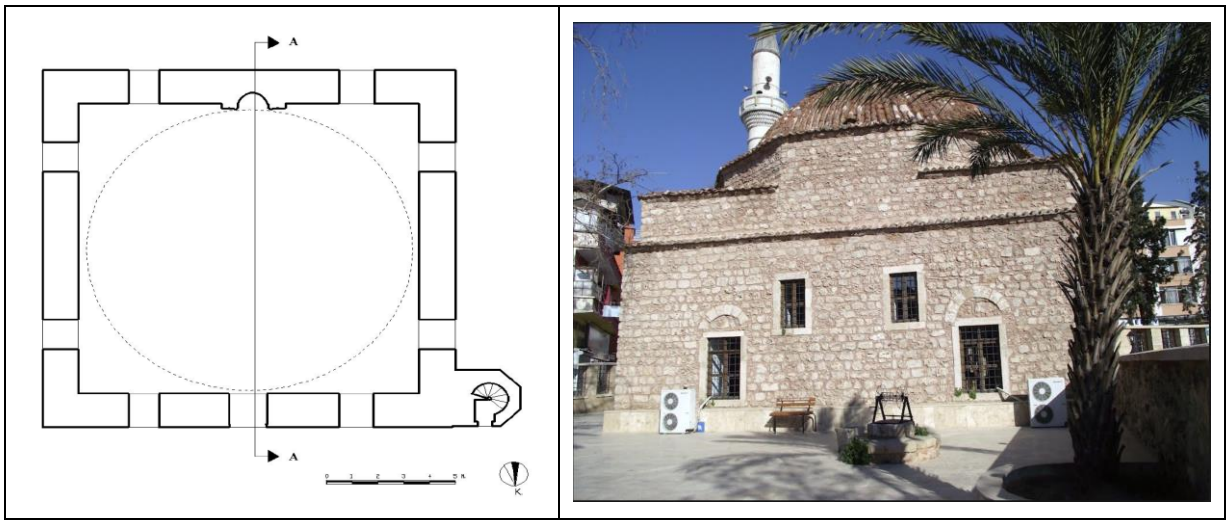

Figure 3. Photo and plan of Bali Bey Mosque

3.3. Murat Pasha Mosque

Murat Pasha Mosque located in Muratpasa, Antalya. Although it was built in the Ottoman period in 1570, the mosque also has Seljuk calligraphy art traces. According to the inscription the mosque constructed by Murat Pasha. The mosque has a rectangular plan, which is close to square, covered with a single dome. Murat Pasha mosque located in a spacious courtyard and courtyard dimensions is 95×98 m. Photo and plan of Murat Pasha Mosque shown in Figure 4.

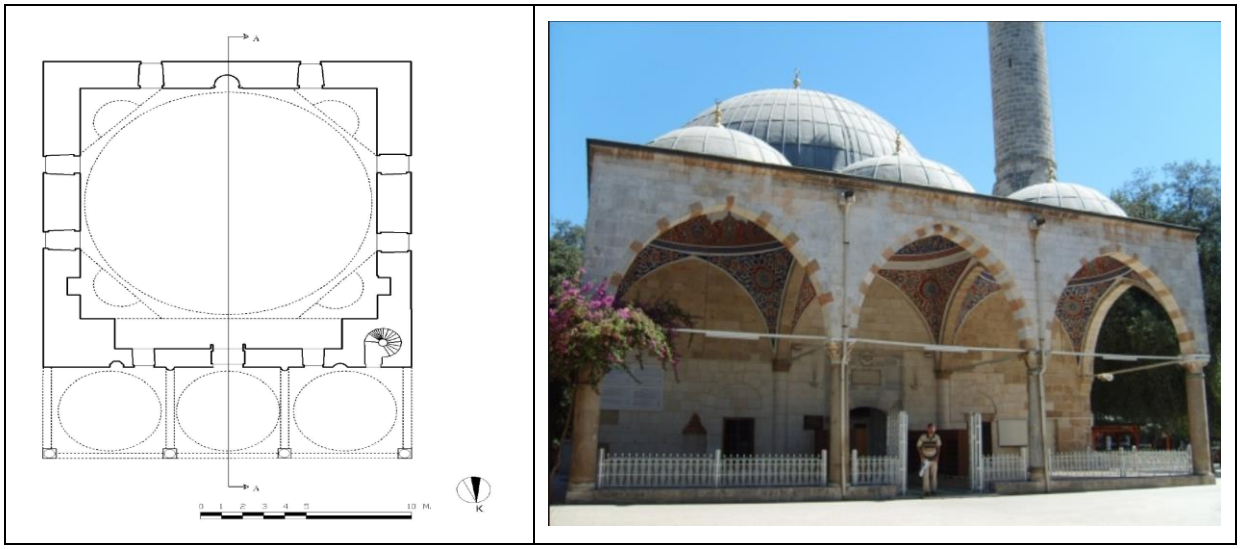

Figure 4. Photo and plan of Murat Pasha Mosque

3.4. Tekeli Mehmet Pasha Mosque

The Tekeli Mehmet Paşa Mosque is a mosque in the city of Antalya, Turkey. Mosque takes its name from Lala Mehmed Pasa. The mosque is constructed in the 18th century in the Kalekapisi district, the mosque is one of the most important Ottoman mosques in the city. Today, the architecture of the mosque, called "Tekeli Mehmet Pasha", "Mehmet Pasha", "Tekeli Pasha", and the construction date are unknown. Photo and plan of Tekeli Mehmet Pasha Mosque shown in Figure 5.

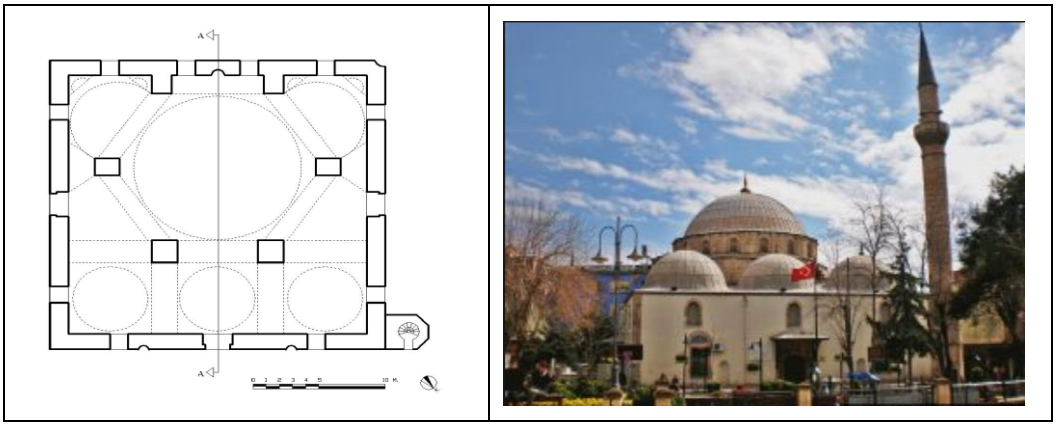

Figure 5. Photo and plan of Tekeli Mehmet Pasha Mosque

3.5. Omer Pasha Mosque

Omer Pasha Mosque was constructed by Ketendji Omer Pasha in 1602. The mosque is located in Elmalı, Antalya Province, Turkey. It reflects the classical Ottoman architecture. The mosque is the biggest Ottoman mosque in the Antalya area. The mosque has a square plan and covered with a central dome. A five-eyed congregation, a fountain, and a madrasah is located the north of the mosque. In the northwest corner, the minaret, which is built adjacent to the harim wall, rises. Photo and plan of Omer Pasha Mosque shown in Figure 6.

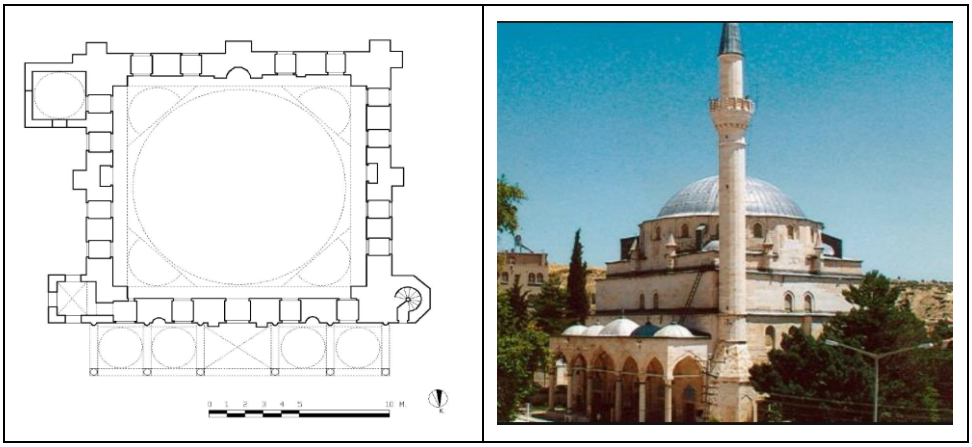

Figure 6. Photo and plan of Omer Pasha Mosque

3.6. Nasreddin Mosque

Nasreddin mosque is 22 km from the Kas accident of Antalya province. It is located in the village of Kasaba. According to the mosque inscription; the mosque was constructed in 1776 by Yusuf aga. The mosque has a square plan and is covered with a single dome. The mosque has a three-eyed congregation in the north and a minaret in the north-western part. Photo and plan of Nasreddin Mosque shown in Figure 6.

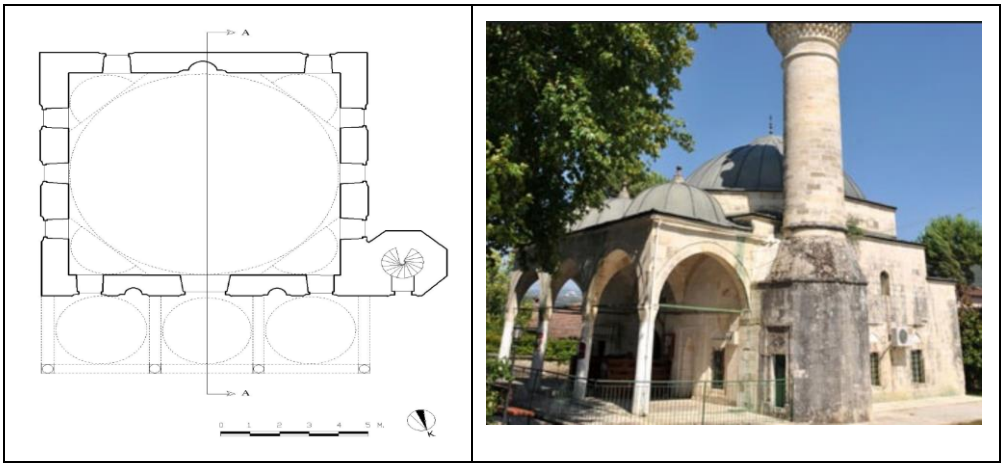

Figure 7. Photo and plan of Nasreddin Mosque

3.7. Musellim Mosque

Musellim mosque, located in Kısla, Antalya, is also known as Teklioglu mosque. According to the mosque inscription the mosque was built in 1796 by Mehmet Aga. Musellim mosque has a square plan and is covered with a single dome. The mosque was restored by the General Directorate of Foundations in 1952, 1955, 1985, 1989 and 1991. Photo and plan of Musellim Mosque shown in Figure 7.

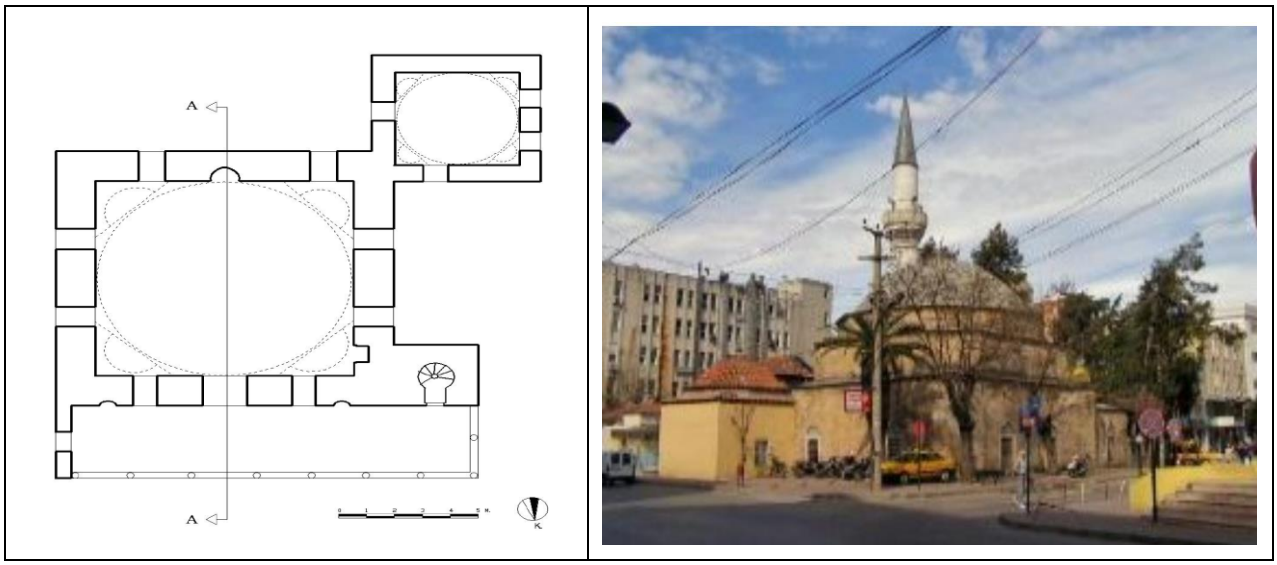

Figure 8. Photo and plan of Musellim Mosque

3.8. Agalar Onu Mosque

Agalar Onu mosque is located in Aksu, Antalya. According to the mosque inscription; the mosque was constructed in 1776 by Yusuf aga. The mosque has a square plan and is covered with a single dome. The mosque, which is functioning today, was restored by the General Directorate of Foundations in 2011. Photo and plan of Agalar Onu Mosque shown in Figure 8.

Figure 9. Photo and plan of AgalarOnu Mosque

3.9. Haskoy Mosque

The mosque is located in Haskoy, 12 km from the Finike district of Antalya. The construction date and are unknown. There is no information about the construction date and architect of mosque. The mosque has a square plan covered with a central dome, which sits on an octagonal pulley. The mosque, which is now closed for worship, was restored in 1983 by the General Directorate of Foundations. Photo and plan of Haskoy Mosque shown in Figure 9.

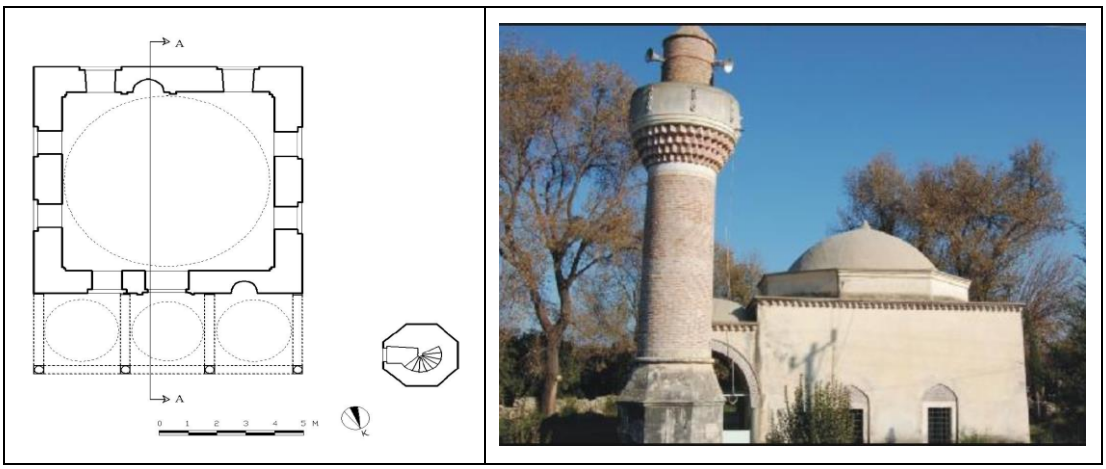

Figure 10. Photo and plan of Haskoy Mosque

3.10. Takkaci Mustafa Mosque

The mosque is located in Muratpaşa, Antalya. There is no exactly information about the construction date and architect of mosque. The mosque has a square plan covered with a central dome, which sits on an octagonal pulley. Photo and plan of Takkaci Mustafa Mosque shown in Figure 10.

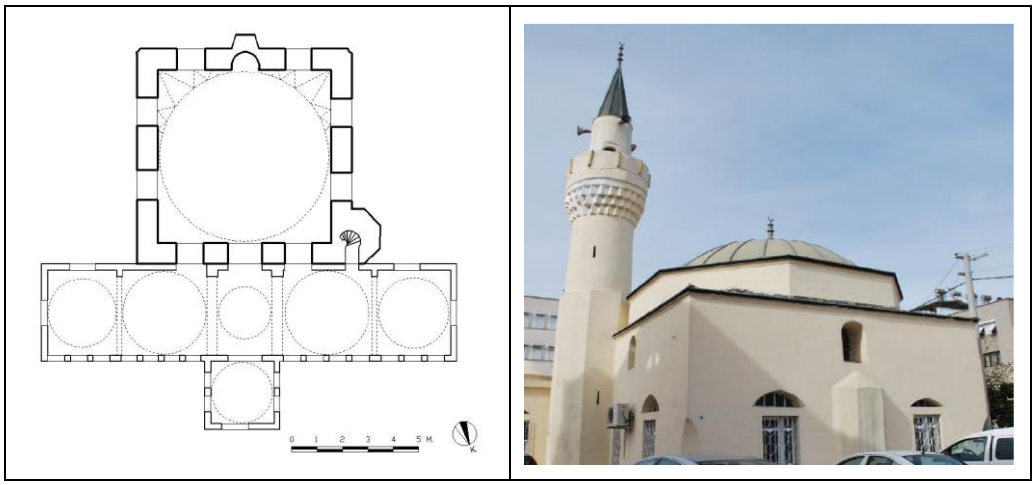

Figure 11. Photo and plan of Takkaci Mustafa Mosque

3.11. Haci Hasan Mosque

The mosque is located in Serik, Antalya. According to the mosque inscription; the mosque was constructed in 1820 by Hacı Hasan Ağa. The mosque has a square plan and main single dome. Photo and plan of Haci Hasan Mosque shown in Figure 11.

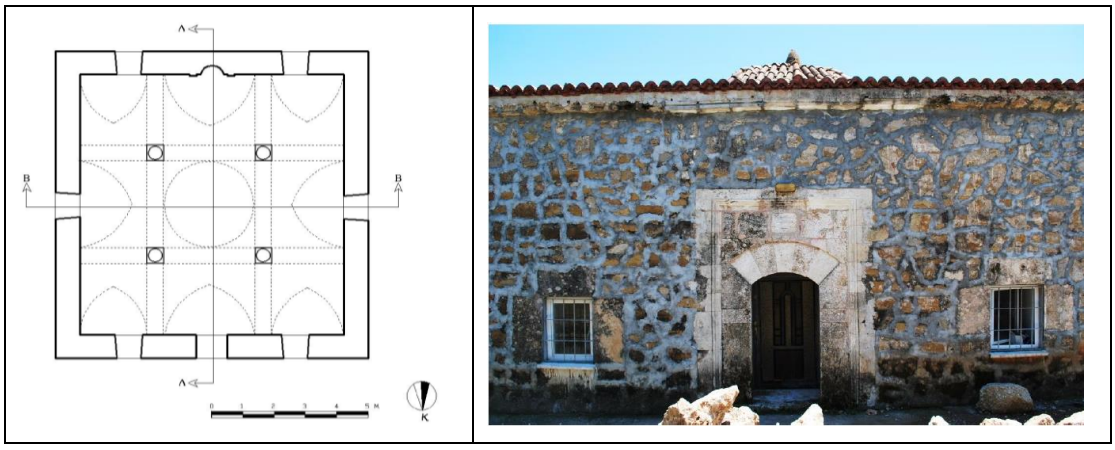

Figure 12. Photo and plan of Haci Hasan Mosque

3.12. Yesilkaraman Mosque

The mosque is located in yeşilkaraman village, 34 km from Antalya. According to the mosque inscription; the mosque was constructed in 1912 but there is no information about built by whom. The mosque has a square plan and main single dome. Photo and plan of Yesilkaraman Mosque shown in Figure 12.

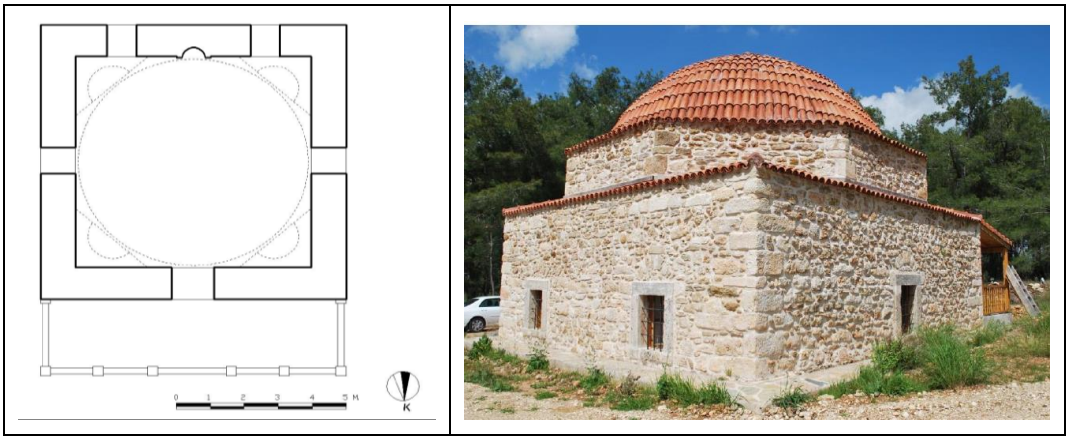

Figure 13. Photo and plan of Yesilkaraman Mosque

3.13. Kizilli Mosque

The mosque is located in kızıllı village, 12,5 km from Varsak, Antalya. According to the mosque inscription; the mosque was constructed in 1912 but there is no information about built by whom. The mosque has a square plan and dome which sits on an octagonal pulley. Photo and plan of Kizilli Mosque shown in Figure 13.

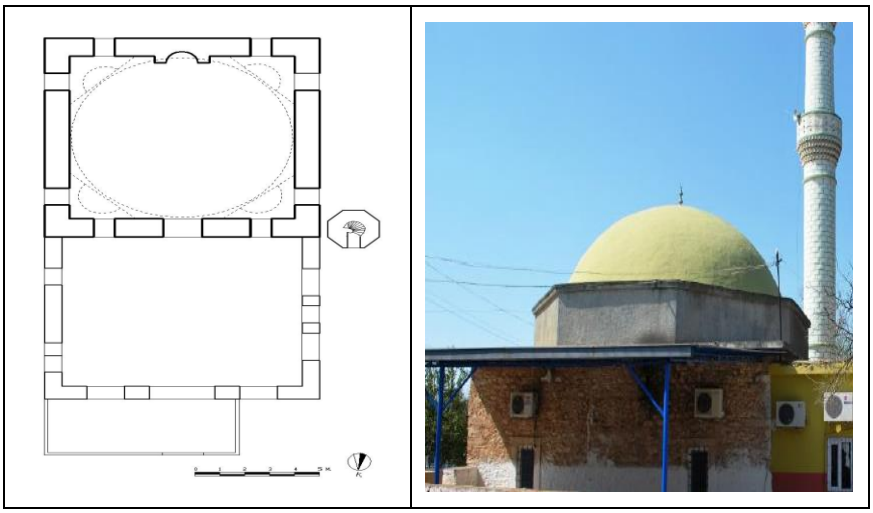

Figure 14. Photo and plan of Kizilli Mosque

3.14. Alacami Mosque

The mosque is located in Serik, Antalya. There is no exact information about the construction date and architect of mosque. The mosque has a square plan covered with a central dome. Photo and plan of Alacami Mosque shown in Figure 14.

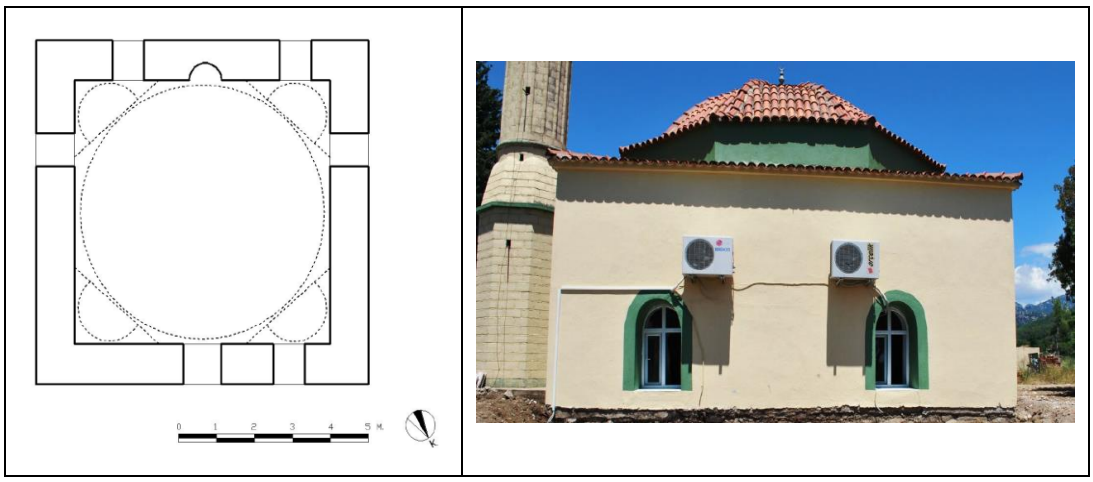

Figure 15. Photo and plan of Alacami Mosque

3.15. Kurus Koyu Mosque

The mosque is located in Kürüş village, Serik, Antalya. According to inscription; the mosque was constructed in 1930 but there is no information about built by whom. The mosque has a square plan covered with a central dome. Photo and plan of Kurus koyu Mosque shown in Figure 15.

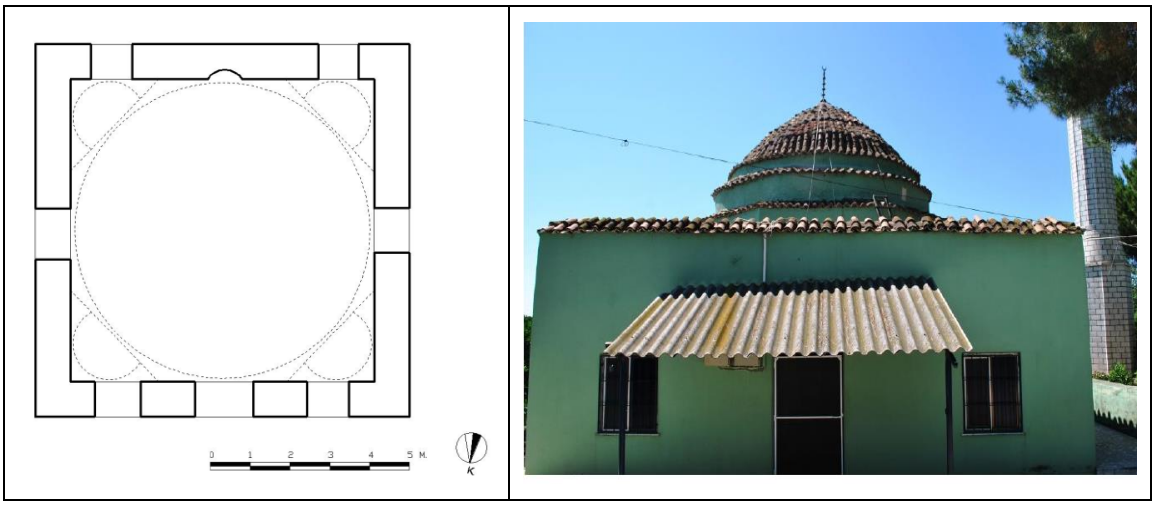

Figure 16. Photo and plan of Kurus Koyu Mosque

4. Results and Discussions

In this approximate method, it was assumed that the materials were similar of all worship buildings, the volumetric weight of masonry was 20 kN/m^3 and β coefficient was equal to 0.037. The values were computed separately for X (longitudinal) and Y (the transversal) directions respectively. The values, which exceed threshold, were highlighted with the shaded cells.

Zone A was taken into account for parameter 10. Each parameter has separate threshold value which is computed in accordance with its properties. Three soil type A was used for the application of the approximate method for parameter 10. According to the all average X and Y direction values are usually approximate.

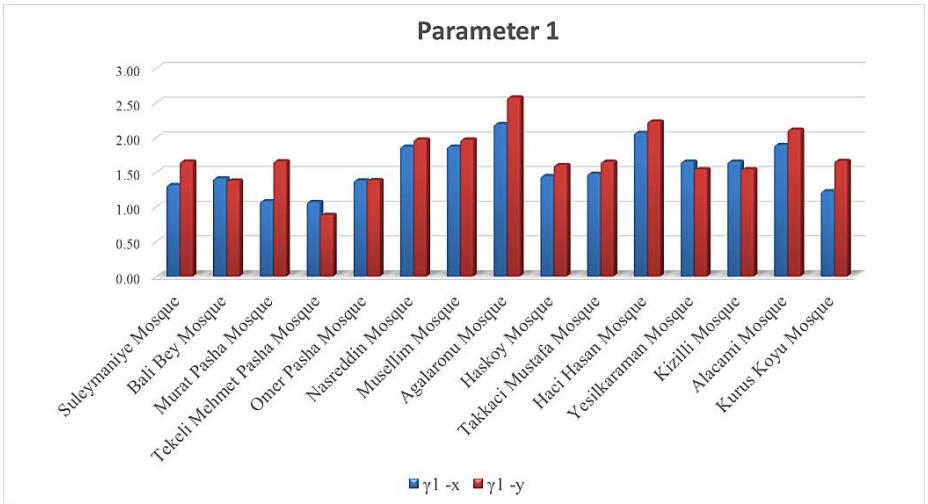

Figure 17. Graph representation of Parameter 1

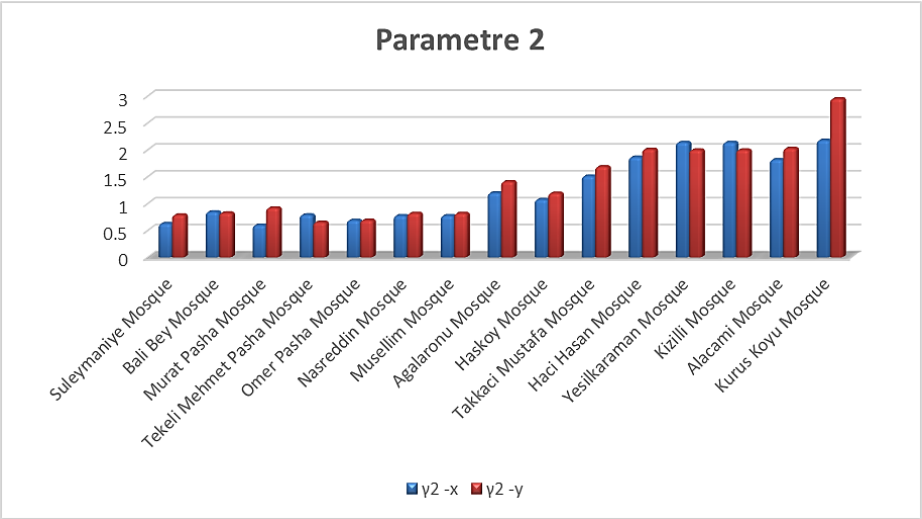

Figure 18. Graph representation of Parameter 2

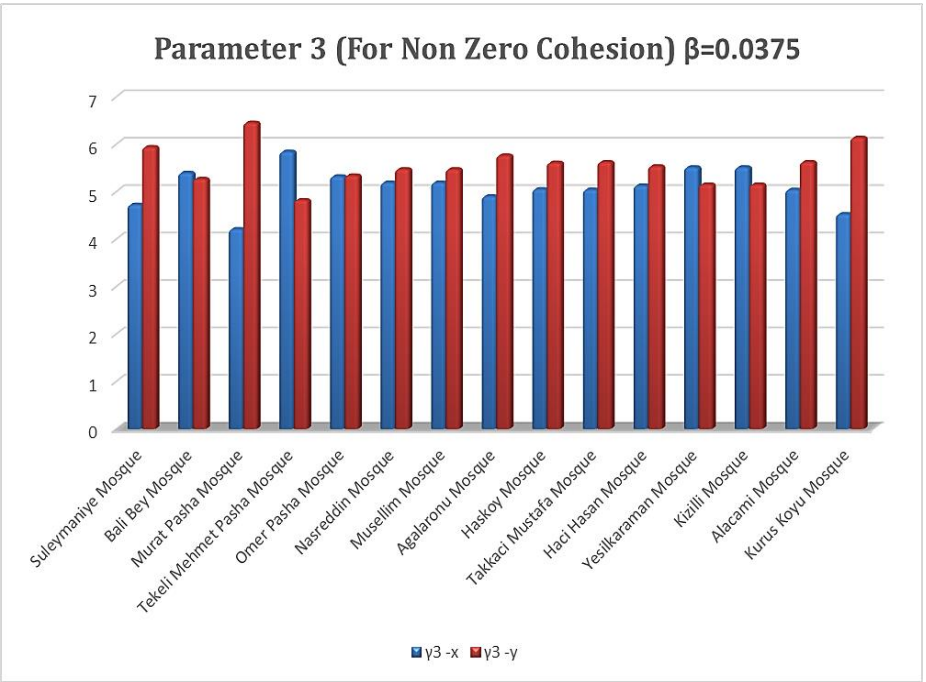

Figure 19. Graph representation of Parameter 3 (a)

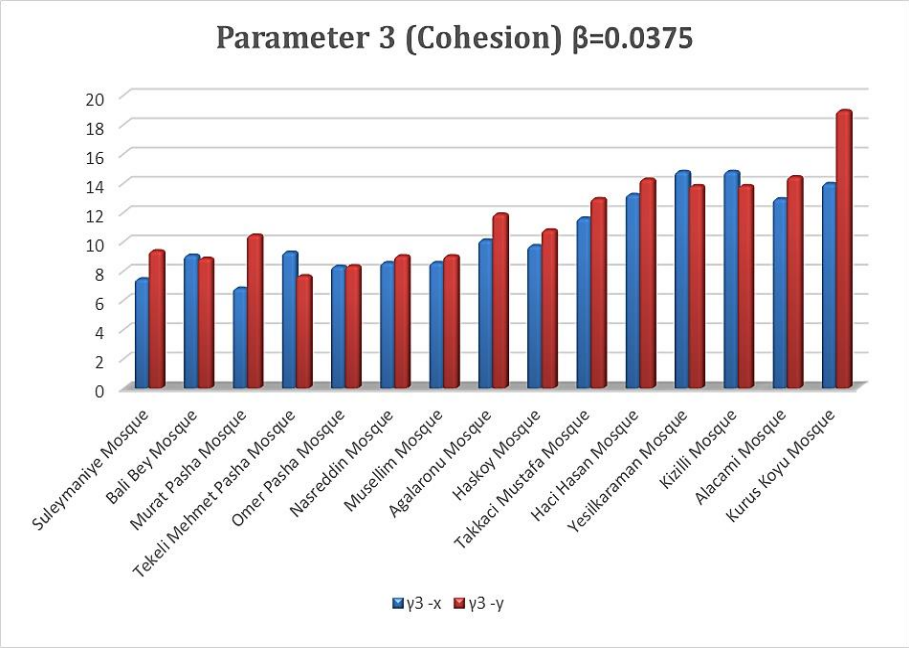

Figure 20. Graph representation of Parameter 3 (b)

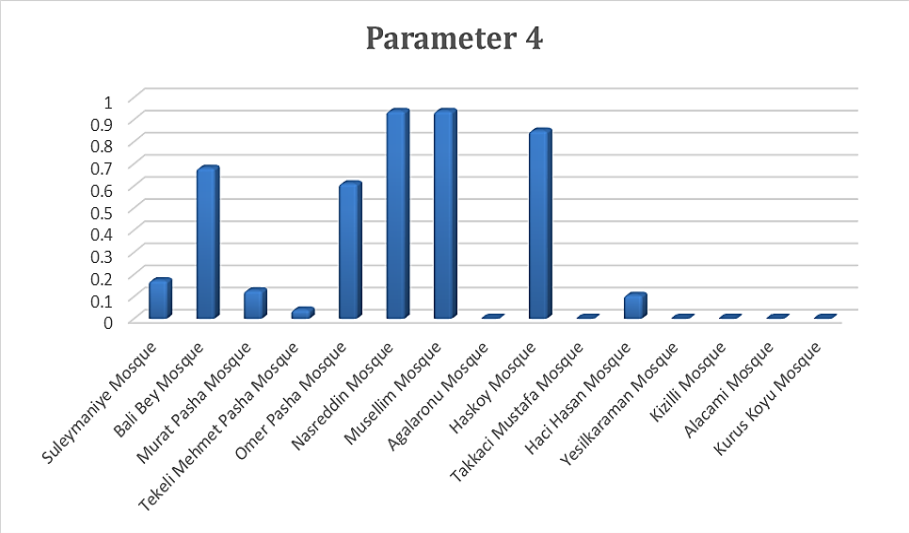

Figure 21. Graph representation of Parameter 4

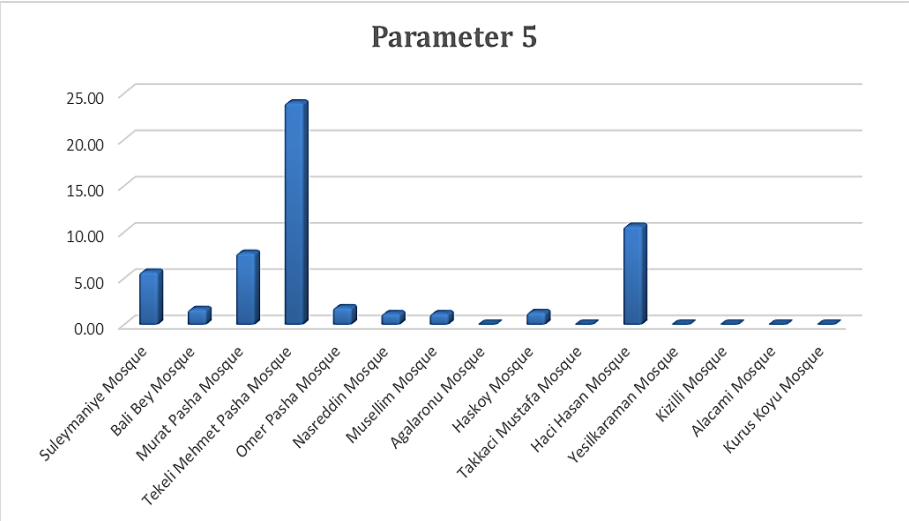

Figure 22. Graph representation of Parameter 5

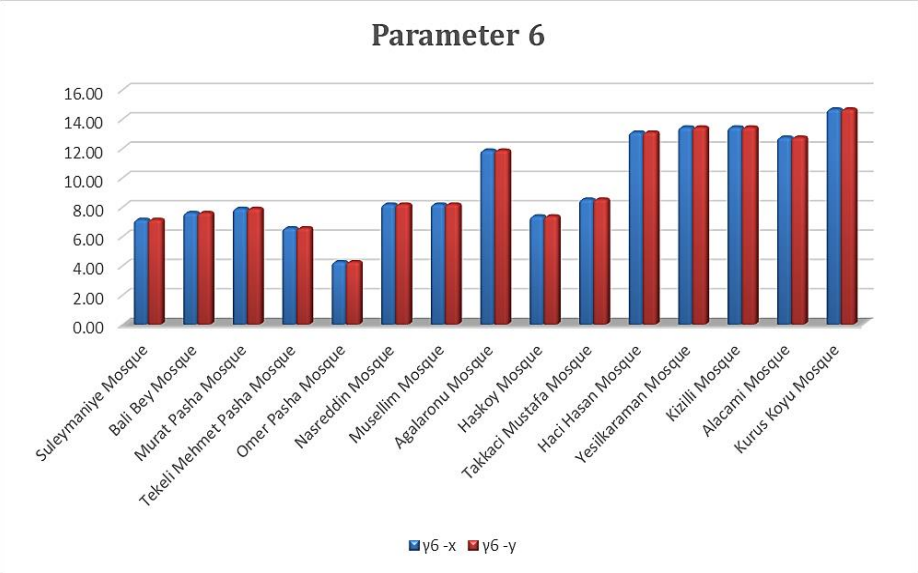

Figure 23. Graph representation of Parameter 6

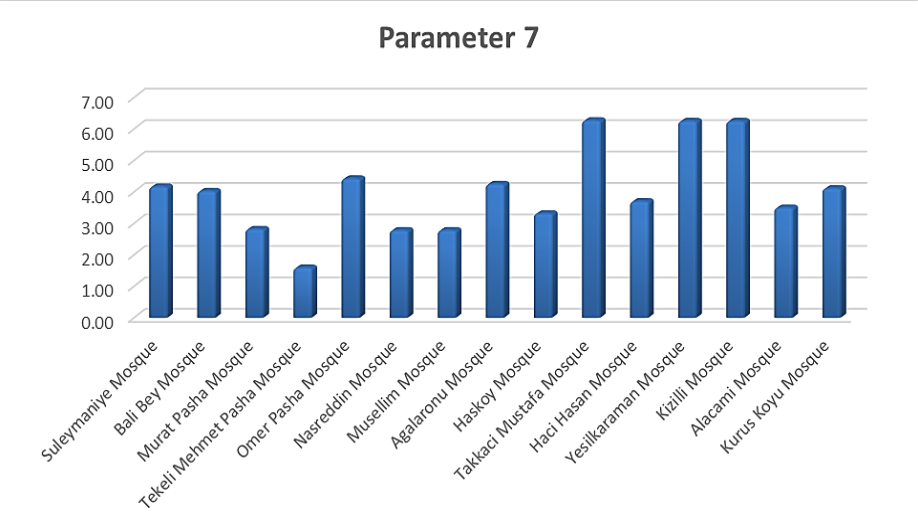

Figure 24. Graph representation of Parameter 7

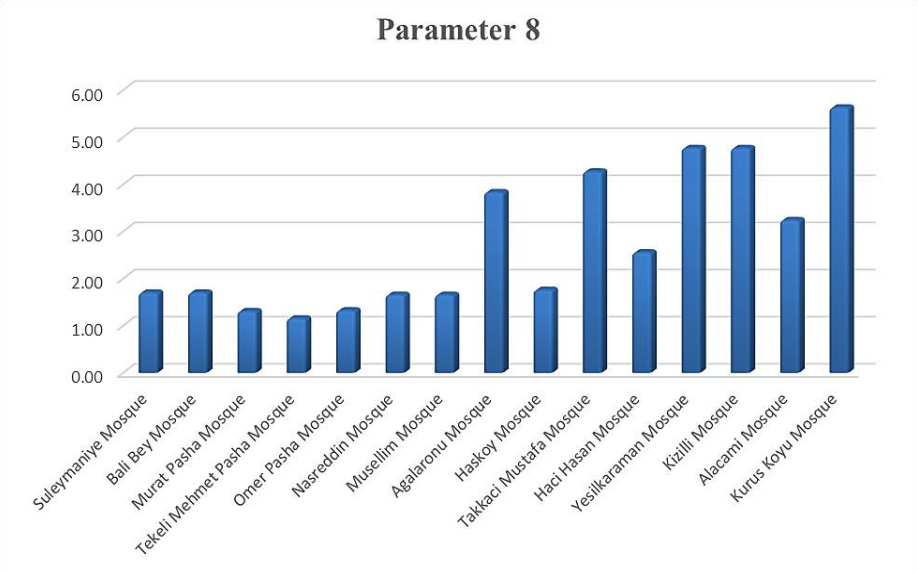

Figure 25. Graph representation of Parameter 8

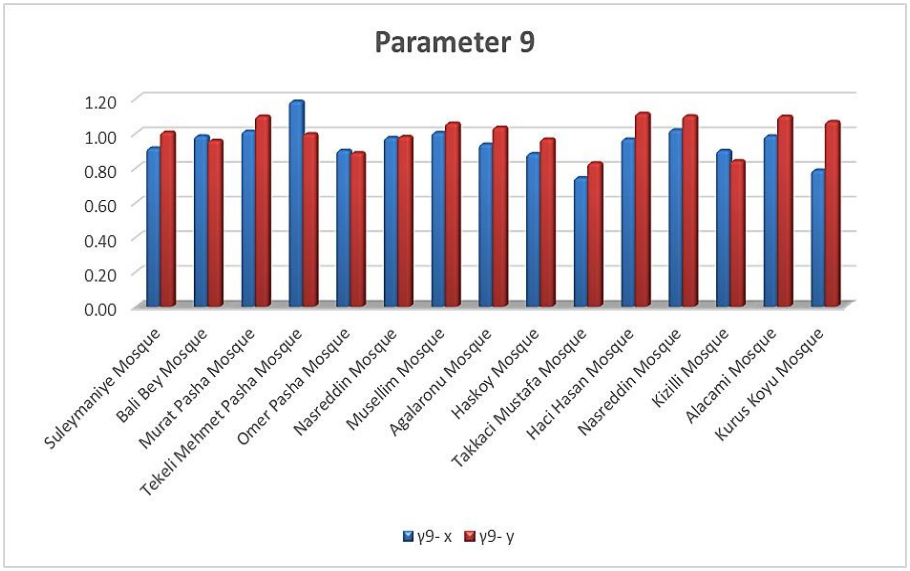

Figure 26. Graph representation of Parameter 9

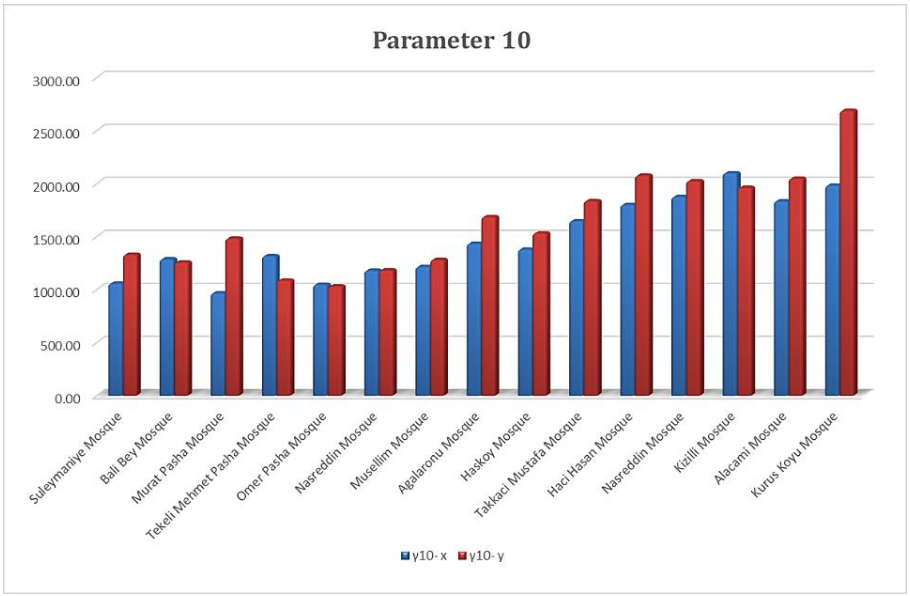

Figure 27. Graph representation of Parameter 10

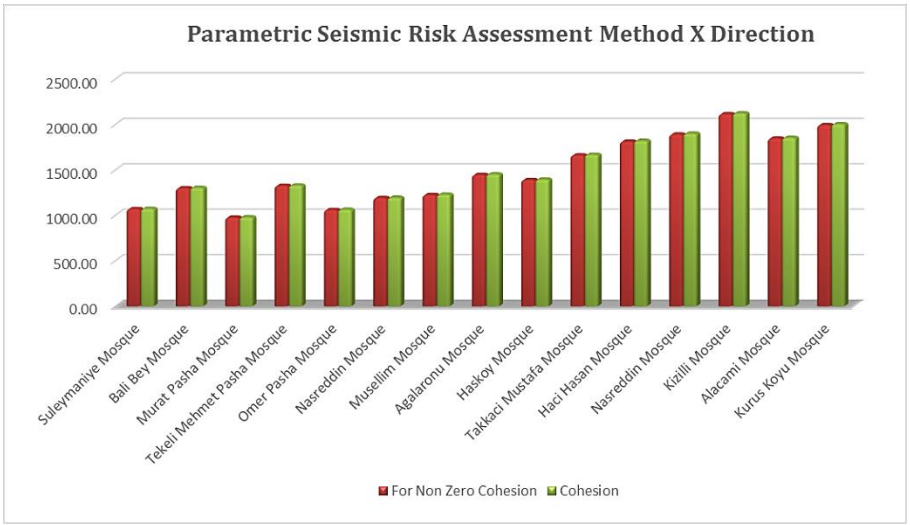

Figure 28. Graph representation of Parametric Seismic Risk Assessment Method X Direction

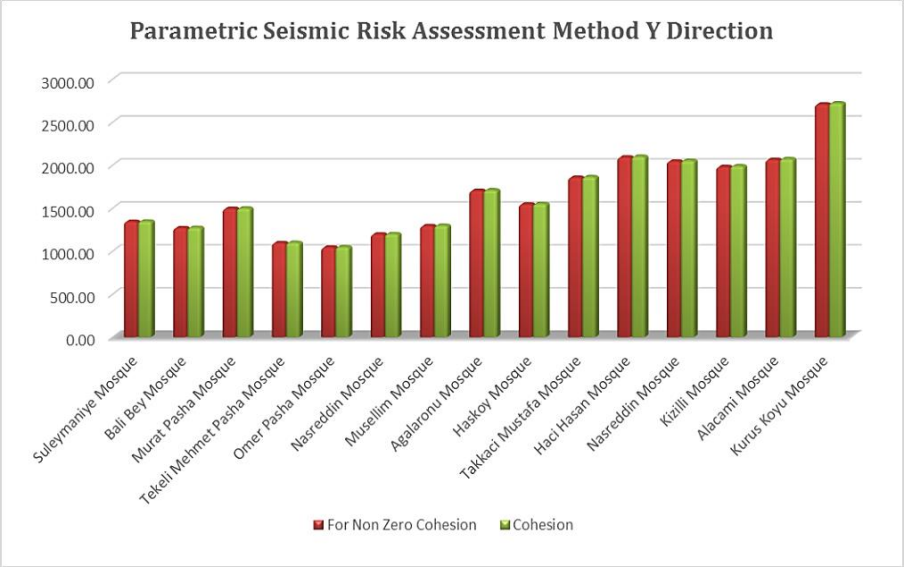

Figure 29. Graph representation of Parametric Seismic Risk Assessment Method Y Direction

In terms of parameter 1, see Table 1, all values of parameter 1 exceed the threshold value except Tekeli Mehmet Pasha Mosque. And the same situation is appropriate for parameter 2, parameter 3, parameter 4, parameter 5, parameter 6, parameter 7 and parameter 9, (see Tables 2 to 11), respectively. In terms of parameter 8 only Tekeli Mehmet Pasha Mosque bellowed threshold value. In terms of values along X and Y direction of parameter- 10 Soil A, all mosque values are below threshold.

Table 1. The result value of Parameter 1

Worship Buildings	X Direction	Y Direction
	Parameter 1(γ1)	Parameter 1(γ1)
Suleymaniye Mosque	1.32	1.66
Bali Bey Mosque	1.41	1.38
Murat Pasha Mosque	1.08	1.66
Tekeli Mehmet Pasha Mosque	1.07	**0.89**
Omer Pasha Mosque	1.38	1.39
Nasreddin Mosque	1.87	1.97
Musellim Mosque	1.87	1.97
Agalaronu Mosque	2.19	2.58
Haskoy Mosque	1.45	1.61
Takkaci Mustafa Mosque	1.48	1.65
Haci Hasan Mosque	2.07	2.23
Yesilkaraman Mosque	1.65	1.54
Kizilli Mosque	1.65	1.54
Alacami Mosque	1.90	2.12
Kurus Koyu Mosque	1.23	1.66

Table 2. Result value of Parameter 2

Worship Buildings	X Direction	Y Direction
	Parameter 2(γ_2)	Parameter 2(γ_2)
Suleymaniye Mosque	0.63	0.79
Bali Bey Mosque	0.85	0.83
Murat Pasha Mosque	0.60	0.92
Tekeli Mehmet Pasha Mosque	0.80	0.66
Omer Pasha Mosque	0.69	0.69
Nasreddin Mosque	0.78	0.82

Musellim Mosque	0.78	0.81
Agalaronu Mosque	1.19	1.41
Haskoy Mosque	1.08	1.19
Takkaci Mustafa Mosque	1.5	1.69
Haci Hasan Mosque	1.86	2.01
Yesilkaraman Mosque	2.14	1.99
Kizilli Mosque	2.14	1.99
Alacami Mosque	1.81	2.02
Kurus Koyu Mosque	2.18	2.95

Table 3. Result value of Parameter 3 (For Non zero Cohesion)

Worship Buildings	**X Direction**	**Y Direction**
	Parameter 3(γ_3)	**Parameter 3(γ_3)**
Suleymaniye Mosque	7.44	9.36
Bali Bey Mosque	9.06	8.84
Murat Pasha Mosque	6.80	10.43
Tekeli Mehmet Pasha Mosque	9.26	7.65
Omer Pasha Mosque	8.30	8.33
Nasreddin Mosque	8.55	9.019
Musellim Mosque	8.55	9.019
Agalaronu Mosque	10.09	11.86
Haskoy Mosque	9.71	10.78
Takkaci Mustafa Mosque	11.59	12.92
Haci Hasan Mosque	13.20	14.25
Yesilkaraman Mosque	14.77	13.80
Kizilli Mosque	14.77	13.80
Alacami Mosque	12.91	14.41
Kurus Koyu Mosque	13.96	18.92

Table 4. Result value of Parameter 3 (For zero Cohesion)

Worship Buildings	**X Direction**	**Y Direction**
	Parameter 3(γ_3)	**Parameter 3(γ_3)**
Suleymaniye Mosque	4.72	5.94
Bali Bey Mosque	5.39	5.26
Murat Pasha Mosque	4.21	6.45
Tekeli Mehmet Pasha Mosque	5.84	4.82
Omer Pasha Mosque	5.32	5.34
Nasreddin Mosque	5.19	5.47
Musellim Mosque	5.19	5.47
Agalaronu Mosque	4.90	5.76
Haskoy Mosque	5.05	5.61
Takkaci Mustafa Mosque	5.04	5.62
Haci Hasan Mosque	5.13	5.53
Yesilkaraman Mosque	5.51	5.15
Kizilli Mosque	5.51	5.15
Alacami Mosque	5.04	5.62
Kurus Koyu Mosque	4.52	6.13

Table 5. Result value of Parameter 4

Parameter 4	γ_4
Suleymaniye Mosque	0.17
Bali Bey Mosque	0.68
Murat Pasha Mosque	0.12
Tekeli Mehmet Pasha Mosque	0.04
Omer Pasha Mosque	0.61
Nasreddin Mosque	0.93
Musellim Mosque	0.93
Agalaronu Mosque	0
Haskoy Mosque	0.85
Takkaci Mustafa Mosque	0
Haci Hasan Mosque	0.10
Yesilkaraman Mosque	0
Kizilli Mosque	0
Alacami Mosque	0
Kurus Koyu Mosque	0

Table 6. Result value of Parameter 5

Parameter 5	γ_5
Suleymaniye Mosque	5.71
Bali Bey Mosque	1.68
Murat Pasha Mosque	7.76
Tekeli Mehmet Pasha Mosque	24.00
Omer Pasha Mosque	1.87
Nasreddin Mosque	1.22
Musellim Mosque	1.22
Agalaronu Mosque	0.00
Haskoy Mosque	1.34
Takkaci Mustafa Mosque	0.00
Haci Hasan Mosque	10.67
Yesilkaraman Mosque	0.00
Kizilli Mosque	0.00
Alacami Mosque	0.00
Kurus Koyu Mosque	0.00

Table 7. Result value of Parameter 6

Worship Buildings	X Direction	Y Direction
	Parameter 6(γ_6)	Parameter 6(γ_6)
Suleymaniye Mosque	7.14	7.14
Bali Bey Mosque	7.61	7.61
Murat Pasha Mosque	7.89	7.89
Tekeli Mehmet Pasha Mosque	6.57	6.57
Omer Pasha Mosque	4.26	4.26
Nasreddin Mosque	8.19	8.19
Musellim Mosque	8.19	8.19
Agalaronu Mosque	11.86	11.86
Haskoy Mosque	7.37	7.37
Takkaci Mustafa Mosque	8.52	8.52
Haci Hasan Mosque	13.10	13.10
Yesilkaraman Mosque	13.44	13.44
Kizilli Mosque	13.44	13.44
Alacami Mosque	12.75	12.75
Kurus Koyu Mosque	14.67	14.67

Table 8. Result value of Parameter 7

Parameter 7	γ_7
Suleymaniye Mosque	4.17
Bali Bey Mosque	4.03
Murat Pasha Mosque	2.82
Tekeli Mehmet Pasha Mosque	1.59
Omer Pasha Mosque	4.43
Nasreddin Mosque	2.78
Musellim Mosque	2.78
Agalaronu Mosque	4.25
Haskoy Mosque	3.32
Takkaci Mustafa Mosque	6.28
Haci Hasan Mosque	3.70
Yesilkaraman Mosque	6.25
Kizilli Mosque	6.25
Alacami Mosque	3.50
Kurus Koyu Mosque	4.11

Table 9. Result value of Parameter 8

Parameter 8	γ_8
Suleymaniye Mosque	1.70
Bali Bey Mosque	1.70
Murat Pasha Mosque	1.31
Tekeli Mehmet Pasha Mosque	**1.15**
Omer Pasha Mosque	1.32
Nasreddin Mosque	1.65
Musellim Mosque	1.65
Agalaronu Mosque	3.83
Haskoy Mosque	1.76
Takkaci Mustafa Mosque	4.27
Haci Hasan Mosque	2.55
Yesilkaraman Mosque	4.77
Kizilli Mosque	4.77
Alacami Mosque	3.24
Kurus Koyu Mosque	5.63

Table 10. Result value of Parameter 9

Worship Buildings	X Direction	Y Direction
	Parameter 9(γ_9)	Parameter 9(γ_9)
Suleymaniye Mosque	0.92	1.01
Bali Bey Mosque	0.99	0.96
Murat Pasha Mosque	1.01	1.10
Tekeli Mehmet Pasha Mosque	1.19	1.00
Omer Pasha Mosque	0.90	0.89
Nasreddin Mosque	0.98	0.98
Musellim Mosque	1.01	1.06
Agalaronu Mosque	0.94	1.04
Haskoy Mosque	0.88	0.97

Takkaci Mustafa Mosque	0.74	0.83
Haci Hasan Mosque	0.97	1.12
Yesilkaraman Mosque	1.02	1.10
Kizilli Mosque	0.90	0.84
Alacami Mosque	0.99	1.10
Kurus Koyu Mosque	0.79	1.07

Table 11. Result value of Parameter 10

Worship Buildings	**X Direction**	**Y Direction**
	Parameter 10(γ_{10})	**Parameter 10(γ10)**
Suleymaniye Mosque	**0.92**	**1.01**
Bali Bey Mosque	**0.99**	**0.96**
Murat Pasha Mosque	**1.01**	**1.10**
Tekeli Mehmet Pasha Mosque	**1.19**	**1.00**
Omer Pasha Mosque	**0.90**	**0.89**
Nasreddin Mosque	**0.98**	**0.98**
Musellim Mosque	**1.01**	**1.06**
Agalaronu Mosque	**0.94**	**1.04**
Haskoy Mosque	**0.88**	**0.97**
Takkaci Mustafa Mosque	**0.74**	**0.83**
Haci Hasan Mosque	**0.97**	**1.12**
Yesilkaraman Mosque	**1.02**	**1.10**
Kizilli Mosque	**0.90**	**0.84**
Alacami Mosque	**0.99**	**1.10**
Kurus Koyu Mosque	**0.79**	**1.07**

In terms of the total parameter calculation results are compared; Suleymaniye mosque, Murat Pasha Mosque, and Kurus Koyu have more risk than other mosques. The risk level of the worship buildings is presented in Figure 30. Risk situation was determined by whether exceeds the parameter values of mosque or not.

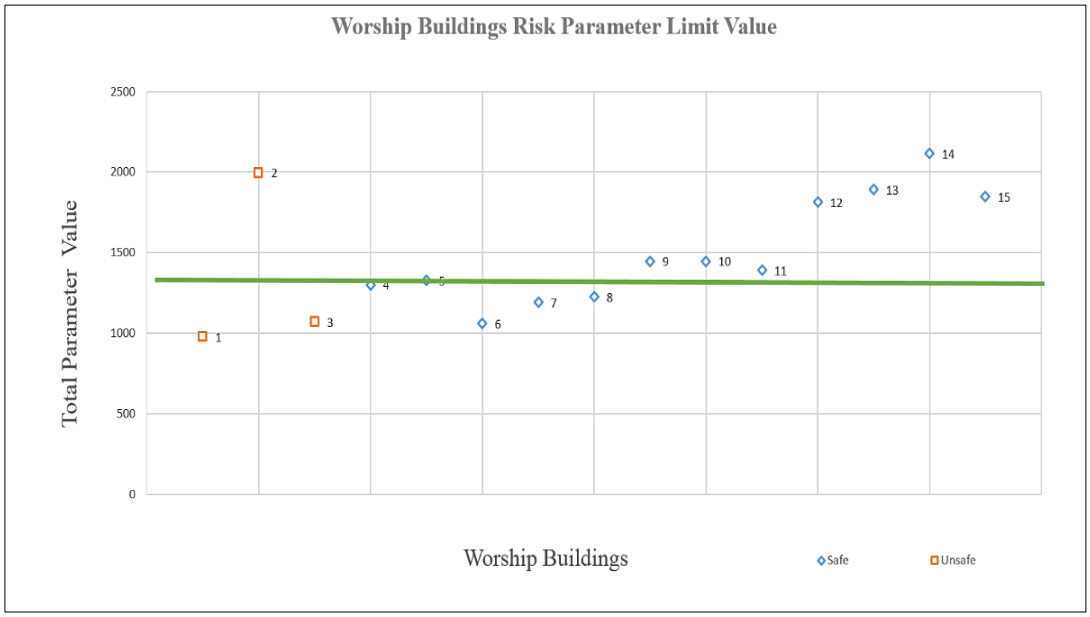

Figure 30. The risk level of Worship buildings

5. Conclusion

This paper presents an application of an approximate method for assessment of worship buildings in Antalya. The database includes 15 mosques. These mosques selected according to the availability of information and plan which has one single dome. Ten parameters and thresholds are used. The first six parameters and threshold values are based on Lourenco and Oliveria (Lourenco and Oliveira 2004), so in this study, it was assumed that threshold values of the first six parameters to be equally applicable for the worship buildings in Antalya.

Generally, the X and Y direction of the worship buildings values are approximately each other. It is thought that the reason for these approximate values is buildings plan, which has square and symmetrical. In terms of the average results all parameters have acceptable results, according to the total parameter formulate results Murat pasha mosque, Kurus koyu mosque, and Suleymaniye mosque are high risky than other worship buildings, so that can be said that other mosques are more reliable under seismic risk.

The methods and parameters as indicators for fast screening and decision to prioritize deeper studies in historical masonry buildings and to assess vulnerability to seismicity. In general, the values of the directions, which are longitudinal (y) and transversal (x), are approximate. The analysis of the parameters shows that a logical common trend can be established. It is very difficult to determine how a masonry building responds against seismic loads. In this regard, there should make seismic analysis by using analytical and experimental methods. Many historical masonry buildings are protected by the General Directorate of Foundations because of their cultural values. Therefore, the examination of buildings in many aspects involves a challenging process. the seismic assessment of the structures should not cause any damage. In this process, it is thought that the parametric seismic evaluation method, which is made considering the geometric and some structural features of the structures and gives approximate results, will meet the need in the first stage.

6. Conflicts of Interest

The authors declare no conflict of interest.

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