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The Effects of the 6 February 2023 Pazarcık-Kahramanmaraş Earthquake on Hatay Province

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Abstract

February 6, 2023 Kahramanmaraş-centered earthquakes had severe consequences in Hatay province, a province of approximately 1.7 million people. As a result of this disaster, 23,065 people lost their lives in Hatay, 13,517 structures were completely destroyed, and 89,025 were rendered unusable. During the Mw 7.7 Pazarcık-Kahramanmaraş earthquake, the highest ground acceleration values were measured in Pazarcık as 2,165.62 cm/s² in the north-south direction, 2,178.72 cm/s² in the east-west direction, and 1,951.68 cm/s² in the vertical direction. In the Defne district of Hatay, 146 km from the epicenter, the second-highest acceleration values were recorded, respectively, at 1,351.50 cm/s² (North-South), 1,198.74 cm/s² (East-West), and 716.94 cm/s² (Vertical). In the assessment of seismic hazards and risks, earthquake hazard maps are created to estimate potential maximum acceleration or intensity values. These maps are widely used in areas such as determining the risk status of structures, determining reinforcement requirements, and managing legal processes related to earthquake damage. This article aims to contribute to relevant studies by revealing the evolution of Hatay's earthquake risk from the first official earthquake zone map in 1945 to the present day. The study also provides information on significant earthquakes experienced in Hatay before and after 1900, focusing on the provincial causes, damage, and measured acceleration values of the February 6, 2023 earthquake.

Keywords

Earthquake, Earthquake Zones Map, Hatay, Maximum Acceleration

6 Şubat 2023 Pazarcık-Kahramanmaraş Depreminin Hatay İline Etkileri

Özet

6 Şubat 2023 Kahramanmaraş merkezli depremler, yaklaşık 1,7 milyon insanın yaşadığı Hatay ilinde ağır sonuçlara yol açmıştır. Bu afet neticesinde Hatay'da 23.065 kişi yaşamını yitirirken, 13.517 yapı tamamen yıkılmış ve 89.025 yapı ise kullanılamayacak duruma gelmiştir. Mw 7.7 büyüklüğündeki Pazarcık-Kahramanmaraş depremi sırasında en yüksek yer ivmesi değerleri Pazarcık'ta Kuzey-Güney yönünde 2.165,62 cm/sn², Doğu-Batı yönünde 2.178,72 cm/sn² ve düşeyde 1.951,68 cm/sn² olarak ölçülmüştür. Depremin merkez üssüne 146 km mesafedeki Hatay'ın Defne ilçesinde ise bu değerler sırasıyla 1.351,50 cm/sn² (Kuzey-Güney), 1.198,74 cm/sn² (Doğu-Batı) ve 716,94 cm/sn² (Düşey) ile ikinci en yüksek ivme olarak kayıtlara geçmiştir. Sismik tehlike ve risklerin değerlendirilmesinde, potansiyel maksimum ivme veya şiddet değerlerini tahmin etmek amacıyla deprem tehlike haritaları oluşturulur. Bu haritalar, yapıların risk durumunu saptama, güçlendirme gereksinimlerini belirleme ve deprem hasarlarına ilişkin hukuki süreçleri yönetme gibi alanlarda yaygın olarak kullanılmaktadır. Bu makale, Hatay'ın deprem tehlikesinin 1945 yılındaki ilk resmi deprem bölgesi haritasından günümüze kadar olan değişimini ortaya koyarak ilgili çalışmalara katkı sağlamayı hedeflemektedir. Çalışma ayrıca, 1900 yılı öncesi ve sonrası dönemlerde Hatay'da yaşanan önemli depremler hakkında bilgi sunarken, 6 Şubat 2023 depreminin il özelindeki nedenlerine, yarattığı hasara ve ölçülen ivme değerlerine odaklanmaktadır.

Anahtar Sözcükler

Deprem, Deprem Bölgeleri Haritası, Hatay, Maksimum İvme

1. Introduction

Hatay province is located in a geography where seismic activity is intense and is under the influence of many main fault systems. These systems include the Dead Sea Fault Zone, which extends from the Red Sea to Antakya in the south, the East Anatolian Fault Zone, which continues from Karlıova (Bingöl) to Antakya in the north, the Southeastern Anatolian Thrust, which starts near Adıyaman in the northeast and reaches Hakkari, and the Cyprus Arc, which crosses the Gulf of Iskenderun from the southwest. In addition to these, secondary faults associated with these systems affect the region. On February 6, 2023, two major earthquakes occurred: the Mw 7.7 Pazarcık-Kahramanmaraş earthquake and the Mw 7.6 Elbistan-Kahramanmaraş earthquake.

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These earthquakes had a significant impact on Hatay province, as in many other provinces, causing the collapse of numerous buildings and resulting in the loss of thousands of lives (see Figure 1). Following the earthquake, more than seventy thousand aftershocks were recorded in the region, with nearly four thousand occurring within the boundaries of Hatay province (Afet ve Acil Durum Yönetimi Başkanlığı, 2024a). The first earthquake ruptured the Narlı segment, located at the northernmost end of the Dead Sea Fault System, and the portion of the East Anatolian Fault, extending from Çelikhan (Malatya) to Antakya. The second earthquake caused the rupture of the Çardak and Doğanşehir faults.

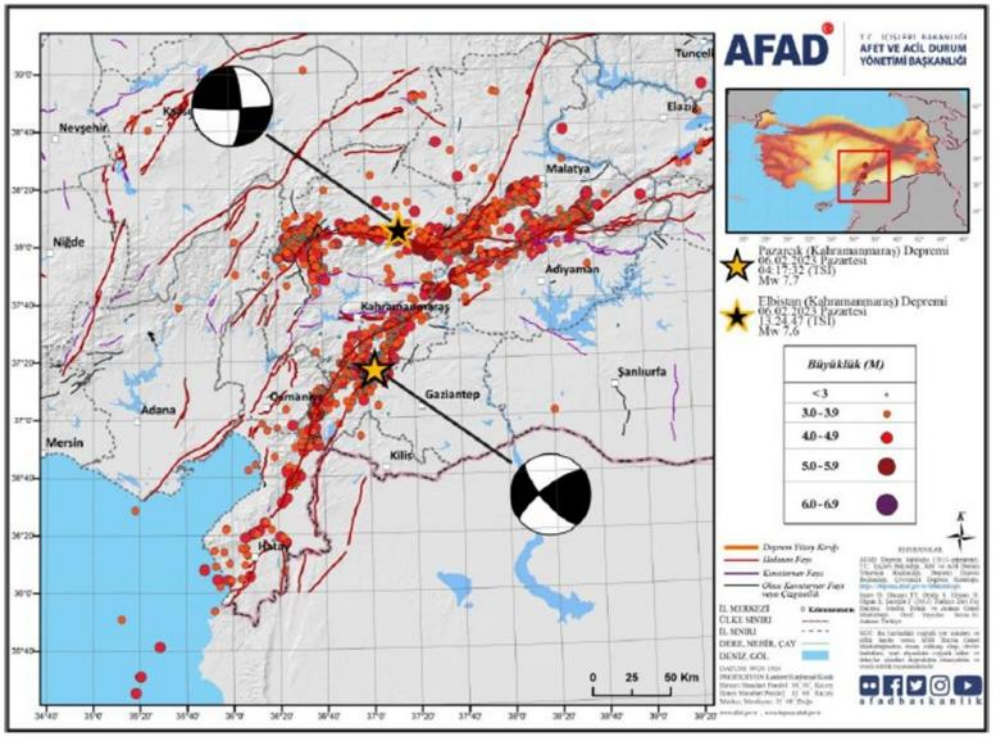

Figure 1: 06.02.2023 Pazarcık (Kahramanmaraş) Mw 7.7 and Elbistan (Kahramanmaraş) Mw 7.6 earthquakes and aftershocks status (Afet ve Acil Durum Yönetimi Başkanlığı, 2023a)

Following the earthquakes on February 6, 2023, a total of 53,587 deaths and 107,213 injuries were officially reported. Furthermore, 35,355 buildings collapsed, 17,491 buildings were deemed in urgent need of demolition, 179,786 buildings were severely damaged, 40,228 buildings suffered moderate damage, and 431,421 buildings sustained minor damage (Cumhurbaşkanlığı Strateji Başkanlığı Raporu, 2023). The earthquakes caused significant loss of life, injuries, and damage to numerous structures, including roads, railways, airports, historical and cultural sites, schools, hospitals, hotels, and other infrastructure. These impacts were observed in the provinces of Kahramanmaraş and Hatay, as well as Adana, Adıyaman, Diyarbakır, Elazığ, Gaziantep, Kilis, Malatya, Osmaniye, and Şanlıurfa. Subsequently, Bingöl, Kayseri, Mardin, Tunceli, Niğde, Batman, and Sivas were also added to the list of affected provinces, bringing the total number of directly impacted provinces to 18 (Afet ve Acil Durum Yönetimi Başkanlığı, 2023b). To ensure rapid and effective implementation, of all necessary actions during the response and recovery phases, including search and rescue operations, a state of emergency was declared for 90 days starting at 01:00 on Wednesday, February 8, 2023. This affected the provinces of Adana, Adıyaman, Diyarbakır, Gaziantep, Hatay, Kahramanmaraş, Kilis, Malatya, Osmaniye, and Şanlıurfa.

The purpose of this study is to compare the accelerometer records obtained from the February 6, 2023 earthquakes with the changes in Turkey's official earthquake zone maps for Hatay province and to investigate whether these changes had an impact on the extent of damage observed in the region.

Within this scope, the study examines measured ground acceleration values within Hatay province, the number of damaged buildings, the condition of the building stock according to past and present earthquake regulations, and hazard maps, and how Hatay's earthquake hazard levels have changed over time according to the officially approved and implemented maps of 1945, 1947, 1963, 1972, 1996, and 2019.

2. Earthquakes Affecting Hatay and The Status of Hatay Province According to Official Earthquake Zone Maps of Turkey

2.1. Earthquakes Affecting Hatay

A total of 68 earthquakes that caused damage occurred within the borders of Hatay province, and its surrounding areas before 1900 (Soysal et al., 1981). Findings related to the earthquakes with an intensity of IX or higher are presented in Table 1.

Table 1: Significant earthquakes occuring before 1900

Date	Latitude (N)	Longtitude (E)	Maximum Intensity	Affected Areas
69 B.C.	36.25	36.10	IX	Caused damage in Antakya and some cities in Syria. Also felt in Magosa (Cyprus) and Egypt.
13.12.115	36.25	36.10	IX	Affected Antakya and surrounding areas.
245	36.25	36.10	X	Affected areas around Antakya.
334	36.25	36.10	IX	Felt around Antakya, Beirut, and Magosa (Cyprus).
14.09.458	36.25	36.10	IX	Affected Antakya and northern Syria.
10.09.506	36.25	36.10	IX	Affected areas around Antakya and Samandağ.
29.05.526	36.25	36.10	IX	Affected areas around Antakya and Samandağ.
29.11.529	36.25	36.10	IX	Affected areas Antakya and surrounding regions.
30.09.587	36.25	36.10	IX	Affected areas around Antakya.
867	36.25	36.10	IX	Affected areas around Antakya.
10.08.1114	36.50	35.50	IX	Felt in Ceyhan (Adana), Antakya, and Kahramanmaraş. Some research suggests that it occurred near Kahramanmaraş (Andreasyon, 1987; Kesik, 2005).
1268	37.35	35.80	IX	Affected Kozan, Ceyhan and surrounding areas. Reportedly caused 60,000 deaths.
21.07.1752	35.60	35.75	IX	Affected areas around Latakia and Tripoli
13.08.1822	36.40	36.20	IX	Affected Antakya, Iskenderun, Kilis, Aleppo, and Latakia. Reportedly caused 20,000 detahs.
02.04.1872	36.25	36.10	IX	Affected areas around Antakya and Samandağ. Reportedly caused 1,800 deaths.

Before 1900, a total of 68 earthquakes occurred in Hatay and its surroundings that caused damage (Soysal et al., 1981). Findings on significant earthquakes with a magnitude of IX and above are presented in Table 1. In the instrumental period covering the year 1900, the earthquakes that caused destruction in Hatay and its vicinity were compiled from various seismic catalogs and given in Table 2.

Table 2: Findings on earthquakes causing damage after 1900

Date	Latitude (N)	Longtitude (E)	Magnitude	Maximum Intensity	Affected Areas
20.03.1945	37.11	35.70	Ms 6.0	VIII	The earthquake caused the collapse of 2,500 houses in Ceyhan, Misis, and nearby villages (Pınar & Lahn, 1952). 13 people lost their lives.
08.04.1951	36.58	35.85	Ms 5.7	VI	Felt in Çukurova and Iskenderun. In Karahüseyinli village (Iskenderun district), one house collapsed; 5 of a 7 member family died, and 12 houses were damaged (Eyidoğan et al., 1991).
07.04.1967	37.40	36.20	Ms 5.4	-	91 houses were severely damaged. No fatalities or injuries were reported.
30.06.1981	36.17	35.89	Ms 4.4	-	2 houses were severly damaged. No fatalities or injuries were reported.
22.01.1997	36.14	36.12	Ms 5.5	VI	55 houses were severely damaged. One person died, and nine were injured.
27.06.1998	36.85	35.55	Mw 6.3	VIII	A total of 10,675 residences were heavily damaged. 146 people died and 940 were injured to varying degrees. Peak ground accelerations were recorded as 223.27 mG (N-S), 273.55 mG (E-W), and 86.47 mG (vertical) (General Directorate of Disaster Affairs).
25.06.2001	37.14	36.40	Ms 5.1	-	489 houses were severely damaged. No fatalities or injuries were reported.

2.2. 2023 Kahramanmaraş Earthquakes

On February 6, 2023, two major earthquakes shook Turkey. According to the Disaster and Emergency Management Presidency (AFAD), the first tremor occurred at 04:17 local time. The epicenter of this earthquake was determined as Pazarcık district of Kahramanmaraş (37.288°N, 37.043°E), the moment magnitude was measured as Mw 7.7 and the focal depth was 8.6 km. At 13:24 on the same day, a second earthquake occurred, this time with the epicenter in the Elbistan district of Kahramanmaraş (38.089°N, 37.239°E). The moment magnitude of this second tremor is Mw 7.6 and the focal depth is 7.0 km (Afet ve Acil Durum Yönetimi Başkanlığı, 2023a).

As a result of these earthquakes, the heaviest loss of life and property occurred in Hatay province. According to the damage assessment reports made throughout the province, there has been a great destruction of the houses. Reports have revealed that 215,255 dwellings are in ruins, badly damaged or in need of urgent demolition. However, 25,957 houses were found to be moderately damaged and 189,317 houses were slightly damaged (Cumhurbaşkanlığı Strateji Başkanlığı Raporu, 2023).

The February 20, 2023 Yayladağı-Antakya Earthquake: The earthquake that occurred at 20:04 local time in Turkey, had a moment magnitude of Mw 6.4 and a focal depth of 21.7 km (Afet ve Acil Durum Yönetimi Başkanlığı, 2023c). The epicenter of the earthquake was determined to be at 36.037°N, 37.021°E with a magnitude of Mw 6.4. The earthquake resulted in the deaths of 6 people and injured 294 others; 18 of whom were seriously injured (Türk Tabipler Birliği Raporu, 2023).

2.3. Status of Hatay Province According to Official Earthquake Zone Maps

Since buildings must be constructed in accordance with the standards and parameters specified in earthquake zone maps and building earthquake regulations, it is essential to be informed about the maps from past to present. Moreover, determining whether existing buildings are at risk, planning retrofitting efforts, and resolving legal disputes arising from collapsed or severely damaged buildings due to earthquakes all require knowledge of which earthquake zone the building was located in at the time of its construction.

This section presents the status of the districts within Hatay province according to the official earthquake zone maps enacted in the years 1945, 1947, 1963, 1972, 1996, and 2019. The changes in the earthquake zone classification of Hatay province and its districts according to official maps are illustrated in Figures 2 to 6.

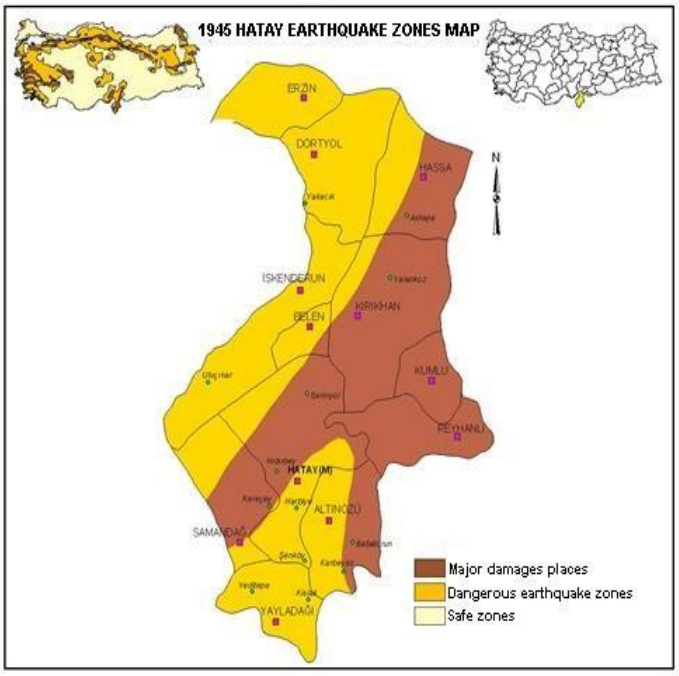

Figure 2: Official seismic zones map of Hatay Province, 1945

Numerous destructive earthquakes have occurred in and around Hatay, particularly during historical times. As shown in Figure 2, Hatay province is divided into two zones: major damages places and dangerous earthquake zones. The district centers of Hassa, Kırıkhan, Kumlu, Reyhanlı, and Samandağ are located within the Severely Damaged Area, indicating that they are in regions of highest earthquake hazard. Meanwhile, the district centers of Antakya, Altınözü, Yayladağı, Erzin, Dörtyol, İskenderun, and Belen fall within the Dangerous earthquake zones.

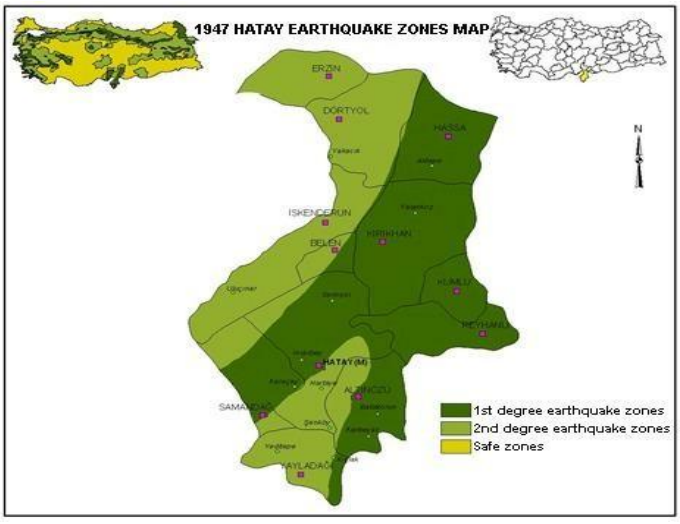

Figure 3: Official seismic zones map of Hatay Province, 1947

An examination of Figure 3 reveals that the First-Degree Seismic Zones have expanded slightly compared to the 1945 map. The districts of Antakya and Altınözü, which were previously classified as dangerous earthquake zones in the 1945 map, are now included within the First- Degree Seismic Zones. Figure 3 also shows that Hatay province is divided into two seismic zones: First and Second Degree Seismic Zones. The district centers of Hassa, Kırıkhan, Kumlu, Reyhanlı, Samandağ, Antakya, and Altınözü fall within the First-Degree Seismic Zone, while Yayladağı, Erzin, Dörtyol, İskenderun, and Belen are located within the Second-Degree Seismic Zone.

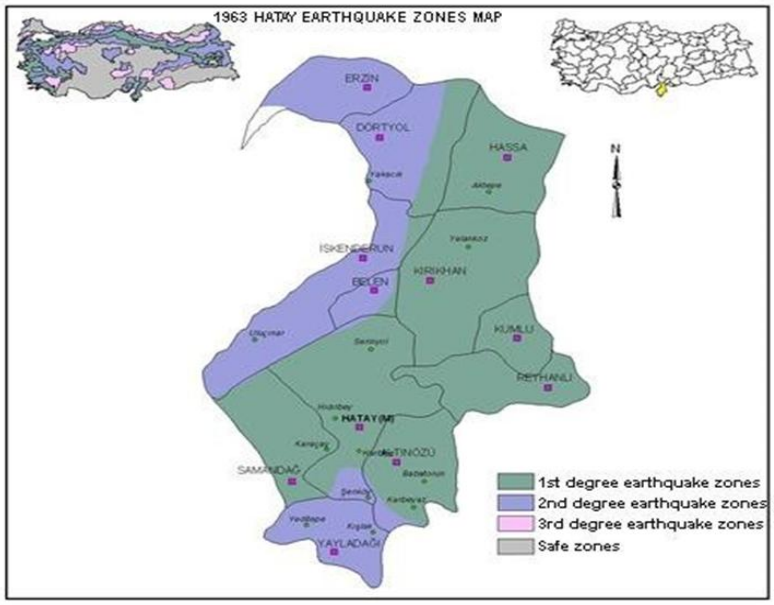

Figure 4: Official earthquake zones map of Hatay Province, 1963

When comparing the 1945 map with the one published in 1947, it is observed that the area designated as a First-Degree Earthquake Zone in Hatay province was slightly expanded (see Figure 4).

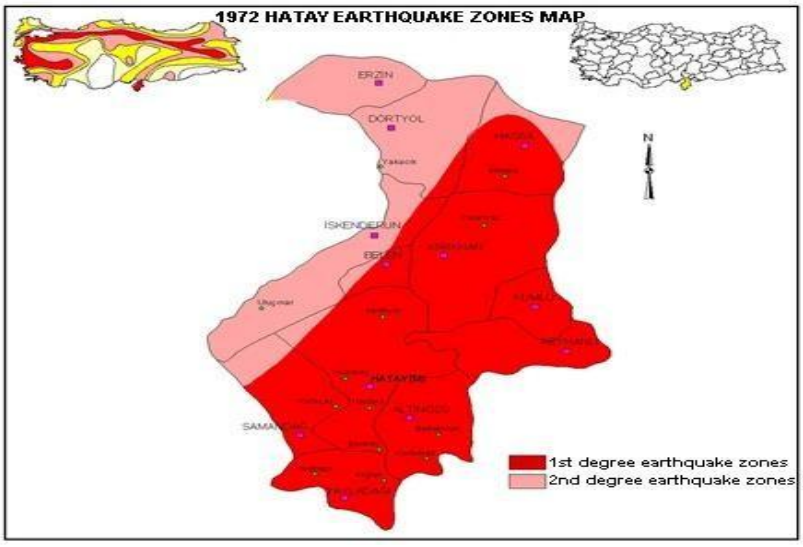

Figure 5: Official earthquake zones map of Hatay Province, 1972

An examination of Figure 5 shows that a large portion of Hatay province is located within the *1st-Degree Earthquake Zone*. When the 1972 map is compared with the 1963 map, it is evident that the area classified as a first-degree earthquake zone in Hatay has expanded slightly, and the **Yayladağı** district has also been included within this zone. In this map, Hatay province is divided into *1st-Degree* and *2nd-Degree Earthquake Zones*.

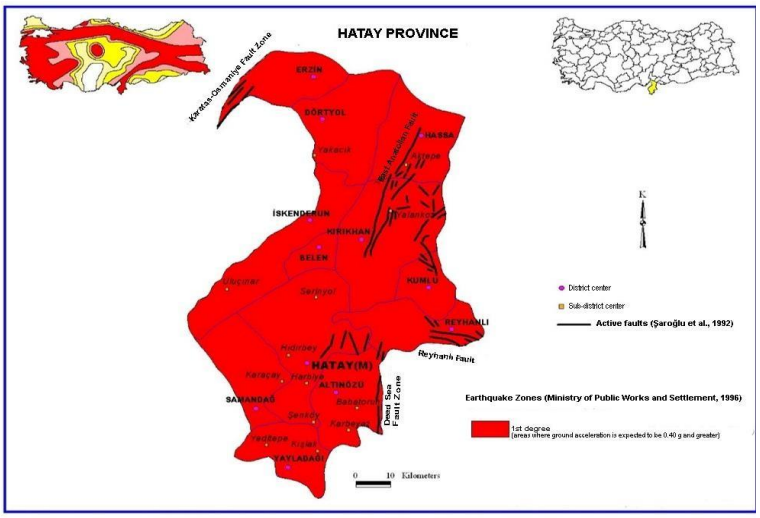

Figure 6: Official earthquake zones map of Hatay Province, 1996

An examination of the map presented in Figure 6 reveals that the entire Hatay province is classified as a First-Degree Earthquake Zone.

3. Strong Ground Acceleration Records

The acceleration records of the Mw 7.7 magnitude Pazarcık-Kahramanmaraş earthquake that occurred on February 6, 2023 at 04:17 were obtained from the AFAD Turkey Strong Ground Motion Database (Afet ve Acil Durum Yönetimi Başkanlığı, 2024b). The records collected from 25 accelerometer stations within the borders of Hatay province are presented in Table 3. The second highest ground acceleration in the earthquake was recorded at station 3129 in the district of Defne, 146 km away from the epicenter. Peak acceleration values were measured as 1,351.50 cm/s² (North-South), 1,198.74 cm/s² (East-West) and 716.94 cm/s² (vertical) at this station. The highest peak ground acceleration in Hatay was recorded in the East-West component, at station 3135 in Arsuz, with a value of 1,371.07 cm/s².

The highest ground acceleration during the earthquake was measured at the accelerometer station coded 4614 in the Pazarcık district of Kahramanmaraş. The peak acceleration values at this station are; It was recorded as 2,165.62 cm/s² in the North-South component, 2,178.72 cm/s² in the East-West component and 1,951.68 cm/s² in the vertical component.

The second highest acceleration values were recorded at the station coded 3129 in Defne district of Hatay province. The peak accelerations measured at this station are 1,351.50 cm/s² in the North-South direction, 1,198.74 cm/s² in the East-West direction and 716.94 cm/s² in the vertical direction.

When the data in Table 3 are examined, it is seen that the highest peak ground acceleration within the borders of Hatay province was recorded at the station in Defne. The maximum acceleration values measured across all stations in Hatay were distributed over a wide range: between 56.45 and 1,351.50 cm/s² in the North-South direction, between 47.51 and 1,372.07 cm/s² in the East-West direction and between 29.12 and 1,296.27 cm/s² in the vertical direction.

Table 3: Acceleration data recorded by stations located within Hatay Province during the 6 Februrary 2023 Pazarcık-Kahramanmaraş Erthquake (Afet ve Acil Durum Yönetimi Başkanlığı, 2024b)

No	Code	Province	District	Peak Ground Acceleraiton (cm/sn²)			Epicentral Distance (Km)	V_{S30} (m/sn)
				North-South	East-West	Vertical		
1	3141	Hatay	Antakya	961.12	868.82	722.66	125	338
2	3124	Hatay	Antakya	572.63	638.32	578.08	140	283
3	3125	Hatay	Antakya	822.62	1121.95	1151.56	142	448
4	3123	Hatay	Antakya	655.57	593.94	867.58	143	-
5	3132	Hatay	Antakya	515.31	514.63	354.18	143	377
6	3126	Hatay	Antakya	1178.12	999.38	921.57	144	350
7	3131	Hatay	Antakya	363.03	366.05	153.96	145	567
8	3136	Hatay	Altınözü	534.22	401.97	220.46	148	344
9	3135	Hatay	Arsuz	740.97	1372.07	588.97	142	460
10	3115	Hatay	Belen	286.72	241.50	214.81	114	424
11	3146	Hatay	Belen	483.85	346.93	341.39	115	560
12	3129	Hatay	Defne	1351.50	1198.74	716.94	146	447
13	3134	Hatay	Dörtyol	246.11	203.91	141.51	90	374
14	3143	Hatay	Hassa	381.09	351.38	412.11	65	444
15	3138	Hatay	Hassa	888.73	746.66	1296.27	72	619
16	3144	Hatay	Hassa	611.27	763.36	451.61	77	485
17	3137	Hatay	Hassa	428.37	670.17	448.37	82	688
18	3116	Hatay	İskenderun	164.28	168.86	165.84	105	870
19	3112	Hatay	İskenderun	171.86	83.64	83.96	111	233
20	3145	Hatay	Kırıkhan	591.88	692.29	609.73	91	533
21	3139	Hatay	Kırıkhan	577.13	504.82	378.62	96	271
22	3142	Hatay	Kırıkhan	651.69	739.29	456.90	106	538
23	3133	Hatay	Reyhanlı	221.41	147.22	87.60	123	377
24	3140	Hatay	Samandağ	194.69	218.71	176.67	166	210
25	3147	Hatay	Yayladağı	56.45	47.51	29.12	177	-

**Shear Wave Velocity measured at the station*

An analysis of Table 3 and Figure 7 reveals that the highest peak ground acceleration (PGA) in Hatay province in the North-South component was recorded at station 3129, located in Defne, 146 km from the earthquake's epicenter, with a value of 1,351.5 cm/s². The second highest value in this component was measured at station 3126 in Antakya, 144 km from the epicenter (see Figure 9).

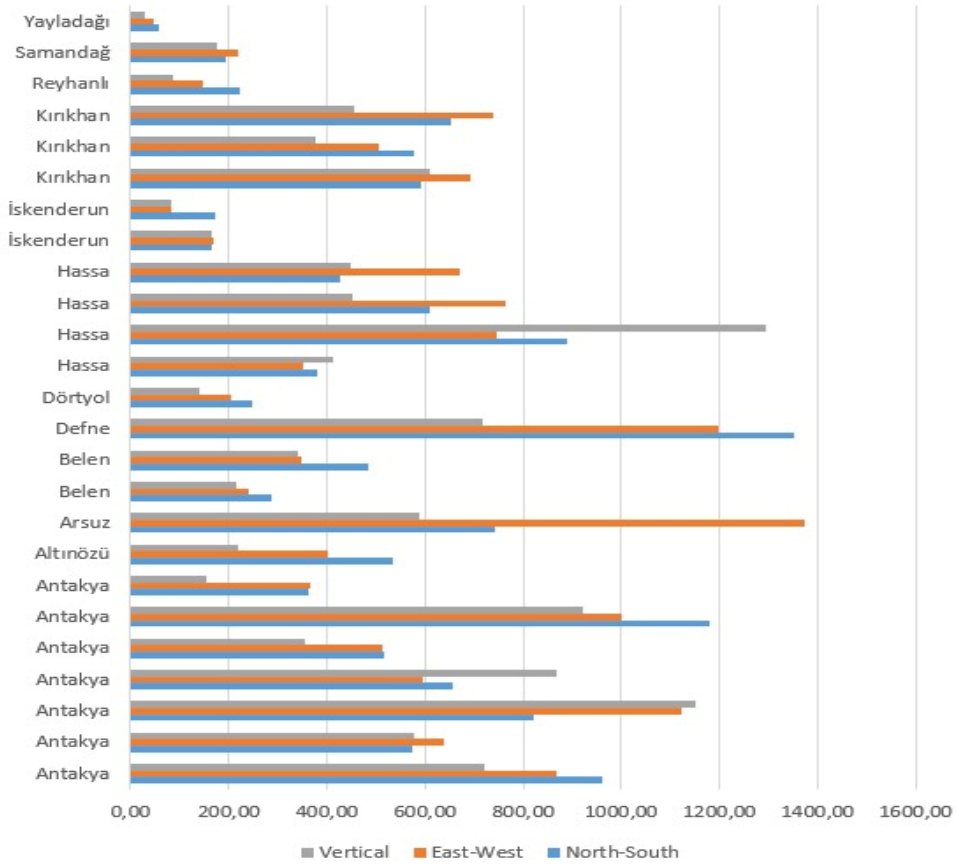

Figure 7: Peak ground acceleration values measured by different stations in Hatay Province (cm/sn^2). Acceleration values recorded by stations located within the borders of Hatay province as a result of the Mw 7.7 earthquake on Februrary 6, 2023

In the East-West component, the highest acceleration was recorded at station 3135 in Arsuz, located 142 km from the epicenter, with a value of 1,371.07 cm/s². The second highest value in this direction was again recorded at the Defne station (3129), with 1,198.74 cm/s² (see Figure 8).

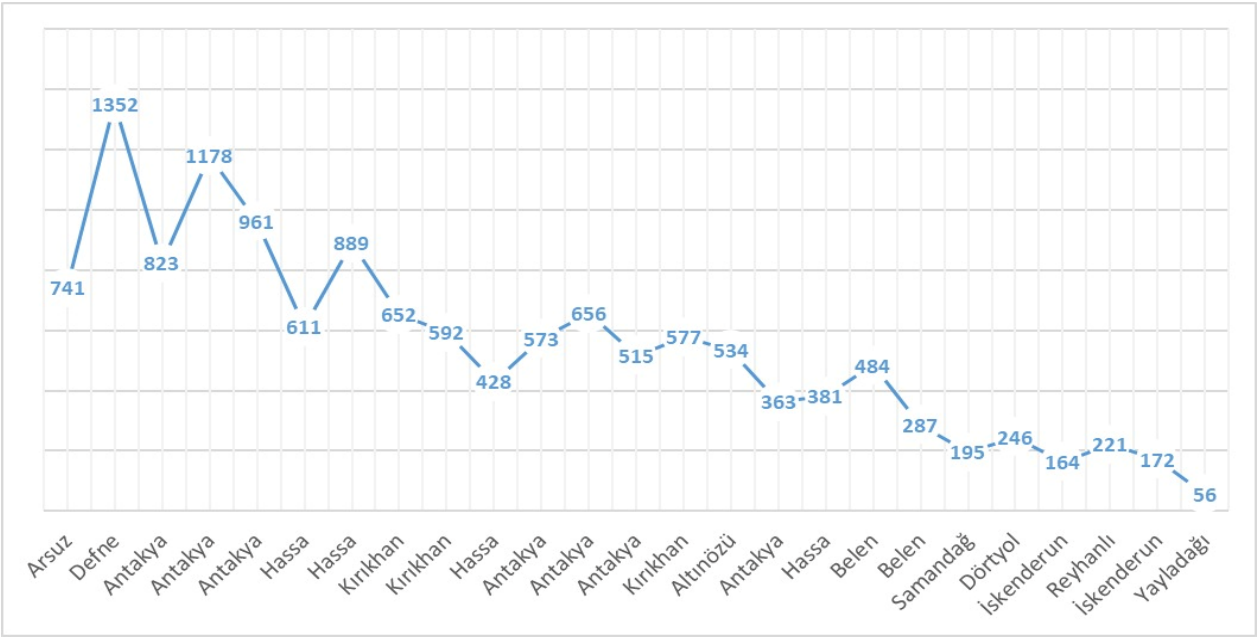

Figure 8: Peak ground acceleration values measured in the N-S component in Hatay Province (cm/s²)

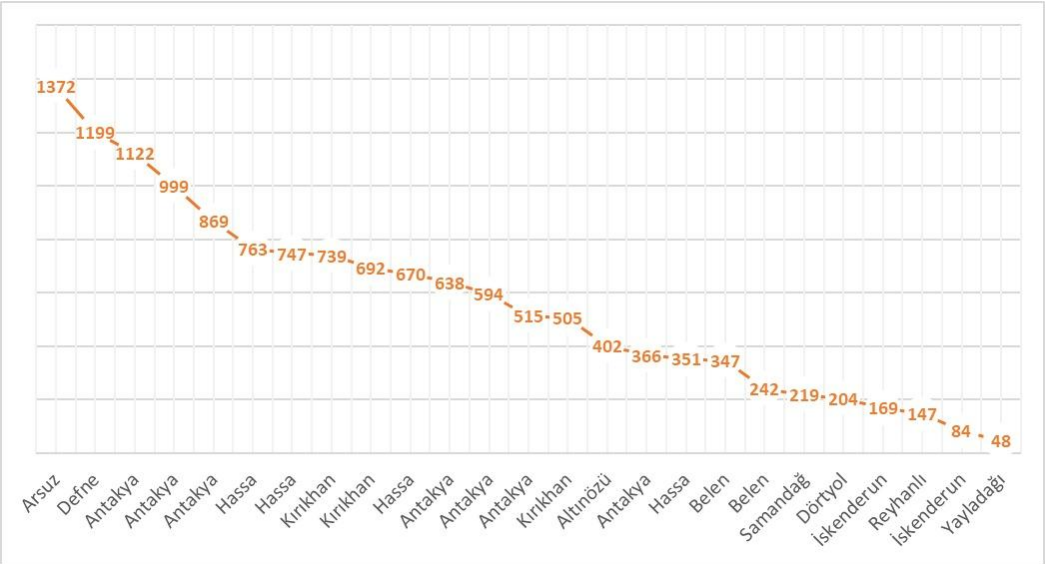

Figure 9: Peak ground acceleration values measured in the E-W component in Hatay Province (cm/s²)

3.1. Number of Collapsed Buildings

According to the Ministry of Environment, Urbanization and Climate Change, 13,517 buildings were demolished within the borders of Hatay province, 8,162 buildings were determined as structures in need of urgent demolition, and 67,346 buildings were classified as severely damaged (Avcı, 2023). A total of 89,025 buildings have been found to have collapsed, needed urgent demolition or were severely damaged. According to İstanbul Planlama Ajansı (2023), one-fifth of the existing buildings in Hatay are located within 2 kilometers of the fault lines, and it has been determined that the rate of damaged buildings increases as they approach the fault line (Table 4, 5 and 6). In the same study, it was determined that 45% (6,037) of the 13,361 collapsed buildings identified in Hatay were within 2 km of the fault lines, and 88% (11,708) were within 10 km. As defined by the Ministry, buildings classified as requiring urgent demolition have suffered damage to their load-bearing elements that are beyond repair or have been completely destroyed. These buildings are no longer safe for entry, and evacuation of belongings inside is impossible. Severely damaged buildings are characterized by widespread and significant fractures in their load-bearing elements caused by the disaster. These buildings have irreparable damage in terms of both structural integrity and economic value.

Table 4: Number of collapsed, emergency demolition required, and heavily damaged buildings by district in Hatay (İstanbul Planlama Ajansı, 2023)

DISTRICT	Collapsed	Emergency Demolition Required	Heavily Damaged	Total
Antakya	6369	3734	21830	**31933**
Altınözü	838	650	3892	**5380**
Arsuz	187	194	2176	**2557**
Belen	139	87	755	**981**
Defne	982	943	8894	**10819**
Dörtyol	115	75	1955	**2145**
Erzin	31	17	880	**928**
Hassa	1046	565	2887	**4498**
İskenderun	534	337	4622	**5493**
Kırıkhan	1886	605	6593	**9084**
Kumlu	131	84	738	**953**
Payas	58	39	630	**727**
Reyhanlı	318	134	1527	**1979**
Samandağ	670	557	8655	**9882**
Yayladağı	213	141	1312	**1666**
TOTAL	**13517**	**8162**	**67346**	**89025**

According to a study conducted by IPA in 2023, one-fifth of the existing buildings in Hatay are located within 2 kilometers of fault lines, and it was determined that the proportion of damaged buildings increases as proximity to the fault line decreases. This proximity to fault lines has been identified as one of the reasons for the severe damage experienced in the city. The same study found that out of 13,361 collapsed structures identified in Hatay, 6,037 (45%) were located within 2 kilometers of fault lines, and 11,708 (88%) of the collapsed buildings were situated within 10 kilometers of fault zones.

Table 5: Distance of damaged buildings from the fault line in Hatay Province (İstanbul Planlama Ajansı, 2023)

Distance from Fault Line (km)	Moderately Damaged Buildings	Heavily Damaged Buildings	Buildings Requiring Emergency Demolition	Collapsed Buildings	Total Number of Damgaed Buildings	%	Total of Buildings
2	6259	15543	2576	6037	30415	41	74401
4	6579	16772	2282	3644	29277	31	90515
6	3440	6962	1087	1346	12835	26	50073
8	1414	1902	196	374	3886	18	21561
10	858	1723	344	307	3232	19	16978
Total Number of Damaged Buildings	**18550**	**42902**	**6485**	**11708**	**79645**	**31**	**253528**
Total Number of Buildings	**22821**	**50658**	**7516**	**13361**	**94356**	**27**	**345692**

Additionally, Hatay Airport became unusable due to the earthquake. A fire broke out at the İskenderun port, causing damage. Railways and highways were also damaged, and disruptions occurred in natural gas, fuel supplies, electricity, and internet access. In addition to buildings, hotels, factories, schools, hospitals, businesses, and agricultural areas were also affected. İskenderun State Hospital and the Old Antakya State Hospital completely collapsed, while the Private Akademi State Hospital and Private East Mediterranean Hospital suffered severe damage. Additionally, a part of Antakya City Hospital collapsed.

The data on the proportion of buildings by construction year in 10 provinces were obtained from the Turkish Statistical Institute (Türkiye İstatistik Kurumu, 2021). The construction year of a building refers to the year when construction was completed or the building officially occupied. In Hatay, the number of households was 449,151. Of these, 13.5% lived in homes built before 1980, 32.6% in homes built between 1981 and 2000, and 50% in homes constructed in 2001 or later.

Table 6: Proportions of buildings in Hatay by year of constructions and their relaiton to erthquake zone maps and seismic building codes

Buildings in Hatay Province by Year of Construction			**Earthquake zone maps and building earthquake regulations that were legally enacted at different times and were required to be used during building constraction.**	
Time Period	**Propotion**	**Number of Households**	**Earthquake Zone Maps and Effective Dates**	**Sesimic Building Codes and Effective Dates**
Before 1980	%13.5	60.710	- July 12, 1945 Earhquake Zones Map, - December 20, 1947 Earthquake Zones Map, - April 24, 1963 Turkey Earthquake Zones Map, - May 15, 1972 Turkey Earthquake Zones Map	- 1940 Temporary Construction Directive for Earthquake Zones, - December 20, 1947 Turkey Earthquake Zones Building Code, -1949 Turkey Earthquake Zones Building Code, - November 3, 1953 Regulation on Buildings in Erthquake Zones, - September 2, 1961 Regulation on Buildings in Disaster Areas , - January 16, 1968, Regulation on Buildings in Disaster Areas, - August 9, 1975 Regulation on Buildings in Disaster Areas
1981 – 2000	%32.6	146.509	- May 15, 1972 Turkey Earthquake Zones Map and, April 18, 1996, Turkey Earthquake Zones Map	-“May 13, 1997 Regulation on Buildings in Disaster Areas,” - “January 1, 1998 Regulation on Buildings in Disaster Areas”, - “July 2, 1998 Regulation on Buildings in Disaster Areas”
After 2001	%50	224.464	- April 18, 1996 Turkey Earthquake Zones Map, - January 1, 2019 Turkey Earthquake - Hazard Map	“March 6, 2007 Regulation on Buildings to be Constructed in Earthquake Zones January 1, 2019 Building Earthquake Code”
Date Unknown	%3.9	17.468	-	

3.2. Official Earthquake Zone Maps and Their Relation with Damage

The changes in earthquake hazard levels of settlements within Hatay province over time have been detailed in the previous section. It is observed that in almost every newly published map, the earthquake zone classifications of Hatay and its districts have changed. The status of Hatay and its districts according to all officially approved and enacted earthquake zones/hazard maps in Turkey is presented in Table 7.

Table 7: Status of the districts in Hatay province according to seismic hazard maps

District	1945 Map	1947 Map	1963 Map	1972 Map	1996 Map
Antakya	Hazard	1	1	1	1
Altınözü	Hazard	1	1	1	1
Arsuz	Hazard	1	1	1	1
Belen	Hazard	2	2	2	1
Defne	Hazard	1	1	1	1
Dörtyol	Hazard	2	2	2	1
Erzin	Hazard	2	2	2	1
Hassa	Hazard	1	1	1	1
İskenderun	Hazard	2	2	2	1
Kırıkhan	Hazard	1	1	1	1
Kumlu	Hazard	1	1	1	1
Payas	Hazard	2	2	2	1
Reyhanlı	Hazard	1	1	1	1
Samandağ	Hazard	1	1	1	1
Yayladağı	Hazard	2	2	1	1

***1**: 1st degree, **2**: 2 st degree*

The new earthquake hazard map, which came into effect on January 1, 2019, eliminated the concept of zoning; therefore, comparisons like those in Table 7 cannot be made for this map (Türkiye Deprem Tehlike Haritası, 2018). With the new map, earthquake hazard is no longer conveyed by zones but is determined on a coordinate or point-based system. The hazard level at each point varies according to its proximity or distance to active faults. According to the earthquake hazard map made available online by AFAD, some districts of Hatay have seen increases in earthquake hazard, while others have seen decreases.

The previous version of the earthquake hazard map, from 1996, showed the entire Hatay province within the First-Degree Earthquake Zone. Accordingly, the ground acceleration values that would not be exceeded with a 90% probability over a 50-year period were calculated as 0.4 g throughout the province. According to building earthquake regulations, this value must be used as a legal requirement in structural design.

When comparing the 1996 and 2019 maps based on the 90% probability ground acceleration values not to be exceeded within 50 years, the largest increases are observed in Hassa (0.6 g), followed by Kırıkhan (0.512 g), Samandağ (0.421 g), and Antakya (0.448 g) districts. The largest decreases were observed in Erzin (0.290 g), Dörtyol (0.291 g), and İskenderun (0.311 g) districts. Thus, according to the new earthquake hazard map enforced in 2019, the earthquake hazard has increased in six districts of Hatay and decreased in nine districts.

Table 8 presents the maximum ground acceleration values recorded by stations in Hatay province during the February 6, 2023 Pazarcık–Kahramanmaraş earthquake, alongside the maximum ground acceleration values that, according to official seismic hazard maps, are not expected to be exceeded with 90% probability over a 50-year period.

Table 8: Expected maximum intensity and acceleration values according to the official seismic zone maps (1963, 1972, 1996, and 2019) for Hatay province and its districts, and the maximum acceleration values measured during the February 6, 2023 earthquake

HATAY	**Expected Maximum Earthquake Intensity on Bedrock (MSK)**		**Maximum Ground Accelerations on Bedrock Not Expected to Be Exceeded with 90% Probability (Within 50 Years) (g)**		
DISTRICT	**1963 Earthquake Zone Map**	**1972 Earthquake Zone Map**	**1996 Earthquake Zone Map**	**2019 Earthquake Hazard Map (PGA, g)**	**Peak Ground Acceleration Measured During the February 6, 2023 Earthquake (cm/s²)**
Antakya	VIII or higher	IX or higher	0.4	0.447	961.12
					638.32
					1151.56
					867.58
					515.31
					1178.12
					366.05
Altınözü	VIII or higher	IX or higher	0.4	0.380	534.22
Arsuz	VIII or higher	IX or higher	0.4	0.257	1372.07
Belen	VII - VIII	IX or higher	0.4	0.348	286.72
					483.85
Defne	VIII or higher	IX or higher	0.4	0.452	1351.50
Dörtyol	VII - VIII	VIII	0.4	0.303	246.11
Erzin	VII - VIII	VIII	0.4	0.290	No Station
Hassa	VIII or higher	IX or higher	0.4	0.602	412.11
					1296.27
					763.36
					670.17
İskenderun	VII - VIII	VIII	0.4	0.313	168.86
					171.86
Kırıkhan	VIII or higher	IX or higher	0.4	0.516	692.29
					577.13
					739.29
Kumlu	VIII or higher	IX or higher	0.4	0.371	No station
Payas	VII - VIII	VIII	0.4	0.304	No station
Reyhanlı	VIII or higher	IX or higher	0.4	0.359	221.41
Samandağ	VIII or higher	IX or higher	0.4	0.468	218.71
Yayladağı	VII - VIII	IX or higher	0.4	0.430	56.45

The maximum ground acceleration values recorded in Hatay province during the earthquake significantly exceeded the acceleration values predicted in both the 1996 earthquake zone map and the current 2019 earthquake hazard map as 50% with a 10% probability of being exceeded within 10 years. This situation has been observed especially in districts such as Antakya, Altınözü, Arsuz, Defne, Hassa and Kırıkhan. One of the main reasons for the great destruction in Hatay is that the acceleration values measured in the February 6 earthquakes were well above the levels predicted in the official seismic zone maps in force. This, combined with other factors, increased the extent of the damage.

Antakya province was recorded Peak Ground Acceleration (PGA) and damage was reported by AFAD (Cetin et al., 2025). In some parts of Antakya, where basin and ground effects were observed, the ground accelerations affecting the structures were much higher than the rock floors, which led to more destruction or heavy damage to the buildings than expected (Işık, 2023). In addition, liquefaction and ground settlements have also caused damage in some areas. It was also found that a large number of structures that were not designed and built in accordance with the regulations were damaged.

4. Conclusion and Recommendations

The extent of damage caused by earthquakes is shaped by multiple variables, including the magnitude of the event, focal depth, proximity to settlements, and the geological and geotechnical characteristics of the affected area. However, these physical parameters alone are not sufficient to explain damage patterns; the engineering quality of buildings, including their design, construction practices, and structural integrity, plays a decisive role in determining the level of destruction.

In this context, the condition of the building stock in Hatay emerges as a significant factor that amplified the earthquake's impacts. In several parts of the Antakya district, basin effects and soil amplification led to ground motion intensities substantially higher than those observed on rock sites. These adverse ground conditions resulted in greater-than-expected settlements, liquefaction-induced damage in certain areas, and severe structural damage to numerous buildings. Furthermore, structures that were not designed and constructed in compliance with the applicable building codes were disproportionately affected.

These observations highlight that creating disaster-resilient cities requires more than technical engineering solutions; it necessitates the effective implementation of a comprehensive disaster risk management approach. Such an approach must integrate legal and administrative dimensions alongside planning and implementation processes. In particular, the proper resolution of post-earthquake disputes depends on accurate knowledge of the seismic zoning maps and building regulations in force at the time of construction.

At this point, understanding how seismic hazard levels have evolved over time becomes critically important. Changes in seismic hazard parameters directly influence the seismic performance of buildings and can either increase or reduce the overall earthquake risk in urban areas. Identifying the locations of settlements within historical seismic zoning maps provides vital data for disaster risk reduction, emergency response, and post-disaster recovery planning.

Therefore, when preparing disaster management plans, assessing high-risk buildings and areas, determining insurance premiums, and planning structural retrofitting interventions, it is strongly recommended to consider the historical evolution of official seismic zoning maps. Adopting this integrated perspective contributes not only to minimizing physical losses but also to ensuring more effective management of legal processes following earthquakes.

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