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Damage Assessment of Buildings in Adıyaman-Gölbaşı after Kahramanmaras Earthquakes (6 February 2023)

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Abstract – According to the data of Disaster and Emergency Management Presidency (AFAD), on 6 February 2023, at 4.17 and 13.24 (at Turkish time), earthquakes with magnitudes of 7.7 and 7.6 (Mw) occurred with epicentres in Pazarcık (Kahramanmaraş) and Elbistan (Kahramanmaraş), respectively. These earthquakes affected 11 provinces of Turkey and were recorded as the most destructive earthquakes in the last century. Adıyaman-Gölbaşı was also highly affected by these earthquakes, which caused loss of life and property, and numerous buildings were destroyed and damaged. In this study, the situation of Gölbaşı district of Adıyaman province after the earthquakes was discussed. The current situation in the city as of May has been documented. Damaged reinforced concrete structures were examined on-site in terms of structural irregularities, application methods and material properties and the causes of the damages were evaluated. It was determined that there were major damages especially in the settlement areas close to the lake. The results of the study clearly reveal that natural disasters that may occur are directly related not only to structural systems but also to ground conditions.

Keywords – Damage Assesment, Earthquake, Building Technology, Material Properties, Gölbaşı.

I. INTRODUCTION

Anatolian lands have been located on active and highly seismic fault lines for many years. These fault lines are North Anatolian Fault, East Anatolian Fault, North East Anatolian Fault and West Anatolian Fault. Among these faults, the North Anatolian Fault and the East Anatolian Fault are the most active faults with short return periods. As a result of earthquakes in Turkey in recent years, these two faults have caused significant loss of life and high amounts of structural damage [1,2,3].

The basic rule of design under earthquake effects is that the structural system of buildings should be as simple and plain as possible [4]. This provides the predictability of earthquake behaviour in buildings [5]. It is of vital importance that the concrete and reinforcements, which are the most important elements of the structural system in reinforced concrete buildings, comply with the standards [6]. Standards are determined according to the earthquakes that occurred in the region. Therefore, these standards have a critical role in taking precautions against earthquakes that may occur in the future.

Şenol [6] has presented a table in his study in order to evaluate the earthquake resistance of the buildings constructed in Turkey and to compare the standards of the buildings. constructed in the past years and the buildings to be constructed today. This table allows the comparison of the standards of the buildings constructed in the past years and the buildings to be constructed today. The development of technical conditions such as the minimum concrete strengths accepted in the construction of buildings, inspection services to be applied and the use of ready-mixed concrete was demonstrated over the years (Table 1). Three different regulations were announced in Turkey and these regulations were generally developed after earthquake disasters. There is also a possibility that a new earthquake regulation will be announced after the earthquakes centred in Kahramanmaraş.

Table 1. For earthquake-resistant design of buildings development of the regulations and methods applied.

Year	Regulation	Technical conditions and methods
1975	Regulation on Buildings to be Constructed in Disaster Areas	Concrete with a resistance lower than C18 cannot be used in the first and second earthquake zones.
1998	Earthquake Regulation	Earthquake zones of the first and second degree, C20 or more high resistance concrete must be used.
2000	TS500 Reinforced Concrete Structures Design and Construction Rules	The use of non-ribbed reinforcement in reinforced concrete structures was prohibited.
2001	Building Inspection Services started.	19 cities were selected as pilot provinces and building inspection services were started to be implemented.
2002	TS EN 206-1	Specification, performance, fabrication and conformity standard of ready-mixed concrete was published.
2004	Ministry of Environment and Forestry / Circular No. 248	The use of ready-mixed concrete became compulsory with the prohibition of manual concrete casting.
2007	Earthquake Regulation	The use of concrete with a resistance lower than C20 was prohibited in all reinforced concrete buildings to be constructed in earthquake zones.
2011	Building Inspection Services became compulsory.	Building Inspection Servics became compulsory in all provinces.
2018	Earthquake Regulation	Minimum cross-sectional dimensions of columns were extended. Minimum C25 concrete type was required to be used in all buildings.
2019	Electronic Concrete Monitoring System (EBIS) application was initiated.	The chips inserted in the concrete samples were monitored electronically and any intervention to any results without the knowledge or authorisation of the Ministry was prevented.

When evaluating the causes of structural damage caused by earthquakes, it would be useful to consider the technical methods and regulations applied during the construction of the buildings. There are quite a number of studies in the literature that performed post-earthquake field research. Maeda et al. [7] evaluated reinforced concrete structures after earthquakes in Japan. Inel et al. [8] performed assessments on the re-evaluation of buildings after the destructive earthquakes experienced in Turkey until 2008. Goretti et al. [9] conducted field research on the post-earthquake safety of structures in Portovejo. Fukuyama and Sugano [10] worked on the rehabilitation of concrete buildings after the Hyogoken-Nanbu earthquake. Lulić et al. [11] analysed the conditions of educational buildings after the earthquake in Zagreb in 2020. Di Ludovico et al. [12] observed and explained the situation of 1514 school buildings after earthquakes in Italy. Didier et al. [13] investigated post-earthquake building safety using rapid visual damage assessment data after the Nepal 2015 Earthquake. Bayraktar et al. [14] evaluated the historical masonry buildings after the Van earthquake in 2011. Romão et al. [15] included the damages observed during a 2-day field research 2 weeks after the earthquake. In this context, field researches and evaluations conducted after the earthquake have a significant role in the literature.

According to the data of Disaster and Emergency Management (AFAD) Earthquake Department; on 6 February 2023, earthquakes with an epicentre of 7.7 magnitude (4.17 pm) in Pazarcık and 7.6 magnitude (13.24 pm) in Elbistan occurred. These earthquakes were experienced in many cities in Turkey. There were 11 provinces (Kahramanmaraş, Hatay, Adıyaman, Osmaniye, Gaziantep, Şanlıurfa, Malatya, Malatya, Diyarbakır, Adana, Kilis and Elazığ) that recorded loss of life and property and the earthquakes were considered to be the most destructive earthquakes of the last century.

This study includes observational damage assessments in Gölbaşı district of Adıyaman province. The buildings in the region were analysed on-site in terms of structural irregularities, materials used, ground problems and the effect of earthquake forces etc. The ground amplification and liquefaction studies of Gölbaşı realised by Gücek et al. [16]. There are also studies on Adıyaman that include damages to both historical and reinforced concrete structures [17-

20]. However, there are no studies in the literature based on observational data for Gölbaşı district.

II. Materials and Method

The study includes an observational assessment of the situation after the 06 February 2023 earthquake in Adıyaman-Gölbaşı district. Gölbaşı has a population of approximately 50 thousand and the number of reinforced concrete buildings has increased recently with the increasing population over time. Gölbaşı Lake is located in the north direction of the city. There is Atatürk Boulevard axis dividing the city into two from the centre from northeast to southwest (Fig. 1).

Fig. 1 Gölbaşı urban settlement

III. Findings

According to the findings obtained during the investigations performed within the scope of the study, it was determined that there were many buildings that collapsed during the earthquake. It was seen that the rubble of these buildings was removed during the field study. It was determined that the collapsed buildings were especially in the residential area located close to the lake area (Fig 2, Fig. 3). It was observed that there were almost no heavily damaged buildings in the area in the eastern direction of Atatürk Boulevard (the direction away from the lake).

Fig. 2 Collapse of a commercial and residential building

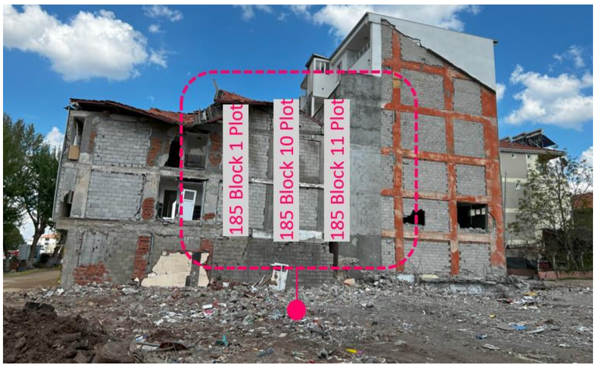

Fig. 3 Collapse of a commercial and residential buildings

It was determined by the municipality authorities that the collapses were caused by weak foundation properties. In the soil survey investigations conducted in the area (location close to the lake), no appropriate ground for construction could be obtained even at a depth of approximately 18 metres (Gölbaşı Municipal Authorities, May 2023).

When the damaged buildings were analysed, it was seen that the earthquake effect:

- It was observed that the effect of the earthquake caused the buildings to collapse several metres at the same location (Fig. 4). This damage was noticed in many buildings. Especially in buildings without structural damage, it is obvious that this problem is related to the ground properties. Failure to select the foundation appropriate to the ground causes this situation.

Fig. 4 Structures collapsing on the site

- There were many damaged buildings which leaned on their sides due to the earthquake despite their strong structure and load-bearing system (Fig. 5). These damages may occur due to weak ground properties, foundation design of the building and incompatibility of the load-bearing system between stories.

Fig. 5 Buildings leaning on their sides due to the earthquake

- It was observed that there were buildings demolished due to their design features. These buildings were demolished because of the lack of a systematic load-bearing system due to the design features. Amorphous form of buildings, unsymmetrical load-bearing elements, inaccurately analysed static properties and weak grounds often cause the buildings to collapse due to torsional effects (Fig. 6).

Fig. 6 Damaged building due to design features

- Due to insufficient vibration and segregations, corrosion of reinforcements and decreased integration of concrete and reinforcements cause deterioration of the pressure equilibrium of the building (Fig. 7). Therefore, the potential of these buildings to be damaged by earthquake forces increases.

Fig. 7 Damaged building as a result of insufficient vibration, segregation and irregular load-bearing system etc.

- Damages were observed in adjacent buildings due to the effect of earthquake on the structures acting on each other. This is caused by the impact of the structural elements against each other during the earthquake and the earthquake effect cannot be absorbed. The building with strong load-bearing elements can stand, while the building with weak elements will be damaged or demolished. Similar demolitions were also observed in Adıyaman-Gölbaşı due to adjacent buildings. For instance, it was determined that the column-beam connection of the adjacent building in Kadirler Apartment Building was not continuous and the joints were cut (Fig. 8).

Fig. 8 Heavily damaged Kadirler Apartment

- Besides ground properties, design problems and structural mistakes, wrong materials used also caused the collapse of the buildings (Fig. 9).

Fig. 9 Collapses caused by material use

The destruction caused by the earthquake effect was clearly visible in the Gölbaşı. Especially in the residential area from Atatürk Boulevard towards the lake, the number of collapsed and heavily damaged buildings is considerable. These demolitions caused many effects such as infill wall damages, deficiencies of stirrups, use of unsuitable aggregate, strong beam-weak column effect, etc (Fig. 10).

Fig. 10 Examples of damaged buildings

IV. DISCUSSION

The damages detected in the region were mostly caused by structural irregularities, inadequate quality of building materials, insufficient construction quality, poor workmanship and non-compliance with Earthquake Regulations.

A process to safeguard against earthquakes should be based on an effective strategy, risk assessment and management. Developing regional earthquake risk maps, assessing building stocks and preparing emergency response plans play a crucial role in reducing earthquake damages. Furthermore, the commitment of local governments to update and implement building standards is also essential.

V. CONCLUSION

This study aimed to evaluate the damage conditions of some buildings in Adıyaman-Gölbaşı after the 6 February 2023 Kahramanmaraş earthquakes and to classify the damaged buildings according to structural damages and their reasons. The results obtained from field observations were presented together with figures. It was determined that the earthquake had a destructive effect on the city. In accordance with information obtained from regional authorities, it has been determined that approximately 480 people lost their lives in Gölbaşı due to the collapsed structures as a result of the earthquake. This tragic loss is directly associated with the casualties caused by the collapsed buildings. Evaluating the impacts of such disasters is crucial for refining disaster management and intervention strategies.

This study concluded that ground features have a significant importance in the urbanisation process. A considerable number of buildings were damaged and collapsed in the areas close to the lake in Gölbaşı. Construction should be avoided in areas with ground liquefaction. The construction process should be managed with appropriate foundation selection in weak grounds.

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REFERENCES

[1] N. Caglar, I. Vural, O. Kirtel, A. Saribiyik, and Y. Sumer, "Structural damages observed in buildings after the January 24, 2020 Elazığ-Sivrice earthquake in Türkiye," *Case Studies in Construction Materials*, 18, e01886, 2023.

[2] Z. Celep, A. Erken, B. Taskin, and A. Ilki, "Failures of masonry and concrete buildings during the March 8, 2010 Kovancılar and Palu (Elazığ) earthquakes in Turkey," *Engineering Failure Analysis*, 18(3), pp. 868-889, 2011.

[3] A. Shabani, M. Zucconi, D. Kazemian, M. Kioumarsi, "Seismic fragility analysis of low-rise unreinforced masonry buildings subjected to near-and far-field ground motions," *Results in Engineering*, 101221, 2023.

[4] *Turkey Building Earthquake Regulation*, 2019, Disaster and Emergency Presidency of Situation Management, Ankara.

[5] E. Hussain, S. Kalaycıoğlu, C. W. Milliner, and Z. Çakir, "Preconditioning the 2023 Kahramanmaraş (Türkiye) earthquake disaster," *Nature Reviews Earth & Environment*, pp. 1-3, 2023.

[6] A. F. Şenol, "Kahramanmaraş Depremleri (6 Şubat 2023) Sonrası Hatay İlindeki Yapıların Hasar Durumlarının Değerlendirilmesi," *In International Conference on Engineering, Natural and Social Sciences*, 1, pp. 75-80, April, 2023.

[7] M. Maeda, H. Al-Washali, and K. Matsukawa, "An overview of post earthquake damage and residual capacity evaluation for reinforced concrete buildings in Japan," *In Proceedings of the Pacific Conference on Earthquake Engineering*, Auckland, New Zealand, pp. 4-6, April, 2019.

[8] M. Inel, H. B. Ozmen, and H. Bilgin, "Re-evaluation of building damage during recent earthquakes in Turkey," *Engineering Structures*, 30(2), pp. 412-427, 2008.

[9] A. Goretti, C. M. Hutt, and L. Hedelund, "Post-earthquake safety evaluation of buildings in Portoviejo, Manabí province, following the Mw7. 8 Ecuador earthquake of April 16, 2016," *International journal of disaster risk reduction*, 24, pp. 271-283, 2017.

[10] H. Fukuyama, and S. Sugano, "Japanese seismic rehabilitation of concrete buildings after the Hyogoken-Nanbu Earthquake," *Cement and Concrete Composites*, 22(1), pp. 59-79, 2000.

[11] L. Lulić, K. Ožić, T. Kišiček, I. Hafner, and M. Stepinac, "Post-earthquake damage assessment—Case study of the educational building after the Zagreb earthquake," *Sustainability*, 13(11), 6353, 2021.

[12] M. Di Ludovico, A. Digrisolo, C. Moroni, F. Graziotti, V. Manfredi, A. Prota, M. Dolce, and G. Manfredi, "Remarks on damage and response of school buildings after the Central Italy earthquake sequence," *Bulletin of Earthquake Engineering*, 17, pp. 5679-5700, 2019.

[13] M. Didier, S. Baumberger, R. Tobler, S. Esposito, S. Ghosh, and B. Stojadinovic, "Improving post-earthquake building safety evaluation using the 2015 Gorkha, Nepal, Earthquake rapid visual damage assessment data," *Earthquake Spectra*, 33(1_suppl), pp. 415-438, 2017.

[14] A. Bayraktar, A. C. Altunışık, and M. Muvafık, "Field investigation of the performance of masonry buildings during the October 23 and November 9, 2011, Van Earthquakes in Turkey," *Journal of Performance of Constructed Facilities*, 30(2), 04014209, 2016.

[15] X. Romão, A. A. Costa, E. Paupério, H. Rodrigues, R. Vicente, H. Varum, and A. Costa, "Field observations and interpretation of the structural performance of constructions after the 11 May 2011 Lorca earthquake," *Engineering Failure Analysis*, 34, pp. 670-692, 2013.

[16] S. Gücek, K. B. Afacan, and İ. Zorluer, "6 Şubat 2023 Depremleri Sonrası Zemin Büyütmesi ve Sıvılaşma Gerçeği: Antakya, Gölbaşı, Türkoğlu Örnekleri," *Afyon Kocatepe Üniversitesi Fen Ve Mühendislik Bilimleri Dergisi*, 23(3), pp. 740-752, 2023.

[17] E. Çambay, "Damage Assessment of Masonry Structures in Adıyaman Province After Kahramanmaraş Earthquakes (February 6, 2023)," *Firat University Journal of Experimental and Computational Engineering*, 2(3), pp. 117-123, 2023.

[18] O. İnce, "Structural damage assessment of reinforced concrete buildings in Adıyaman after Kahramanmaraş (Türkiye) Earthquakes on 6 February 2023", *Engineering Failure Analysis*, 156, 107799, 2024.

[19] M. L. Ivanov, and W. K. Chow, "Structural damage observed in reinforced concrete buildings in Adiyaman during the 2023 Turkiye Kahramanmaras Earthquakes," *Structures* 58, p. 105578, 2023.

[20] E. Işık, F. Avcil, E. Arkan, A. Büyüksaraç, R. İzol, and M. Topalan, "Structural Damage Evaluation of Mosques and Minarets in Adıyaman due to the 06 February 2023 Kahramanmaraş Earthquakes," *Engineering Failure Analysis*, 107345, 2023.