8th International Conference on Seismology & Earthquake Engineering
11-13 Nov. 2019, Tehran, Iran

LESSONS FROM NOVEMBER 2017, M7.3 EZGELEH EARTHQUAKE

Erfan ALAVI
Ph.D., Structural Dep., Sazeh Consultants, Tehran, Iran
e.alavi@sazeh.co.ir
Seyyed Mohammad Hossein SHAMEKHI
M.Sc., Structural Dep., Sazeh Consultants, Tehran, Iran
m.shamekhi@sazeh.co.ir

Keywords: Construction deficiencies, Design deficiencies, Ezgeleh earthquake, Crisis management

Iran is one of the most seismically active countries in the world, being crossed by several major active faults on the Alpine-Himalayan Belt. The earthquake of the evening of November 12, 2017 with a moment magnitude of 7.3 has been one of the most destructive earthquakes over the past two decades in Iran. This earthquake was strong enough to be felt in a vast region by over 100 million people and resulted in a large number of casualties in Kermanshah province (620 people according to the latest published reports) in addition to extensive financial losses.

The earthquake epicenter was located 10 km south of Ezgeleh and about 37 km northwest of Sarpol-e-Zahab (34.84°N, 45.7°E) with approximately 18 km in depth.

The major faults of the region include the Zagros Mount forehead fault and the High Zagros Fault. The large width of the aftershock zone shows that the slope of this fault is very low. The presence of scattered clusters demonstrates that aftershocks might have been occurred as the result of the activity of existing small faults. Earthquake catalog of Sarpol-e Zahab County shows two strong shocks of M6.8 and M6.5 in 958 and 1226 A.D., respectively.

This study aims to investigate and address some of considerable deficiencies in construction and design of buildings in the region. Also, main learned lessons are drawn and some solutions are suggested to decrease earthquake consequences as far as possible. Some of damages to structural systems, members and connections are analyzed and discussed, too.

Status of remaining parts of collapsed or damaged members showed that there could have been problems in verifications from beginning of design to end of construction. Many of structural connections and members were constructed incorrectly, inconsistent with the common engineering practices and guidelines.

On the other side, social media effects and public sympathy, raised morale among the victims after the earthquake. People in the region evacuated the survived buildings for a time and prepared for probable after-shocks. Addition to governmental recovery operations, a number of non-governmental organizations and individuals cooperated to redress the situation.

Outcomes and lessons from widespread destructions over the cities of the earthquake struck region have been evaluated and concluded as the following reasons:

1- Geotechnical issues: Large horizontal and vertical displacements of the ground, soil types and dynamic behavior of the soil, landslides and rockfalls near the slopes and escarpments caused some severe damages to properties.

2- Deficiencies in construction: More than half of the constructed properties were of masonry structure types. Nevertheless, both concrete and steel structures were also seriously damaged. The reasons may vary from superintendence to construction methods and materials further to engineering calculations.

Most of masonry buildings were unreinforced, with no lateral force resisting systems. Although some old arch brick ones survived the earthquake (Figure 1), many of the walls and roofs collapsed during the not long lasting quake shocks (Figure 2).

Construction methods were not followed correctly according to the available standards and specifications. Low quality materials, inadequate strength of concrete, inappropriate welding procedures have been of the most observed problems.


Figure 1. Survived old building with arch bricks.


Figure 2. Damaged walls and roofs.

Local and international design codes should be regarded in engineering calculations. In many cases, neither structural nor non-structural members were properly designed in accordance with design guidelines. For instance, incorrect chevron beam design, insufficient development length of reinforcements, and insufficient out-of-plane lateral support of infills were noticeable in structural systems (Figure 3).


(a)


(b)

Figure 3. Structural failures due to design errors: (a) Chevron beam failure; (b) Rebar debonding in concrete; courtesy of Milad Shamsodin.

3- Organizational and official aspects: Verification and validation of design procedures, technical notes, and design drawings should have been properly carried out by authorized members of construction engineering organization; all construction methods and required tests should have been adequately checked and ordered by authorized superintendents during the construction period.

One of the most important defects before a strong earthquake hit is pre-disaster management. From humanitarian actions such as public preparedness, adaptable makeshift tents, muster stations, safe houses to governmental crisis prevention activities could be previously planned. Non-structural elements, especially facades, and their connections shall be also designed for seismic drifts. Many life losses might be prevented by efficient and strict construction supervision and secondary hazard identification such as fire spreads and lifelines survival.

REFERENCES

Alavi, E., Mahootchian, A., Yadegari, S., Shamsodin, M., Babania Nouri, M., and Ordoubadi, B. (2018). *Report of M7.3 Ezgele, Kermanshah, Iran Earthquake on November 12, 2017.* Oakland: Earthquake Engineering Research Institute.

BHRC (2017). *Findings of Kermanshah, Sarpol-e Zahab Earthquake*. Road, Housing & Development Research Center Seminar, Tehran, Iran.

Hosseini Hashemi, B., and Jafari, M.A. (2012). Experimental evaluation of cyclic behavior of batten columns. *Journal of Constructional Steel Research, 78*, 88-96.

Stern, R.J. and Johnson, P. (2010). Continental lithosphere of the Arabian plate: a geologic, petrologic, and geophysical synthesis. *Earth-Science Reviews, 101*, 29-67.