SOME LESSONS FROM THE SARPOL-E ZAHAB EARTHQUAKE OF NOVEMBER 2017

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The Sarpol-e Zahab, Kermanshah earthquake of November 12, 2017, with a moment magnitude of 7.3, was one of the most destructive earthquakes in the past two decades in Iran. This earthquake was felt over more than half of the country and resulted in a large number of casualties in Kermanshah province (estimated as between 600 to 700 people) in addition to extensive financial losses. The earthquake epicentre was located 10 kilometres south of Ezgeleh and about 37 kilometres northwest of Sarpol-e Zahab with an estimated depth of 18 kilometres.

Damage was extensive in both the traditional and confined masonry buildings, as well as, the code-designed framed buildings. The reason for the extensive damage may primarily be attributed to the poor workmanship as has been reported from other major earthquakes of the past three decades in Iran (Maheri, 1990, 1992, 1998; Maheri et al., 2005). However, some shortcomings of the current seismic codes, such as Standard 2800 and Discussions 8, 9 and 10 of the Iranian National Building codes could be noted regarding the performance of the buildings during the Kermanshah earthquake.

In the proposed paper, a critical look is made on some aspects of the seismic and other Iranian building design codes regarding both the code-recommended confined masonry, as well as the RC and steel framed buildings. Some of the highlights of discussion include:

1. Inefficiency of the current levels of confinement in masonry buildings specified in Standard 2800 and version 2 of the Discussion 8 of the National Building Code to provide adequate seismic resistance for masonry buildings taller than one storey (see Figure 1).

Figure 1. Inadequacy of the code provisions for confined masonry.

2. The severe damage to some code-designed framed buildings was unexpected. The damage to framed buildings were evidently a function of the type of soil the buildings were built upon. In Sarpol-e Zahab, the seven-storey RC framed buildings of the Maskan Mehr complex situated on the alluvial soft soil near the river were severely damaged and

some collapsed. The very high intensity of shaking in this location during the earthquake was evident, not only from the level of structural damage, but also from the major damage to the non-structural elements such as infills. On the other hand, almost similar height buildings of another Maskan Mehr complex in Sarpol-e Zahab, which were located on a foothill and almost the same distance from the epicentre compared to the RC buildings of the other complex, were not damaged at all. In fact, as it can be seen in Figure 2, even all the free-standing thin masonry walls situated at the roof level survived the earthquake, which indicates no or very little dynamic magnification occurring at the latter site. It can be noted that, two sets of buildings, which according to 2800 Standard have almost identical natural periods of vibration and being effectively the same distance away from the epicentre, behave completely different during the earthquake shaking. The difference in response is evidently due to the type of soil they were located on. In the proposed paper, an attempt is made to correlate the response factor (B) of the Standard 2800 for these two sets of buildings, with their actual seismic performance.

Figure 2. Site effects on two similar building complexes in Sarpol-e Zahab.

3. Another major consideration to be discussed in the paper is the level of damage to the non-structural elements, particularly at the RC buildings of the Maskan Mehr complex. In most buildings, the structural damage appeared to be limited; however, the non-structural damage was severe, indicating very high levels of inter-storey drifts in these flexural frame buildings. It is evident that the flexural frames alone were not able to control the excess inter-storey drift; therefore, it is argued that for this type of low to mid-rise buildings, dual systems become mandatory and similar to masonry buildings, a minimum shear wall (and/or bracing system) requirement be imposed on framed buildings. In this way, not only the drift, and therefore, non-structural damage will be controlled, but also a secondary resisting system is incorporated, should the primary system fail to achieve its objectives, as was the case in these buildings.

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