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POST-EARTHQUAKE RECONNAISSANCE OF SARPOL-E ZAHAB CONCRETE BUILDINGS AFTER 6.4 MAGNITUDE AFTERSHOCK

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In the 7.3 magnitude earthquake of November 12, 2017, the concrete buildings in Sarpol-E Zahab were severely damaged and even collapsed. The concrete building systems can be divided into three categories: moment resisting frames, shear walls and dual systems. Moment resisting frame systems are very popular because of their low cost and ease of construction. In this type of structural system, both gravity and lateral forces are supported by beams and columns.

Shear wall systems in concrete buildings are used to provide stiffness and strength of the buildings against lateral forces such as earthquakes. Such structures are usually stiff and they behave well specially if they are combined with moment resisting frames.

Ductility of the concrete elements depends highly on reinforcement detailing. Our observations show that insufficient bending details in stirrups, inadequate overlap length for longitudinal bars and deficient curing of the concrete are the main reasons of damages in such buildings.

Figure 1. concrete structure having a shear wall in one direction and a moment resisting frame in another.

Figure 2. Lack of sufficient stirrups in columns.

Most regular repairing methods are as: columns strengthening by steel/concrete jacketing (Figure 3) or FRP, addition of shear walls or strengthening the existing ones (Figure 4) and foundation rehabilitation. Despite the criteria to design the columns stronger than beams, no plastic hinge was observed in beams and all of them were occurred in columns. This may be due to having a thick concrete floor connected to the beams, resisting against moment and protect them for

cracking.

Efficiency of the repairing methods are naturally tested in 6.4 magnitude aftershock occurred on 25 November 2018, which are reported in this paper. Figure 4 shows a repaired three-story concrete building, before and after the aftershock.

Figure 3. columns strengthening by steel Jacketing.

Figure 4. Meshing on the shear wall.

(a) Before the aftershock

(b) After the aftershock

Figure 5. A repaired three-story concrete building.

REFERENCES

Hosseini Hashemi, B. and Lukzade, A. (2018). Brief study on rehabilitation and retrofitting damaged structures in the first anniversary of Sarpol Zahab earthquake. *The 1st National Conference on the Role of Civil Engineering in Hazard Mitigations*.

Hosseini Hashemi, B., Abbasnejadfard, M., and Keykhosro Kiany, B. (2018). Performance of Masonry Buildings in November 12, 2017, Sarpol-e Zahab-Ezgeleh Earthquake (M_W 7.3). *Journal of Seismology & Earthquake Engineering*, *20*(3).

Hosseini Hashemi, B. and Keykhosro Kiany, B. (2019). Performance of Steel Structures and Associated Lessons to be Learned from November 12, 2017, Sarpol-e Zahab-Ezgeleh Earthquake (MW 7.3). *Journal of Seismology and Earthquake Engineering*, *20*(3), 33-46.