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Performance of Masonry Structures During the 2019 Durrës (Albania) Earthquake

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Keywords: Durrës Earthquake, unreinforced masonry, failure, collapse

1 INTRODUCTION

Since masonry is one of the most economically available building materials, unreinforced masonry (URM) construction has been commonly used in Albanian building stock (Bilgin and Hysenlliu, 2020). Older buildings were mostly built from stone or brick walls. Reviewing the seismic performance of this type is valuable given the increased interest in seismic hazard reduction in existing URM buildings around the world (Decanni et al, 2004).

Albanian building stock is dominated by the masonry, built in the absence of modern earthquake-design requirements (i.e. KTP-63, 1978; KTP-N2, 1989). These buildings are at greater risk than the new ones not only because they have been designed no or little seismic requirements but also not being capable of absorbing energy through large inelastic deformations (Bilgin and Huta, 2018). Many construction companies have introduced European norms (Eurocode 6; Eurocode 8) in their products. Despite of this fact, according to the Albanian legislation in the field of construction, the design of structures still must follow the KTPs–Albanian Technical Codes.

The main purpose of this paper is to demonstrate the damage suffered by masonry buildings during Durres Earthquake, and to explain why numerous types of observed failures occurred. Most of lessons learned from this assessment are believed to be applicable and have implications for the design practise under seismic forces.

2 STRUCTURAL DAMAGES

2.1 Building stock and damage types in the region

The types of construction in the earthquake-stricken area can be classified as follows;

- Reinforced concrete (RC) frames with masonry infill walls. This type is used for all building heights. As these masonry infill walls have a dominant effect on the performance of the main structural system, a short overview of this seismic performance is remarkable.
- Older masonry buildings mainly constructed stone and brick masonry,
- Industrial buildings.

There is a direct correlation among the qualities of construction materials, peak ground acceleration and damage (Kaplan et al., 2010). The failures observed from the Durres Earthquake varied depending on the building type, the location, and the age of construction. The observed failure modes of masonry buildings can be classified as follows;

- In-Plane and out-of-plane failures,
- Anchorage-related failures,
- Diaphragm-related failures.

These failure patterns are defined in the subsections with the observed damaged buildings.

2.2 Structural damages to masonry buildings

In many of the damaged buildings, shear in plane failures were common expressed by double-diagonal shear cracks. Excessive shear or bending produced in-plane failures in many old buildings in Albania (Fig. 1.).

Fig. 1. In-plane shear failure of URM walls

In masonry facades where numerous window openings, spandrels and the short piers failed in shear (Fig 2.).

Fig. 2. In-plane shear failure of URM piers

In the absence of anchorage, the exterior walls behaved as cantilevers over the height of the buildings and resulted in failures in many buildings (Fig.3.).

Fig. 3. Failure due to the lack of proper anchorage

Another observed damages on URM buildings were occurred due to the lack or rigid diagram actions (Fig. 4.).

Fig. 4. Diagram related failures

Material quality induced failures were also common in many masonry buildings (Fig. 5.).

Fig. 5. Poor material quality and workmanship induced failures

3 CONCLUSIONS

In this study, earthquake performance of existing masonry buildings during 2019 Durrës Earthquake has been presented. The various failure modes of URM buildings have been defined and exemplified. The extensive damage which occurred in Albania demonstrates the potential catastrophic seismic performance of brittle structural systems. A large number of URM structures severely damaged and collapsed during this earthquake.

However, in some cases, the response of such systems was satisfactory if sufficient over-strength was present to ensure elastic behaviour. This good performance was observed in older masonry buildings with good material and construction quality.

ACKNOWLEDGEMENTS

Authors thank for the support given by the Instituti i Ndërtimit during the inspection of earthquake. Also, authors express their deep gratitude to Mr. Agron Hysenlliu for his sincere guidance and help during the site visits.

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