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THE EFFECT OF AFTERSHOCKS ON STRUCTURAL LIFETIME

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Structures are generally under the risk of earthquake events, especially in regions with high seismicity. However, rather than occur individually, the seismic events tend to happen in sequence of the mainshock and the multiple aftershocks, which would cause additional damage to the damaged buildings in post-mainshock environment and increase the probability of collapse (Figure 1).

When a mainshock occurs, it will be generally followed by a sequence of ground motions with relatively lower intensities. These small following seismic events are called “aftershocks”. Despite aftershocks usually having smaller intensities than their preceding mainshocks, their higher rate of occurrence will leave less time for repair or retrofit of the damaged buildings. Furthermore, if a building is considerably damaged in the mainshock event, the aftershocks will be more likely to cause further damage to the building, leading to the extra financial loss and fatalities. The downtime for building repairing after the seismic events would therefore be elongated with the occurrence of aftershocks. Hence, it is necessary to take the mainshock-aftershock sequence effect into consideration when performing seismic risk analysis (Yeo & Cornell, 2005).

Most of the seismic risk assessment tools only consider an initially undamaged structure hit by one mainshock event. However, structures may be initially damaged from past earthquakes, and a seismic sequence is commonly made of a mainshock followed by series of aftershocks. In this post-mainshock context, during which the structure is not repaired, the rate of earthquake occurrence is significantly increased (due to the presence of aftershocks) and the physical vulnerability of possibly mainshock damaged buildings may also increase. In this context, the updated knowledge of the vulnerability of the damaged buildings is of critical importance to accurately assess the associated risk and guide building-occupancy policies after a main seismic event (YAO, 2019).

Figure 1. Collapse of a building caused by aftershock in turkey 1999 (Yeo & Cornell, 2005).

In recent years, the researchers have begun addressing the effects of deterioration on the seismic fragility of structures. Rao et al. (2017) developed time-dependent fragility functions for deteriorating reinforced concrete bridge piers with different levels of reinforcement corrosion in California. They investigated the effect of deterioration on structural demand and capacities of both older and newly designed RC bridge columns. Biondini et al. (2011) study the performance of concrete decks exposed to corrosion and subjected to seismic excitations. Structural deterioration has been considered by Akiyama & Frangopol (2014), in the development of an overall risk model for RC concrete piers and for reliability-based durability design of such structures. In these studies, a hazard model is considered to capture the degree of chloride concentration at the location of the bridge relative to the coastline. (Ghosh & Padgett, 2010) evaluated the impact of lifetime exposure to chlorides on the seismic performance of continuous highway bridges, including reduction in strength of bridge columns due to decrease in diameter of the corroded reinforcement.

Consequently, in this study, mainshock event considered as a deterioration function on the structural performances. The objective of this study is to develop the procedure for considering afretshocks in seismic performance evaluation of a building. For a thorough and advanced assessment, uncertainties associated with earthquakes, structural geometries, and materials shall be considered in the modelling. The three-storey steel moment-resistant frame subjected to the set of main shock events and its seismic fragility curve compared with the same frame subjected to the set of mainshock-aftershocks events.

The steel frame subjected to set of 7 earthquake records and the fragility curves has been concluded from incremental dynamic analysis (IDA) using Opensees software.

The result shows that considering aftershocks as the deterioration function in structural performances is very important and can affect the rehabilitation decision making.

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