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Seismic Behavior of Existing Reinforced Concrete Buildings in California under Mainshock-Aftershock Scenarios

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Abstract : Numerous cases of earthquakes (main-shocks) that were followed by aftershocks have been recorded in California. In 1992 a pair of strong earthquakes occurred within three hours of each other in Southern California. The first shock occurred near the community of Landers and was assigned a magnitude of 7.3 then the second shock occurred near the city of Big Bear about 20 miles west of the initial shock and was assigned a magnitude of 6.2. In the same year, a series of three earthquakes occurred over two days in the Cape-Mendocino area of Northern California. The main-shock was assigned a magnitude of 7.0 while the second and the third shocks were both assigned a value of 6.6. This paper investigates the effect of a main-shock accompanied with aftershocks of significant intensity on reinforced concrete (RC) frame buildings to indicate nonlinear behavior using PERFORM-3D software. A 6-story building in San Bruno and a 20-story building in North Hollywood were selected for the study as both of them have RC moment resisting frame systems. The buildings are also instrumented at multiple floor levels as a part of the California Strong Motion Instrumentation Program (CSMIP). Both buildings have recorded responses during past events such as Loma-Prieta and Northridge earthquakes which were used in verifying the response parameters of the numerical models in PERFORM-3D. The verification of the numerical models shows good agreement between the calculated and the recorded response values. Then, different scenarios of a main-shock followed by a series of aftershocks from real cases in California were applied to the building models in order to investigate the structural behavior of the moment-resisting frame system. The behavior was evaluated in terms of the lateral floor displacements, the ductility demands, and the inelastic behavior at critical locations. The analysis results showed that permanent displacements may have happened due to the plastic deformation during the main-shock that can lead to higher displacements during after-shocks. Also, the inelastic response at plastic hinges during the main-shock can change the hysteretic behavior during the aftershocks. Higher ductility demands can also occur when buildings are subjected to trains of ground motions compared to the case of individual ground motions. A general conclusion is that the occurrence of aftershocks following an earthquake can lead to increased damage within the elements of an RC frame buildings. Current code provisions for seismic design do not consider the probability of significant aftershocks when designing a new building in zones of high seismic activity.

Keywords : reinforced concrete, existing buildings, aftershocks, damage accumulation
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