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Title :
Seismic Performance of Full-Scale Precast Non-Seismic Beam-Column Joints with Corbels Under In-Plane Lateral Cyclic Loading

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Precast concrete building had been widely used in Malaysia for the public amenities such as residential housings, shopping complexes, hospitals, and school buildings. Moreover, most of the precast concrete buildings in Malaysia were designed in accordance to British Standard (BS8110) which has no specific detailing design of joint for precast elements under seismic loading. Thus, this study aims to evaluate the behavior of non-seismic designed precast buildings when subjected to long-distant earthquakes from Sumatera and near-field earthquakes. Three sub-assemblages of the specimens consisting of corner, interior and exterior of precast beam-column joints, were designed, constructed and tested under reversible in-plane lateral cyclic loading. These sub-assemblages were representing the main joints in the prototype precast two-storey school building. Direct Displacement-Based Design (DDBD) approach was utilized in developing load versus displacement curve (hysteresis loops) for all three sub-assemblages studied. Subsequently, the exterior beam-column joint was retrofitted using Carbon Fiber Reinforced Polymer (CFRP) wrapping and steel plate bonding. Ruaumoko Programming was utilized in modeling the inelastic behavior of the joints and overall structural deformation of the school building. The hysteresis loops of the precast beam-column joints were modeled using Hysteres program. The behavior of prototype school building was analyzed using Ruaumoko 2D and the mode shapes of the structural failure were illustrated by using Dynaplot program. In addition, a seismic assessment under Performance Based Earthquake Engineering (PBEE) was carried out using the fragility curve based on the Design Basis Earthquake (DBE), Maximum Considered Earthquake (MCE) and four past earthquake records. Finally, the capacity-demand response spectrum of the prototype two-storey precast school building was developed. Experimental results have demonstrated that the corner joint with corbel suffered severe damage when tested up to ±1.35% drift. Large gap opening between precast beam and column were also observed during experimental work. Nonetheless, the interior beam-column joints were tested up to ±1.15% drift and exterior precast beam-column joints were tested up to ±1.0% drift and suffered moderate damage called as captive column, due to strong beam-weak column design. Major crack at the cast-in-place (monolithic) area near the beam-column joint were also observed for all specimens. The retrofitted precast beam-column exterior specimen was tested up to ±1.75% drift and exhibited approximately 9.7% increment in lateral loading capacity as compared to the specimen before retrofitting work. Finally, a guideline of repair and strengthening of beam-column joints has been proposed for the damage structures so that it is easier for designer to apply the retrofitting procedures to the damaged elements after earthquake. From the capacity-demand response spectrum analysis, it can be concluded that the precast beam-column joints would not survive when subjected to earthquake excitation with surface-wave magnitude, Mw, more than 5.5 Scale Richter (Type 1 of spectra) which means that the beam-column joint which is designed by using BS8110 would severely damage when subjected to strong earthquake excitation. Therefore, this study help in enhancing the understanding of the behavior of non-seismically designed beam-column joints under earthquake loadings.

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