Seismic Performance of Precast Hybrid-Steel Concrete Connections

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This article presents experimental and analytical investigations of hybrid-steel concrete connections. In the experimental study, four full-scale specimens including one cast-in-place and three precast specimens were tested under cyclic load reversals. The performance of the specimens in terms of energy dissipating capacity, cracking patterns, and variation of strains along the main reinforcement is described. However, due to the inherent complexity of beam-column joints and the unique features of the tested specimens, the experimental investigation was not sufficient enough to fully understand the influence of several parameters. Therefore, an analytical investigation based on the FE models using DIANA software is presented. Validation of the FE models against the experimental results has shown a good agreement. The critical parameters influencing the joint’s behavior such as the continuation of beam bottom reinforcement, column axial load, the size and embedded length of the angle sections are varied, and their effects including possible implications on code specifications are discussed.

Keywords  Finite Element; Hybrid-Steel Concrete; Material Nonlinearity; Cyclic Loading; Geometric Nonlinearity; Hysteresis Loops

1. Introduction

For many years, precast concrete members have been known for the inherent benefits such as speed in productivity, considerable improvement in service and quality, and overall reduction in construction cost. A recent trend in low-to-moderate seismic regions like Singapore, Eastern, and Central parts of the United States, Malaysia, etc., has shown a steep hike in the usage of precast elements in construction. Although precast reinforced concrete (RC) elements can speed up the construction of structures, especially in high-rise buildings, proper design of joints and their execution during the construction is a matter of serious concern. The catastrophic failure of precast structures, particularly the joints during earthquakes, showed a possible drawback in the system. Major problems associated with precast structures during seismic events have been related to the low-energy dissipating capacity of precast elements and the ability of the overall structure to undergo large deformations without substantial loss of strength. In order to successfully achieve an innovative and robust connection system, Nanyang Technological University (NTU) Singapore has embarked upon a series of experiments on hybrid-steel concrete joints.

In precast structures, normally a beam rests on the column edges, thus coinciding with the inherent plastic hinge location. This kind of arrangement makes the beam-column joint the most vulnerable, especially under the action of seismic forces. The experimental study by Sheikh et al. [1989] showed that the crushing of concrete in...