Experimental and Analytical Performance Evaluation of Engineering Wood Encased Concrete-Steel Beam-Column Joints

Hiroshi Kuramoto; Bing Li; Kimreth Meas; and Fauzan

Abstract: The seismic performance of engineering wood encased concrete-steel (EWECS) beam-column joints is investigated and reported within this paper. Experimental and analytical investigation was carried out on a total of two interior and two exterior beam-column joints. These four beam-column joints typically consisted of an EWECS column and a wood encased steel beam. The primary parameter was the failure modes of the specimens, namely the beam flexural failure and the joint shear failure. The response of the specimens was presented in terms of their hysteresis loop behavior, crack pattern, joint shear distortion, and deformation decomposition ratios. In addition, the results obtained from a three-dimensional nonlinear finite-element analysis simulating their seismic behaviors were also compared with the test data. The finite-element analysis incorporated both bond stress-slip relationship and crack interface interaction at the unbonded connection region. The analytical prediction of joint shear strength was satisfactory for both interior and exterior joints. This validated numerical model was subsequently used to examine the contributions of the steel frame mechanism formed by the column flange, column web, and stiffener. DOI: 10.1061/(ASCE)ST.1943-541X.0000334. © 2011 American Society of Civil Engineers.

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Introduction

In high seismic regions, building structures constructed of composite steel reinforced concrete (SRC) have been reported to behave in a ductile manner by Sheikh et al. (1989). Azizinamini and Schneider (2004) reported that concrete filled steel tubes (CFT) add significantly more stiffness to frame structures by utilizing the concrete within the steel to prolong the local buckling of the steel tubes. In return, the steel provides confinement to the concrete to prevent it from spalling. It was from the SRC and CFT ideologies that a new hybrid engineering wood encased concrete-steel (EWECS) was developed for low to high seismic zones. This new composite material overcomes the limitation of the number of stories that can be constructed by utilizing wood as a material on its own. This system consists of a concrete encased steel (CES) column core wrapped with an exterior wood panel. The beam consists of a wood panel wrapped around a steel beam. The construction of this joint began by attaching the wood panel to the column beam with wood glue. The wood panel utilized to wrap the column was initially assembled using the wood glue. The final step involved casting the concrete within the wood panel of the column. The connection between the wood panel of the beam and column was left in contact without any application of wood glue. It is believed that constructing a building with this system would be environmentally friendly and save time during construction. This is because the wood panel in this proposed system can also act as formwork, unlike buildings constructed from normal SRC. Upon completion of construction, these wood panels, apart from providing additional support, also improve the aesthetic appeal of the building.

There have been previous experimental and analytical studies conducted on EWECS columns to investigate their seismic performance in the past four years, reported by Fauzan et al. (2005, 2006). The results indicated that EWECS columns had excellent hysteresis behavior. The wood panel wrapped around the column was shown to improve its flexural capacity by up to a maximum of approximately 12%, as documented by Kuramoto and Fauzan (2005). Further studies were conducted to investigate the effect of providing a shear stud to attach the wood panel to the core concrete of the column. These studies found that the shear stud provided almost no increase to the strength of the column. However, significant improvement to the column ductility was reported by Meas et al. (2006). An experimental and analytical study was conducted to establish a deeper understanding of the behavior of such interior and exterior joints when subjected to seismic loadings. A three-dimensional (3D) nonlinear finite-element (FE) analysis was also conducted on the EWECS interior and exterior beam-column joint specimens that utilized FINAL version 99 developed by Obayashi Corp. (2004). This FEM analysis was carried out to supplement the experimental research program on the EWECS structural system.