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Experimental Behaviour of Sustainable Flush End Plate Beam-to-Column Composite Joints with Deconstructable Bolted Shear Connectors

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Abstract
This paper presents the results of static tests conducted on four full-scale Flush End Plate Semi-Rigid (FEPSR) beam-to-column joints in a novel deconstructable and sustainable structural system. In this system, precast "Green Concrete" (GC) slabs having reduced CO2 emissions during their manufacture are attached compositely to the steel beam using a novel method of shear connection that takes advantage of Post-installed Friction-grip Bolted Shear Connectors (PFBSCs) and the composite steel beams are connected to concrete-filled steel tubular columns (CFSTs) using flush end plates with blind bolts. The proposed structural system can be deconstructed at the end of its service life that allow for minimising demolition waste and maximising of component recycling. The test results show that these novel composite joints have credible rotation and moment capacities according to EC3 and EC4, and fracture of the joints occurs after the development of substantial rotation.
Keywords: Blind bolt; Bolted shear connectors; Concrete-filled steel tube (CFST); Semi-rigid beam-to-column joint; Deconstructability.

1. Introduction

Traditional Flush End Plate Semi-Rigid (FEPSR) composite joints exhibit excellent structural performance and provide for ease of construction and economical connections compared to rigid connections. Moreover, the rigidity and ductility of FEPSR connections allows for adequate moment distribution in steel frames subjected to overload and extreme loading scenarios. These FEPSR composite connections have higher initial stiffnesses and moment capacities as well as rotational ductility compared to bare steel connections, owing to beneficial effect of the reinforcing steel bars placed in the slab.
The use of concrete-filled steel tubular (CFST) columns can reduce the construction time by eliminating formwork and the need for tying of reinforcing steel cages. Furthermore, the application of CFST members can improve the seismic performance of framed structures by retarding the local buckling of steel tubes and providing high strength, ductility and energy absorption capacity [1, 2]. Accordingly, CFST members have found increased usage over the past decades and using FEPSR composite joints in conjunction with CFST columns appears to be a superior structural system that requires further in-depth investigation [3, 4]. However, within the current paradigms of lowering carbon emissions and enhancing the possibly of materials recycling in the construction industry, traditional steel-concrete composite floors are problematic on a number of fronts. Firstly, composite action between the conventional concrete slab and steel beam is typically provided by stud shear connectors welded to the top flange of the steel beam, but demolition of such composite members requires considerable amount of time and energy and also it is associated with much construction waste. Secondly, construction of conventional steel-concrete composites is labour intensive, time consuming and costly, because slabs are typically cast in-situ and reinforced with steel bars/meshes placed in the formwork on site. Thirdly, existing composite systems mostly utilise conventional concrete made from Portland cement whose production is attributed to a large portion of carbon emissions worldwide [5].
Friction-grip bolted shear connectors can be installed through bolt holes placed in precast slabs and pre-drilled in the flange of the steel beam. These bolted shear connectors can provide efficient composite action between the precast slab and the steel beam by friction-grip and bearing mechanisms. Furthermore,