Numerical Analysis of Bolted Connectors in Prefabricated Steel-Lightweight Aggregate Concrete Composite Beams

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Abstract

This paper presented a three-dimensional (3D) numerical model to explore the shear behavior of bolt connections embedded in steel-lightweight aggregate concrete composite beams (SLACCBs) by utilizing the ABAQUS software. Nonlinear geometric effects and material nonlinearities were considered in the finite element (FE) modelling. The accuracy and reliability of the FE modelling were validated against the push-off tests initially. Subsequently, the basic shear properties of the bolted connection embedded in SLACCBs were studied and compared with that of the bolted connection embedded in the normal concrete (NC) slab by applying the verified FE modelling. Meanwhile, the effects of the concrete strength, concrete density, bolt diameter, and bolt tensile strength on the shear behaviour of bolt connection embedded in SLACCBs were also investigated by extensive parametric studies.

Keywords: bolt shear connector; lightweight aggregate concrete (LAC); push-off test; finite element model; shear bearing capacity.

1 Introduction

Steel-concrete composite beams (SCCBs), which combine full advantages of two materials (tensile strength of steel and compressive strength of concrete), have long been employed in buildings and bridges [1-2]. Reliable shear connectors that resist the relative slip between the steel-concrete interface are the critical feature to guarantee the composite behaviour [3]. Traditional connectors (e.g., steel studs and Perfobond ribs) with outstanding mechanical performance and the ease of construction have been adopted and investigated extensively in SCCBs in recent decades [4-5]. However, dismounting and reusing the elements (i.e., steel beams, shear connectors and concrete slabs) is challenging when conventional SCCBs reach the end of their service life because the connections are not only welded to steel girders but embedded into the cast in situ concrete slabs. To achieve this challenging goal and to improve construction sustainability, high-strength bolts are applied in SCCBs to substitute traditional connections as the shear connection.

Dallam [6] first reported the shear behaviour of high-strength bolts embedded in the NC slab by push-off tests. Test results showed that the shear resistance of high strength bolts was twice that of steel studs with the same dimensions. Subsequently, Dedic and Klaiber [7] elucidated the possibility of utilizing the high-strength bolts in rehabilitation work with older bridges by push-out

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