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Nonlinear Finite Element Analysis of Concrete Filled Steel I-Girder Bridge

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Abstract : Concrete filled steel I-girder (CFIG) bridge was proposed and the bending and shear strength was confirmed by experiments. The area surrounded by the upper and lower flanges and the web is filled with concrete in CFIG, which is used to the intermediate support of a continuous girder. Three-dimensional finite element models were established to simulate the bending and shear behaviors of CFIG and to clarify the load transfer mechanism. Steel plates and filled concrete were modeled as a three-dimensional 8-node solid element and steel reinforcement bars as a three-dimensional 2-node truss element. The elements were mostly divided into the 50 x 50 mm mesh size. The non-linear stress-strain relation is assumed for concrete in compression including the softening effect after the peak, and the stress increases linearly for concrete in tension until concrete cracking but then decreases due to tension stiffening effect. The stress-strain relation for steel plates was tri-linear and that for reinforcements was bi-linear. The concrete and the steel plates were rigidly connected. The developed FEM model was applied to simulate and analysis the bending behaviors of the CFIG specimens. The vertical displacements and the strains of steel plates and the filled concrete obtained by FEM agreed very well with the test results until the yield load. The specimens collapsed when the upper flange buckled or the concrete spalled off. These phenomena cannot be properly analyzed by FEM, which produces a small discrepancy at the ultimate states. The FEM model was also applied to simulate and analysis the shear tests of the CFIG specimens. The vertical displacements and strains of steel and concrete calculated by FEM model agreed well with the test results. A truss action was confirmed by the FEM and the experiment, clarifying that shear forces were mainly resisted by the tension strut of the steel plate and the compression strut of the filled concrete acting in the diagonal direction. A trail design with the CFIG was carried out for a four-span continuous highway bridge and the design method was established. Construction cost was estimated about 12% lower than that of a conventional steel I-section girder.

Keywords : concrete filled steel I-girder, bending strength, FEM, limit states design, steel I-girder, shear strength
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