Abstract

This study deals with a nonlinear three dimensional finite element modeling of composite concrete-steel beams under bending loads up to failure. The modeling is used to predict the load-deflection behavior of composite beams consisting of a reinforced concrete slab and a steel beam with shear connectors under static loads. The analysis system computer program (ANSYS V. 9.0) is used for this purpose.

For the concrete slab, eight-node isoparametric brick elements have been used, while the steel reinforcing bars are modeled as axial members (bar elements) connecting opposite nodes in brick elements with full bond assumption. Four-node isoparametric shell elements have been used to model the steel beam while the shear connectors by truss (bar) elements. Interface elements are used in this analysis, which consider the dowel action of (Millard and Johnson) dowel formula to resist slip and uplift separation between the concrete and the steel components.

Material nonlinearity due to cracking and crushing of the concrete, and yielding of the steel girder and reinforcing bars are taken into consideration during the analysis. In tension, the crack is represented by a fixed smeared crack with post-cracking tension stiffening. Also, a shear transfer model representing the aggregate interlock and dowel action is used.

The nonlinear equations of equilibrium are solved by an incremental-iterative technique. The full Newton-Raphson method is used as a nonlinear solution algorithm and a force criterion is used for convergence checking. The numerical integration has been conducted by using the four-point Gaussian rule for the shell element, and eight-point Gaussian rule for the brick element.

To check the validity and accuracy of the adopted models, a specimen beam of Chapman-Balakrishnan experimental test has been chosen to be analyzed by the proposed nonlinear finite element method. The solution is compared with the experimental results. In general good agreement is obtained between the finite element and the experimental results. The maximum percentage difference in ultimate load-carrying capacity is 5.5%.

Parametric studies have been carried out to investigate the effect of several important parameters on the behavior of composite beams under bending loads. These parameters include concrete compressive strength, the thickness of concrete, the slab width to span ratio, the degree of partial connection, and the use of unsymmetrical I-steel beams.