New Models for Structural Analysis of Composite Beams

Jose TURMO
Professor
UniversitatPolitècnica de Catalunya, Spain
Jose.turmo@upc.edu

Jose Antonio LOZANO
Assistant Professor
University of Castilla-La Mancha, Spain
joseantonio.lozano@uclm.es

Enrique MIRAMBELL
Full Professor
UniversitatPolitècnica de Catalunya, Spain
enrique.mirambell@upc.edu

Dong XU
Full Professor
Tongji University, China
xu_dong@tongji.edu.cn

Summary

Most codes assume a rigid interaction between concrete and steel in composite beams. This assumption assumes that there is no relative slip at the interface of both materials and Navier's hypothesis is fully applicable. Nevertheless, all shear connections are flexible to some extent and therefore, full interaction is rarely achieved in practice. For this reason, partial interaction, with a relative slip at the interface, always appears in actual structures. The simulation of this relative slip is of primary importance because it affects both the deflections and the stresses in concrete and steel members. To carry out this simulation, a number of analytical and numerical models are proposed in the literature. The main problem of most of these models is that they cannot be easily applied for design work. To fill this gap, a two-dimensional finite element model is proposed. In this model, the different elements of the composite beams are simulated only by frame elements, easing its practical application. To validate the accuracy and the efficiency of the proposed model, a finite element model is verified against those results obtained by analytical equations available in the literature.

Keywords: Partial Interaction, Finite Element Model, Composite Beam.

1. Introduction

Current popularity of steel–concrete composite beams is due to construction speed, structural and cost advantages. In this structural system the tensile strength of the steel and the compressive strength and mass of the concrete slab are exploited together. To enable these materials to act compositely they are connected with different elements, such as shear struts. For a composite beam with rigid connection, there is full interaction between the steel and the concrete members. In this case, there is no relative slip at the interface of both materials and Navier hypothesis is fully applicable. This approach is traditionally followed by codes (see e.g. [1, 2]). Nevertheless, all shear connections are flexible to some extent and therefore, full interaction is rarely achieved in practice. For this reason, partial interaction, with a relative slip at the interface, commonly appears in actual structures (see [3]). The simulation of this relative slip is of primary importance because it affects both the deflections and the stresses in both the concrete and steel members. Therefore, partial interaction occurs to some extent in all composite beams.

A number of studies have been carried out to simulate the behavior of composite beams with partial interaction. According Sousa et al. [4], the first analytical model including partial shear interaction for beams is attributed to Newmark et al. [5]. In this method, the equilibrium and compatibility equations for an element of the composite beam are reduced to second order differential equations. This model assumes distributed bonds at the concrete–steel interface. These bounds enforce contact between components and allow longitudinal interlayer slip. The differential equation approach of this method was also followed by Martínez and Ortiz [6], who defined the analytical solutions for elastic simply supported composite beams under simple loading cases. This procedure assumes that the deflections of the centroids of steel and concrete cross-sections are the same and continuous connection at the concrete–steel interface. The main inconveniences of these analytical methods are

https://doi.org/10.2749/222137816819258717
Distributed by structurae