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Toward Practical Modelling of Reinforced Concrete Flat Slab Systems

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Abstract

There is increasing demand for practical modelling procedures that can be used to assess the performance of reinforced concrete (RC) structures. The numerical assessment of RC slabs at the system level typically involves one of two modelling procedures: i) models constructed with the use of three-dimensional solid finite elements, or ii) models constructed using some form of layered element, usually developed on the basis of the plane sections assumption. The use of solids has been shown to provide good structural performance estimates for RC flat plates; however, the investigation of even a single slab-column connection can be extremely costly as fine meshes consisting of many degrees of freedom are usually required. Conversely, while layered elements are computationally more efficient, they typically provide extremely coarse estimates of the out-of-plane (through-thickness) shear response and generally cannot capture the influence of disturbances developed in slab-column connection regions.

This paper presents the application of an alternative RC slab system modelling procedure. Low-cost layered thick-shell finite elements that can adequately model through-thickness shearing effects were used to capture global slab system behaviour and a simple sectional analysis modification procedure was used to accommodate strength enhancements attributed to slab disturbances. Employing the formulations of the Disturbed Stress Field Model (DSFM), the thick-shell finite element analysis procedure was used to model the response of RC slab-column connections under concentric shear loading conditions. Shell element-based numerical responses were compared with those obtained using more conventional modelling procedures (e.g., solid continuum), and were contrasted with experimental data. Further, the validated RC slab modelling procedure was used to analyze the response of a slab subsystem test available in the current database of experimental literature, and was shown to provide good agreement with test results.

Keywords: Punching shear; nonlinear finite element analysis; shell element; disturbed region.

1 Introduction

Reinforced concrete (RC) flat plate slab systems are frequently employed in the design of modern concrete infrastructure. Characterized by efficient load-carrying capabilities, these systems can provide significant functional and economic benefits making them ideal candidates for use in a broad range of demanding structural applications.

Currently, two main finite element modelling approaches are typically employed to study the behaviour of RC flat plates: i) models constructed explicitly with the use of three-dimensional (3D) solid elements, and ii) models constructed using some form of layered shell or plate element which is usually developed on the basis of the plane sections assumption. Recent studies have shown that the use of 3D solids can provide good load-

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