Numerical Investigation of Slab-Column Connections with Various Reinforcement Ratios

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Abstract

This work considers three-dimensional non-linear finite element models (FEMs) to obtain insight into the contribution of flexural reinforcement ratio to the failure mode of slab-column connections. The correlation between punching and flexural-punching failure modes is examined. The models are calibrated to simulate the punching shear failure of reinforced concrete flat slabs under vertical monotonic loading and a constant gravity load in combination with monotonic unbalanced moment using a smeared concrete model, denoted as Concrete Damage Plasticity (CDP). In this regard, previously tested slab-column connections with various reinforcement ratios are selected from literature. The numerical outcomes are validated in terms of load-deflection (or moment-deflection) curves. The comparison between test and numerical results shows that the numerical analyses using the CDP model can accurately predict the rotation and punching capacity along with the failure mode of the slabs. As a parametric investigation, the FEM is utilised to characterise further the failure process of slabs with reinforcing ratios varied from 0.2% to 2%. The numerical results are compared with predictions from the design code ACI 318-19 and the Critical Shear Crack Theory.

Keywords: nonlinear finite element method; calibration; reinforcement ratio; vertical gravity loading; unbalanced moment; parametric investigation; code provisions.

1 Introduction

Slab-column connections without transverse reinforcements have the potential of brittle punching shear failure in reinforced concrete two-way flat plate systems. Various modelling approaches have been developed to define the punching shear failure. Punching failure models are either based on empirical approaches, analytical solutions, or numerical methods. Although analytical models are more consistent and provide the engineer an insight into the physical phenomenon of punching, current design codes (e.g., ACI 318-19) are still based on empirical models. Meanwhile, the current design code provisions for punching shear differ since they are based on empirical formulations derived from limited and different experimental test databases. Accordingly, numerical finite element models (FEMs), can be used as a substitution for