Prediction of the Effective Concrete Strength for Column-Slab Connections

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ABSTRACT

For cases where the column concrete strength exceeds 1.4 times the slab concrete strength, the KCI Code requires that either: puddled high-strength concrete(HSC) be used in the slab, or the use of vertical dowels and spirals through the joint, or the use of an effective concrete strength in the joint. This paper studies on the third strategy. A prediction model of the effective concrete strength for interior columns was proposed using an analogy of brick and mortar in brick masonry. The proposed prediction model is verified by comparison with experimental results and various design equations.

1. Introduction

A typical structure of concrete column-slab is similar to that of brick masonry. The uniaxial compressive strength and the modulus of elasticity of the mortar are significantly lower than the corresponding values of the brick. When an axial load is applied on the brick masonry structure, shear stresses at the brick-mortar interface result in an internal state of stress which consists of triaxial compression in mortar and bilateral tension coupled with axial compression in bricks. This development of stress state is very similar to that of a column-slab structure under axial compression [1].

2. Development of Prediction Model

In this study, the design equation for the compressive strength of masonry specified by Eurocode 6 was modified to produce a reliable and practical design equation for the prediction of the effective compressive strength of interior high-strength concrete(HSC) column-normal strength concrete(NSC) slab joints. Eurocode 6 presents the following expression for the compressive strength of masonry, as follows:

$$f'_{ce} = K(f'_{cc})^{\alpha}(f'_{cs})^{\beta} \tag{1}$$

where f'_{ce} =effective concrete strength, f'_{cc} =column concrete strength, f'_{cs} =slab concrete strength, and K,α,β= constants. Based on regression analysis of the experimental results, the values of α and β were determined as 0.72 and 0.25, respectively. K was defined to consider the aspect ratio of slab thickness to column dimension, h/c. Note that K was decreased with the increase of the h/c ratio for the ratio of column strength to slab

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strength f'_{cc}/f'_{cs} greater than 1.4 while K was constant regardless of the h/c ratio for the ratio of f'_{cc}/f'_{cs} less than or equal to 1.4. In addition, the effects of confinement provided by the surrounding slab and slab loading was considered.

Consequently, the new equation to predict the effective concrete strength of interior columns can be expressed as

$$f'_{cc}/f'_{cs} \le 1.4\,; \quad f'_{ce} = f'_{cc} \tag{2a}$$

$$f'_{cc}/f'_{cs} > 1.4\,; \quad f'_{ce} = \phi\lambda\left[K(f'_{cc})^{0.72}(f'_{cs})^{0.25}\right] - (0.01 f_s) \le f'_{cc} \tag{2b}$$

where $K = 0.91/[(h/c)^{0.29}]$, ø= resistance factor applied to the slab confinement effect, 0.9, λ= slab confinement factor, 1.23, and f_s= calculated stress in reinforcement at specified service loads on the slab, which can be calculated by $E_s \times \epsilon_{init}$, where E_s= modulus of elasticity of reinforcement, and ϵ_{init}= the average longitudinal strain in slab top reinforcement at column face right after the slab load was applied.

3. Verification of Prediction Model

The predictions by the proposed equation in this study and other design equations[2-4] were compared with experimental results tested by various researchers[2-5]. With an average test-to-predicted ratio of 1.11, standard deviation of 0.135, and coefficient of variation of 12.18 %, the proposed Eq. (2) provides superior predictions than most other design approaches.

4. Conclusion

The highly reliable prediction model of the effective concrete strength for interior columns is proposed by employing an analogy with brick masonry structure. The prediction expression is further enriched to take into account the aspect ratio of slab thickness to column dimension, the confinement effect provided by the surrounding slab, and slab loading.

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