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Numerical Investigation of Stress Block for High Strength Concrete Columns

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Abstract

This paper is intended to investigate the stress block for high strength concrete (HSC) using the finite element model (FEM) and analytical approach. New stress block parameters were proposed for HSC including the stress intensity factor (α_1) and the depth factor (β_1) based on basic equilibrium equations. A (3D) finite element modeling was developed for the columns made of HSC using the comprehensive code ABAQUS. The proposed stress parameters were validated against the experimental data found in the literature and FEM. Thereafter, the proposed stress block for HSC was used to generate interaction diagrams of rectangular and circular columns subjected to compression and uniaxial bending. The effects of the stress block parameters of HSC on the interaction diagrams were demonstrated. The results showed that a good agreement is obtained between the failure loads using the finite element model and the analytical approach using the proposed parameters, as well as the achievement of a close agreement with experimental observation. It is concluded that the use of proposed parameters resulted in a more conservative estimation of the failure load of columns. The effect of the stress depth factor is considered to be minor compared with the effect of the intensity factor.

Keywords: High Strength Concrete; Stress Block; Column; ABAQUS; Finite Element Model.

1. Introduction

A column is one of the most critical members of a framed structure, the failure of which could lead to a catastrophic failure of the whole structure. In recent years, high strength concrete (HSC) columns have been widely used in major construction projects, especially, in high-rise buildings. The advancement in concrete technology and the development of new types of mineral and chemical admixtures have enabled the production of concrete with compressive strength exceeding 150 MPa. HSC could lead to smaller member sizes for compression members and therefore provide considerable savings associated with material costs and a reduction of dead loads. Moreover, due to the superior durability of HSC [1], a considerable reduction of the maintenance efforts and an increase in the service life of the structure can be attained as compared to the normal strength concrete (NSC).

The increasing use of HSC has led to concern over the applicability of current design codes and standards. Although, the latest ACI code provides uniaxial bending interaction curves for up to $f'c$ = 83 MPa, the curves are based on the stress block for normal concrete. Recent research indicates that the behavior of HSC is different from NSC in many aspects. The shape of the stress–strain relation of HSC differs from that of NSC [2].

Equivalent rectangular stress blocks have been proposed for HSC by either different standard codes or researchers.

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