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Experimental behaviour of steel fiber high strength reinforced concrete and composite columns

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ABSTRACT

This paper presents experimental behaviour of eccentrically loaded plain and steel fiber high strength reinforced concrete and concrete-encased composite columns. In the experimental study, a total of 32 square section both reinforced concrete and composite column specimens were fabricated at 0, 0.5, 0.75 and 1.0% volume fractions of steel fiber contents to examine the effects of steel fibers on column behaviour. Besides this, the composite columns were constructed and tested using almost the same conditions with reinforced concrete columns to investigate the column experimental behaviour. The complete load−deflection behaviour and strength of column specimens were obtained and the results were discussed in the study. In addition, the column specimens were analysed based on a theoretical method considering the nonlinear behaviour of the materials. The presented experimental study indicates that the inclusion of steel fibers in the range 0.75 to 1.0% volume fraction improves confinement and ductility features of high strength reinforced concrete and composite columns significantly.

1. Introduction

High strength concrete has been increasingly used in the construction of structures, such as high-rise buildings, bridges, piles etc. High strength concrete offers many significant benefits in terms of strength, durability, and modulus of elasticity. However, it is widely believed that high strength concrete exhibits brittle behaviour under compression. The inclusion of steel fibers into high strength concrete definitely improves confinement, ductility and deformability of concrete. Several experimental and analytical studies were carried out to describe the mechanical behaviour of steel fiber high strength concrete. Fanella and Naaman [1] studied on the stress–strain properties of fiber reinforced concrete and an analytical relationship was proposed to predict the complete stress–strain curve of fiber reinforced mortar in compression. Ezeldin and Balaguru [2] presented experimental stress–strain behaviour of fiber reinforced concrete with compressive strength ranging from 35 MPa to 85 MPa. An analytical expression was proposed to represent the complete stress–strain curve of steel fiber reinforced concrete. Hsu and Hsu [3] conducted an experimental research to determine the complete stress–strain relationship of steel fiber high strength reinforced concrete under compression and empirical stress–strain equations were proposed in the study. Taerwe and Van Gysel [4] presented experimental and analytical researches to describe the realistic stress–strain curve for high strength fiber concrete. Maalej and Lok [5] examined the flexural behaviour of steel fiber concrete. Nataraja et al. [6] proposed a simple analytical model to generate both ascending and descending portions of the stress–strain curve of steel fiber reinforced concrete. Ramesh et al. [7] tested prism specimens to study the behaviour of confined steel fiber reinforced concrete and an analytical model was suggested to predict the stress–strain behaviour of confined fiber reinforced concrete. Lim and Nawy [8] investigated the mechanical characteristics of plain and steel fiber reinforced high strength concrete under uniaxial and biaxial loading conditions. Thomas and Ramaswamy [9] reported an experimental program and analytical assessments of the influence of addition of fibers on the mechanical properties of concrete. Empirical relationships were developed to assess the strength properties of steel fiber reinforced concrete. Bencardino et al. [10] researched the stress–strain behaviour of steel fiber reinforced concrete in compression and the validity of the models proposed in literature in defining the post peak behaviour of steel fiber concrete was examined.

Ductility and confinement are very important features for high strength concrete column members especially in the seismically active regions. Therefore, using steel fibers into high strength concrete columns has become popular. It is significant to describe the behaviour of such members for analysis and design. Ganesan and Ramana Murthy [11] conducted experimental research to describe the behaviour of steel fiber reinforced concrete columns under axial load. Hsu et al. [12] and Foster and Attard [13] tested square section steel fiber high strength reinforced concrete columns to investigate the effects of steel fibers on the strength and ductility of columns. Foster

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