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Experimental and Analytical Study on Recycled Aggregate RC Columns: Short and Slender Loaded Axially and Eccentrically

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Abstract: To protect the environment and preserve natural resources, it is crucial to use recycled aggregate (RA) in construction. The recycled coarse aggregate reinforced concrete columns with the addition of steel fiber evaluated under concentric and eccentric loadings for short and slender columns were examined experimentally and analytically in this research. Twenty-four column specimens were built for this study to examine the impact of steel fiber, recycled aggregate, slenderness, and eccentricity on the behavior of reinforced concrete columns. This research examined the failure mode, maximum load-carrying capacity, strain in the concrete, strain in the reinforcement, and ductility. Based on the results, it can be concluded that employing recycled concrete aggregate is a potential approach to meet design codes. The addition of 1% steel fiber effectively prevents concrete from crushing and spalling. Steel fiber, however, improved the columns' ductility and strength. The results showed the maximum load-carrying capacity of the specimens and the results of using ACI-318 code equations agreed very well. Furthermore, a model is proposed for columns with both natural and recycled aggregate and which accounts for the eccentricity and slenderness to forecast the load-carrying capacity. The outcomes demonstrated that the design principles were met well. Plots of load–moment interaction diagrams for short and slender columns made with the ACI-318 method are compared to the findings of the experiments.

Keywords: recycled aggregate concrete; steel fiber; reinforced concrete columns; eccentric compression load; concentric load

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1. Introduction

Replacing natural aggregate (NA) with recycled concrete aggregate (RA) in the concrete mix design is an important step toward a green environment [1,2]. When utilizing recycled aggregate instead of natural aggregate, the computed net carbon balance is about 20% lower [3]. The environmental and economic implications of recycled aggregates manufactured from waste concrete blocks were demonstrated to have a reduction factor of 0.420 g of CO_2/EUR cent, and this implies that using recycled aggregate will cut CO_2 emissions per unit expense [4]. Different research was conducted in past years to determine the effect of steel fiber on the behavior of structural members made with RA, and some studies have shown an improvement in the compressive strength of concrete [5,6]. Research has also shown an improvement in the shear and bending behavior [7,8]. However, it was observed that current research mainly studied the performance of columns by taking RA into account, but not with a content of steel fiber [9]. In general, the steel fibers could improve the cover–core interface and improve the strength and ductility of reinforced concrete columns [10,11]. Five series of columns were tested to determine the differences in the behavior between columns made with recycled aggregate in comparison with samples made with natural aggregate. The results showed similar behavior during the loading up to failure, as well as a similar bearing capacity and the greater ductility of the samples with recycled aggregate recorded because of the slower nature of