Effect of Slenderness on the Design of FRP reinforced Concrete Columns

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Abstract

Fibre-reinforced polymer (FRP) bars can be a promising sustainable alternative to steel due to their low life-cycle cost and potentially low environmental impact as a reinforcement. Also due to their corrosion resistance and electromagnetic neutrality, they have attracted significant interest for use in reinforced concrete (RC) structures. This paper investigates the behaviour of FRP-reinforced concrete (FRP-RC) columns with varying slenderness ratios. The reduction in moment capacity, axial load capacity and load-moment interaction diagrams of FRP-RC columns with the increase in slenderness are studied in comparison to steel-reinforced concrete (steel-RC) columns. The study shows that guidelines and design standards such as Eurocode 2 for steel-RC pertaining to the simplified design of slender columns, slenderness limit and minimum reinforcement ratio need to be revised for FRP-RC columns.

Keywords: Fibre-reinforced polymer bars, FRP-reinforced concrete columns, slender columns, column curvature, second-order analysis, stability, slenderness limit, Eurocode 2, column stiffness.

1 Introduction

Owing to increasing global concerns about climate change and the need to reduce carbon emissions, sustainable and durable infrastructure is one of the most important factors in achieving sustainable development. Fibre Reinforced Polymer (FRP) reinforcement may be a promising solution for developing sustainable infrastructure due to its corrosion resistance, low life-cycle costs [1] and potentially low environmental impact [2] compared to traditional steel reinforcement. Despite having high tensile strength, they have low axial stiffness compared to steel, which makes their behaviour in reinforced concrete structures of concern when they replace steel bars. Considerable research work has been reported in the literature examining the flexural behaviour of FRP-reinforced concrete (FRP-RC) structures. However, limited work has been done on FRP-RC columns, especially slender FRP columns, and their design guidelines. In this study, the behaviour of FRP-RC columns is examined along with the consideration of geometric non-linearity arising out of slenderness. A comparison between the behaviour of FRP-RC columns and steel-reinforced concrete (steel-RC) columns is presented so as to ascertain the applicability of the available guidelines of steel-RC design standards such as Eurocode 2 [3] for FRP-RC columns.

2 Non-linear analysis of reinforced concrete columns

A numerical method based on the sinusoidal assumption of the column curvature is implemented in Matlab (R2022b) for the analysis of the reinforced concrete columns. The assumed

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