Load-carrying Capacity of Reactive Powder Concrete Columns retrofitted with CFRP

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Abstract

External confinement of concrete by means of Carbon Fiber Reinforced Polymer (CFRP) can significantly enhance its strength and ductility. One area where the use of CFRP has attracted considerable interest is in the strengthening of Reactive Powder Concrete (RPC) columns. Proper design of such hybrid columns, however, requires an accurate estimate of the performance enhancement. As a result of CFRP confinement, the constitutive model of RPC in compression i.e. the stiffness, compressive strength of RPC can be completely changed. This paper presents a finite element model capable accurately to estimate the load-carrying capacity of RPC columns strengthened with CFRP under compressive loads. Results from finite element model of CFRP-RPC are compared with RPC specimens, and it shows enhancement in strength and ductility. Also the compression between the tests from previous researches and finite element analysis shows good agreement.

Keywords: Confining, Reactive Powder Concrete, Ductility, Model, CFRP

1. Introduction

During the past two decades, significant improvement has been made on the physical and mechanical properties of reinforced concrete. Reactive Powder Concrete (RPC) is one novel type of composite material which was invented in the early 1990s by Bouvgues laboratory in France [1]. It's characterized by externally superior physical properties, particularly its ultra-high strength and high toughness. Enhanced properties of RPC are obtained though grain size optimization, incorporation of micro-silica and post-set heat-treating. Compressive strength of RPC can range from 200MPa to 800MPa.

Over the past decade, much research has been undertaken on the composition of RPC. Thus, in order to ensure the efficient use of RPC in new construction projects, a need has been arisen for the development of structural and constructive elements adapted to its characteristic attributes.

Therefore, it's feasible to apply RPC to the construction of columns. RPC columns may become lighter due to ultra-high strength of RPC and seismic inertia loads may be reduced. Ductility of RPC columns can be improved using external confinement. A new strengthening technique using Carbon Fiber Reinforced Polymers (CFRP) was introduced instead of the conventional methods. These high-performance materials have unique properties, making them attractive for structural applications. FRPs are noncorrosive, have high strength to weight ratios, possess good fatigue behavior, and allow easy handling and installation. Therefore confined RPC columns have larger bending moment capacity and ductility, as well as larger axial load carrying capacity. But most research conducted on the field of concrete mechanics has been devoted to evaluate the behavior of confined conventional concrete columns [2-4].

In evaluating the nonlinear finite element analysis of concrete columns retrofitted by CFRP wraps, Doran et al [5] and Maaddawy [6] conducted nonlinear finite element analysis (NLFEA) for CFRP confined concrete columns but they are applicable mainly for square conventional concrete columns and conventional concrete columns respectively. Thirteen specimens, tested by researcher are numerically analyzed for behavior of concrete and composite wrap [7]. Specimens divided into 9 RPC columns with steel fiber and 5 RPC columns without steel fiber that tested under compressive loads with and without eccentricity. Details of material, geometrical and load characteristics of concrete specimens confined with CFRP are provided in