English Increasing the flexural capacity of geopolymer concrete beams using partially deflection hardening

Title: cement-based layers: Numerical study

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Abstract: cement based composites for strengthening the beams. This paper numerically investigates the feasibility of adding thin deflection hardening fiber reinforced layers to the bottom of geopolymer concrete beams to enhance the flexural performance. To properly predict the structural behavior and crack patterns of beams, the smeared crack approach was adopted to simulate the beams. The numerical simulations executed in the FEM-based computer program. To validate the developed numerical models, the tested experimental tests beams with two layers cross section were numerically simulated. Regarding the results obtained, the models would well predict the structural behavior and crack patterns of beams. Ensuring the efficiency and accuracy of the adopted constitutive model to predict the structural behavior and crack patterns of beams, the numerical FE models used to simulate the added hardening deflection fiber reinforced layer to the bottom of geopolymer concrete beams. The numerical results revealed that adding a thin fiber reinforced layer to geopolymer concrete beams results in increasing ultimate load capacity, ultimate deflection, and ductility. The greatest enhancement in the flexural performance of the strengthened beams was found in the ultimate load capacity of the strengthened beams.

English FEM; Material nonlinear analysis; Flexural strengthening; DHCC; enlargement method
Increasing the flexural capacity of geopolymer concrete beams using partially deflection hardening cement-based layers: Numerical study

Mastali M.*, Mastali M., Abdollahnejad Z., Dalvand A.

a Ph.D., ISISE, Department of Civil Engineering, University of Minho, 4800-058 Guimaraes, Portugal
Email of corresponding author: m.mastali@civil.uminho.pt, Mobile: 00351-915427040
b Ph.D. student, Faculty of Civil Engineering, Western Michigan University, Kalamazoo, MI 49008-5316, USA
c Ph.D., C-TAC Research Centre, Department of Civil Engineering, University of Minho, 4800-058 Guimaraes, 4800-058, Portugal
d Assistant Professor, Department of Engineering, Lorestan University, Khorramabad, Iran

Abstract

Experimental research has demonstrated the great flexural performance of deflection hardening cement based composites for strengthening the beams. This paper numerically investigates the feasibility of adding thin deflection hardening fiber reinforced layers to the bottom of geopolymer concrete beams to enhance the flexural performance.

To properly predict the structural behavior and crack patterns of beams, the smeared crack approach was adopted to simulate the beams. The numerical simulations executed in the FEM-based computer program. To validate the developed numerical models, the tested experimental tests beams with two layers cross section were numerically simulated. Regarding the results obtained, the models would well predict the structural behavior and crack patterns of beams. Ensuring the efficiency and accuracy of the adopted constitutive model to predict the structural behavior and crack patterns of beams, the numerical FE models used to simulate the added hardening deflection fiber reinforced layer to the bottom of geopolymer concrete beams.

The numerical results revealed that adding a thin fiber reinforced layer to geopolymer concrete beams results in increasing ultimate load capacity, ultimate deflection, and ductility. The greatest enhancement in the flexural performance of the strengthened beams was found in the ultimate load capacity of the strengthened beams.

Keywords: FEM; Material nonlinear analysis; Flexural strengthening; DHCC; enlargement method.
1. Introduction

In the last two decades, consumption of concrete as the most widely used building material in the world increased significantly, so that it is estimated that the demand of Ordinary Portland Cement (OPC) will be reached to total of 6 Gt/year up to 2050 [1]. High levels of carbon dioxide (CO$_2$) gas are emitted during cement production. Massive emissions of carbon dioxide bring serious environmental problems for humans. Therefore, some environmental friendly alternatives like geopolymers (also termed alkali-activated binders) were recently developed to replace with the OPC in concrete. Despite good mechanical and durability properties of concrete made with OPC, in the last decade, great interest is rising toward using environmental friendly alternatives instead of OPC due to massive emissions of carbon dioxide. Therefore, in 1990, geopolymer concrete was developed as environmental friendly alternative to Portland cement by Davidovits et al. [2]. These binders emissions much lower carbon dioxide compare to concrete made with Portland cement (0.184 tons of CO$_2$ per ton of binder) [2].

The main problem for plain concrete made with OPC, in addition to massive emissions of toxic gas, is low ductility and load carrying capacity under the imposed loads. This problem is also valid for plain concrete with alkali-activator binders.

Section enlargement is one of the effective strengthening techniques, which are used to improve structural behavior of reinforced concrete (RC) elements. In this technique, an external layer is attached to the element to enhance the structural performance under the imposed loads. The external layer would be a thin fiber reinforced concrete layer. Lots of research has conducted to assess the efficiency of this technique in strengthening RC elements. Previous studies in [3-7] demonstrated that this strengthening technique has significant effects on enhancing the structural performance of repaired elements.

Fiber Reinforced Cementitious Composites (FRCC) is a term commonly used for a broad class of materials. Every FRCC consists of two basic components: a cementitious-based material called matrix, which is reinforced by steel or synthetic fibers. The most widely accepted proposition is to classify FRCCs by their stress–strain response in direct tension and load–deflection response in flexure. Some FRCCs (Fiber Reinforced Cementitious Composites) are not strain-hardening in direct tension but they can present a hardening behavior in flexure. These materials are called deflection-hardening FRCCs and form the category of Deflection Hardening Cement Composites (DHCC). The DHCC material offers high ductile behavior due to bridging action of fibers, which enables the formation of multiple cracks on the tensile surface. Fiber bridging action is capable of arresting the further opening of cracks, and as a result, new