Finite element modeling of concrete beams reinforced with basalt FRP bars

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1 Abstract

Fiber-reinforced polymer (FRP) bars can replace conventional steel reinforcing rebars to prevent from corrosion in reinforced concrete structures exposed to highly corrosive environments. In this contribution, three tested concrete beams reinforced with BFRP (Basalt Fiber Reinforced Polymer) bars are analyzed using three-dimensional finite element methods. In the numerical analyses, concrete is modeled as nonlinear using plasticity and damage principles, while BFRP is modeled as linear elastic material. The main focus of this research is to present the calibration process that should take place prior to any parametric studies. This calibration suggests that the concrete model should be regularized using a characteristic length and material post-yield fracture energies in both tension and compression to provide mesh-size independent results. The numerical results are compared to the test results with regard to failure load and cracking.

Keywords: concrete-damage plasticity; FEA; concrete beams; FRP bars.

2 Introduction

FRPs perform high tensile strength, little to no yielding before failure, corrosion resistance. Among the different types, glass fiber reinforced polymer (GFRP) and carbon fiber reinforced polymer (CFRP) are the most common. A new type of FRP that is now available is the basalt FRP (BFRP). BFRP is categorized according to ACI 440.6-15 as a type of natural fiberglass fiber. However, since BFRP is new, limited use exists. Its failure stress is almost twice that of a similar sized steel reinforcing rebar with its modulus of elasticity being about one fifth that of steel (Urbanski et al., 2013). Additionally, like most other FRPs, BFRP has a linear stress-strain behavior with little to almost no yielding before failure. Ultimately, BFRP can be considered as a potential replacement for GFRP as it is stronger and has a higher stiffness, while, its price is competitive with GFRP.

In terms of research, experiments have already performed in reinforced concrete beams using BFRP bars as internal reinforcement (Tomlinson and Fam (2015), El Refai and Abed (2015), Issa et al. (2016)). The results showed that the shear strength of BFRP reinforced concrete beams is in good agreement with the shear behavior of concrete beams reinforced with other types of FRP bars. However,

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