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Shear Strength of FRP Reinforced Deep Beams without Web Reinforcement

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Abstract

Deep beams are common elements in concrete structures such as bridges, water tanks and parking garages, which are usually susceptible to harsh environmental conditions. To mitigate corrosion induced damage in those structures, steel reinforcement is being increasingly replaced by Fiber Reinforced Polymers (FRPs). Yet Eurocode doesn't provide any guidance regarding the design of FRP reinforced concrete structures in general and deep beams in particular. This study proposes a Eurocode based Strut and Tie Model (STM) to assess the shear strength of FRP reinforced deep beams without web reinforcement. The proposed STM as well as those adopted by other codes were evaluated using a data base of 52 deep beams reinforced with different types of FRPs. The proposed STM has proven to be not only accurate but also conservative with a mean predicted to experimental value of 0.96 and a standard deviation of 0.13. While the STMs adopted by other codes have either overestimated or underestimated the shear strength

Key words: FRP reinforcement; Deep Beams; Strut and Tie Model

1 Introduction

During the past century, numerous steel reinforced concrete structures have been built to support our infrastructure. Some of those structures such as parking garages, bridges and water tanks are susceptible to harsh environmental conditions, which lead to corrosion of steel reinforcement, and consequently the deterioration of concrete. This imposes high maintenance costs and reduces the service life of the structure. To overcome this problem, FRP rebars were suggested among other materials to replace the steel reinforcement owing to their non-corrodible behavior. Furthermore, FRPs have a high tensile strength which leads to an increase in the flexural capacity of the member. However, their relatively low modulus of elasticity decreases aggregate interlock and dowel action while increases crack width, thus reducing the shear capacity of the member [1-2].

The Shear strength of concrete beams is directly influenced by the shear span to effective depth ratio (a/d). Based on this, codes such as ACI 318M-14 [3] and CSA A23.3-14 [4] divide beams into two categories: deep beams when the a/d ratio is less than or equals to 2.0 and slender beams when the a/d ratio is greater than 2.0. Eurocode 2 [5] at the other hand takes a slightly more conservative approach, it classifies a member as a deep beam, if its clear span to depth ratio (l/h) is less than 3. Unlike slender beams, deep beams are entirely dominated by a disturbed region (D region) where the strain distribution is no longer liner, and thus the sectional model used to assess the shear strength of

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