Finite Element analysis of FRP strengthened grooved concrete beams

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Abstract

In concrete buildings it may appear to be a need for the structural members to be rehabilitated as it ages by time. This issue may arise from different reasons such as increasing in applied loads, concrete deterioration due to environmental effects, ageing of the structure, design and performance mistakes.

Since recent years Fiber Reinforced Polymers (FRP) plate installation to different structural members has been considered as a premier method for strengthening concrete structures. This method's superiority rather than steel plate installation is due to those FRP characteristics such as being light weight, easy consumption and having much more tensile strength than steel plates.

Due to smaller sections required in modern architectures, researchers tried to optimize concrete sections such that members sustain much more service loads. Recently researchers improved FRP flexural strengthening of concrete beams using few parallel grooves along the beam length called Externally Bonded Reinforcement on Grooves (EBROG). By using this method we can improve the premature de-bonding occurred during load application. Experimental results indicated a better behavior and an increasing strength compared to Externally Bonded Reinforcement (EBR) beams. In this paper a numerical study of the grooved beams strengthened with FRP (EBROG) is performed and this method's prominence is expressed as an excellent rehabilitation method.

Keywords: FRP, De-bonding, Grooved beams, FE analysis

1- INTRODUCTION

The bonding of fiber reinforced plastics (FRP) plates or sheets to the tensile side of a concrete beam or slab is found to be an effective technique for flexural strengthening. Priority of this method compared to conventional rehabilitation methods refers to particular properties of this material like for example good durability facing environmental unfavorable intense factors, high tensile strength, small thickness, ease of application and transportation, high corrosion resistance, small changes in section size and appearance of the retrofitted member. These characteristics make FRP plate bonding technique the most desirable method of rehabilitation.

As a result, a large number of studies have been carried out during last decades on the behavior of these FRP-strengthened beams. Most of these studies considered the effect of failure and de-bonding mechanism throughout the member. To the present time over 30 failure modes have been observed in experimental programs, but in a general classification these items can be summarized as: (1) Flexural failure by FRP rupture; (2) Flexural failure by crushing of compressive concrete; (3) Shear failure;; (4) concrete cover separation; (5) plate end interfacial de-bonding; (6) intermediate flexural crack-induced interfacial de-bonding; (7) intermediate flexural shear crack-induced interfacial de-bonding. Of the mentioned failure modes, the first three failure mechanisms could be observed also in ordinary reinforced concrete members, but the next failures is particularly referred to the plated reinforced beams and is arranged under the title of de-bonding which usually arise before beams bending and shear capacity is achieved [1].