Using NSM Method in R/C Beams Strengthening by FRP Strips

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Abstract

Reinforced concrete flexural elements may be required to strengthen during their service life due to various reasons, e.g. defect or decay in mechanical materials properties, imperfections on construction, or increasing of design loads due to changing in utilization or rules of the codes. Various FRP products – as composite materials- are recently used in different technique to strengthen the structural elements. In a very newest technique, which is called Near-Surface-Mounted (NSM) method, the FRP strips (or rods) are laid down on the epoxy filled grooves which already created on the external surfaces (top or bottom) of the concrete beams or slabs. Compare to the traditional use of FRP sheets adhering to the external surfaces, this method cause better transferring of the loads to the surrounding concrete by enhancing the bonding stresses, as well as better protecting the mechanical properties of the FRP strips against any environmental defects.

In this study, behavior of nine reinforced concrete beams (in three groups of different reinforcing ratios) which already strengthened by FRP strips (by NSM method), were simulated numerically by Finite Element Method. The numerical results were compared to the experimental ones.

Results show impressive compatibility between the numerical and the experimental load-displacement curves from the initial stage of loading, up to the peak load and further down to total strength degradation. Crack pattern and deformation, and also the failure process, all reproduced in a good and reasonable estimate of the experimental results. Increase in strength along with decrease in ductility was shown by both results. Strength and stiffness of all the strengthened beams (by FRP strips) were higher compare to the control beams (with no FRP), the same as observed in the experiments. Also, it shown that for the specimens with higher reinforcements, increase in CFRP strips resulted lower efficiency in strength, the same trend in the experiments.

Keywords: NSM method, FRP composite material, R/C beams, Finite Element Modeling.

1. Introduction

The need for structural rehabilitation of civil infrastructures all over the world is well known and a great amount of research is going on in this field. Recently, there are many changes in the contributing factors to structure deterioration, such as an increase in load requirements, corrosion deterioration due to exposure to aggressive environments, changes in the functionality, potential damage caused by mechanical and environmental effects, etc.

Many different methods are suitable for repair and strengthening, such as shotcrete with steel meshes, additional reinforcement covered by concrete, and external steel plate bonding, which the latter one, is widely using to externally strengthen reinforced concrete structures [2],[3]. Although this method can be effective in increasing the strength capacity of the structure, but sometimes heavy machines are needed to install steel plates, as well as steel is susceptible to corrosion which results cost of maintenance. Another point is that the high self-weight of steel plates reduces the load carrying capacity of structure.

Recently, a new repair and strengthening method has been introduced, which is plate bonding with Fiber Reinforced Composites (FRP). FRP composite is material with high stiffness and strength and serves as reinforcement when bonded onto a structure surface. All varieties of FRP materials enjoy of high strength