NUMERICAL STUDY OF THE BENDING BEHAVIOR OF THE CONCRETE BEAMS STRENGTHENED WITH CARBON FIBER LAYERS

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Abstract

Recently, FRP layers have attracted attentions significantly due to the ratio of resistance to high weight, resistance against corrosion, chemicals and fatigue arising out of loading, and easy installation, they are used for the repair and reconstruction of structures especially concrete ones.

The technology of using FRP sheets was firstly introduced by the Federal Laboratory of Swiss in 1984 [1]. FRP layers, whose weight is twenty percent of those of steel layers, are two to ten times more resistant than steel layers. This characteristic caused these fibers to be used in different industries However, the high price of this type of fiber restricted its application in construction industry in the past.

Considering that the technique of strengthening has been developed from middle of 1990s, fewer researches have pursued to study behavior of these fiber layers. In 1995, Chajes and Januszka [2] studied the shear resistance of T-beams strengthened with fiberglass and aramid layers. In this laboratory research,8 beams were strengthened using FRP layers to enhance their shear resistance. The beams were loaded until they fractured, and it was cleared that the resistance of the strengthened beams was increased by 60 to 150 percent. In 1999, Ross & Jerome [3] conducted a laboratory research to study the bending strength of the beams reinforced with FRP layers. In this research, 24 beams, whose bending strength was low, were strengthened with FRP layers, and 6 different ratios of steel surface were studied.In general, it was observed that the bending resistance of beams was increased by 30 to 120 percent. However, strengthening of beams causes reduction in their formability up to 40 percent.. In 2003, Brena and Bramblett [5] investigated the increase in the bending strength of the reinforced concrete. They strengthened beams with 4 different patterns using FRP. The purpose of this research was to determine the best pattern of fibers attached to concrete beams to increase their strength. The results indicated that the increase in the contact surface of fibers and concrete may not be an important factor for separation of concrete from fibers. For such a separation, it is required to attach vertical and continuous links to beam web.

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In this paper, we study the results of the analysis carried out 2 and 3 dimensionally. It is based on finite element method for the bending strength of reinforced concrete beams, whose tension surface is strengthened using CFRP layers. For introduction of concrete materials to software, a nonlinear model with nonlinear stress-strain curves as well as possibility of cracking and crushing were used. To introduce steel into the said software, a bilinear relation was employed, and carbon fiber layers made of materials with the properties of composites are used for modeling. The graphs of load-dislocation illustrated based on the results of ANSYS software show that the responses of those non-crushed areas of strengthened samples are almost similar to those of control groups, but when strengthened beams are cracked, they behave in a more hardening manner, in such a way that after yield of steels, the strengthened beams harden more and more. At this stage, if fiber layers are not separated from the beams, the resistance of such beams increases by 30 to 120 percent, and its unusual upper limit is due to the utilization of low percent of cross section of tension steel which were used for the modeling of samples. In this paper, the comparison of the behavior of the samples modeled numerically with that of the laboratory studies shows that the results of the modeled beams conform to those of the laboratory ones in such a way that error percent between the final resistance of the laboratory studies and that of numerical model is only from 3 to 9.

Keywords: FRP fibers, Bending Resistance, Finite Element, Carbon Fiber Layers, Ductility

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