THE EFFECT OF MULTI LAYERS OF CFRP ON LOADING CAPACITY OF STRENGTHENED REINFORCED CONCRETE BEAMS BY EBROG METHOD AND COMPARING IT BY USING ONE LAYER OF AFRP

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ABSTRACT

Externally Bonded Reinforcement On Grooves (EBROG) is a new promising method that has been introduced at Isfahan University of Technology (IUT) to postpone or eliminate debonding of FRP sheets from concrete surface in concrete beams strengthened for flexure. Experiments have shown that the probability of debonding when attached to concrete substrate using EBROG method is much lower than the other methods; and in some cases debonding is completely eliminated. The aim of the current study is to examine the efficacy of grooving method when used under multilayer CFRP sheets analytical and comparing it with the results of one layer of AFRP. For this purpose, beam specimens with dimension 120*140*1000 mm were modeled in ABAQUS program. We assigned concrete damage plasticity for concrete, and fully elasto-plastic for both steel and CFRP and AFRP. We use dynamic,explicit analysis and meshed the specimens by o.o2m size. The interaction between mesh bar and concrete beam was embedded and interaction between CFRP, AFRP and concrete beam was tie. Using mesh bar is related to preventing any shear failure . Finally, the results shown that using 3 layers of CFRP is much better than 1 layer of AFRP . The rate of increment loading capacity is about 51.85 percent .

Keywords: Aramid Fiber Reinforced Polymer (AFRP); Carbon Fiber Reinforced Polymer (CFRP), strengthening, Externally Bonded Reinforcement on Grooves (EBROG), loading capacity, ABAQUS program

INTRODUCTION

Over the past decade, conventional materials such as concrete and steel are being replaced by Fiber Reinforced Polymer (FRP) composites for repairing and rehabilitation of concrete structures. Numerous advantages such as high tensile strength, high durability and corrosion resistant, low weight and easy installation, and no limitation in size and configuration, have made FRP to be highly desirable and implemented in a large number of practical projects worldwide.

It has been shown through experimental and numerical studies that externally bonded FRP composites can effectively improve the load carrying capacity of concrete beams as well as their stiffness and durability, known as Externally Bonded Reinforcement (EBR) technique. According to EBR method, after surface preparation, FRP sheet is adhesively bonded to the tension face of the concrete beam. It should be noted that the purpose of surface preparation is to remove d regularize the concrete surface to promote the adherence capacity of concrete substrate.

Previous research efforts have investigated the behavior of these FRP strengthened beams when subjected to flexural loading. Results have shown that the ultimate load carrying capacity of the retrofitted elements is directly influenced by the interface bonding performance and EBR technique cannot mobilize the full tensile strength of the FRP composite due to their premature debonding from the concrete substrate.

Mostofinejad and Mahmoudabadi (2009) have introduced an alternative method of surface preparation to postpone debonding of FRP laminates in concrete beams. In EBROG method, first the longitudinal grooves on the concrete surface of the elements were cut using a diamond blade cutter in order to strengthen the element. The grooves were then cleaned by jet air and filled with the epoxy resin. FRP sheets were later installed on the concrete surface saturated with the epoxy resin and the resin in excess was removed. This method is called Externally Bonded Reinforcement On Grooves (EBROG). It should be noted that what is herein called EBROG technique, was previously named as Grooving Method (GM).

EBROG method has shown great promises in dealing with debonding problems. Experiments have revealed that in this technique, debonding is postponed and in some cases is completely eliminated. Generally the EBROG method is superior to EBR method due to a number of advantages. (1) As mentioned before, the EBROG technique postpones the debonding compare to the EBR method and in some cases provides the full elimination of debonding of FRP laminates and this is the most important aspect of this technique. (2) The amount of site installation work may be reduced since surface preparation other than grooving is no longer required. This leads to less economic losses due to less work activities; (3) Due to elimination of surface preparation, EBROG technique has less environmental impacts.

So far, the performance of the EBROG method is examined only with single layer of fiber and there is no research when multilayer fibers are used to strengthen beams with EBROG method. The aim of the current study is to carry out some analytical data for improving loading capacity when we used multilayers of CFRP instead of FRP laminates and comparing it with the results that carried out when we had used one layer of AFRP before.

MODELING

We modeled a concrete beam with 120*1000 mm dimension, CFRP/AFRP with 100*800 mm dimension, length of grooves with 850 mm, with of grooves with 8 mm and depth of grooves with 10 mm in ABAQUS program. We assumed distance between grooves with 15 mm. Finally, for preventing any shear undesired shear failure, create mesh bar with 120*140 mm dimension and distance between grooves with 5 mm.

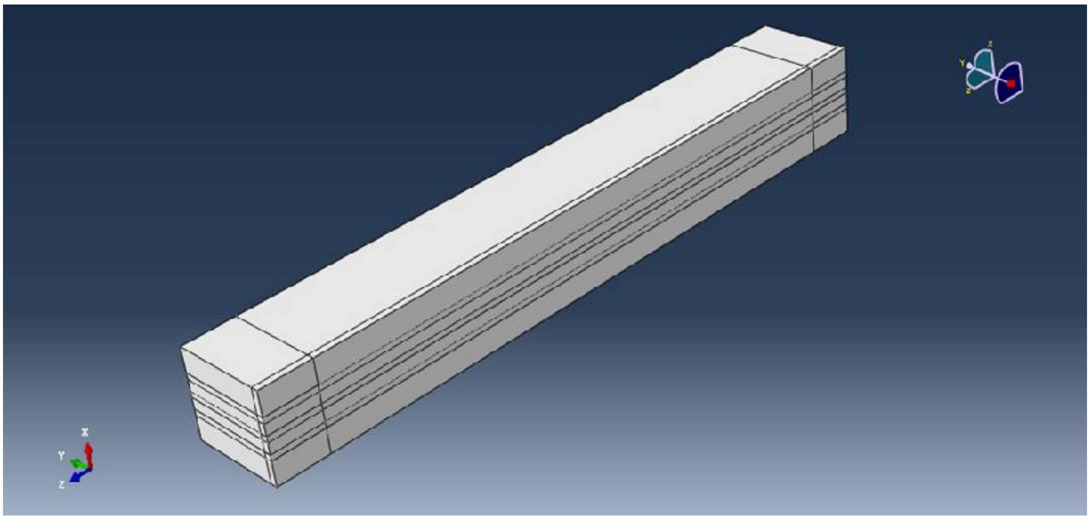

Figure1. Concrete beams with grooves

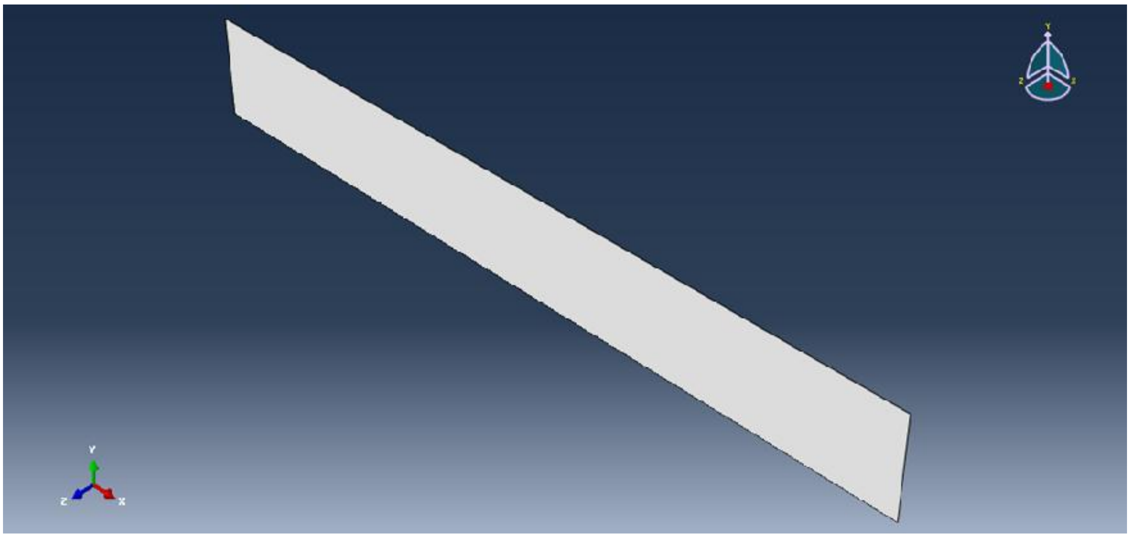

Figure2. CFRP/AFRP layer

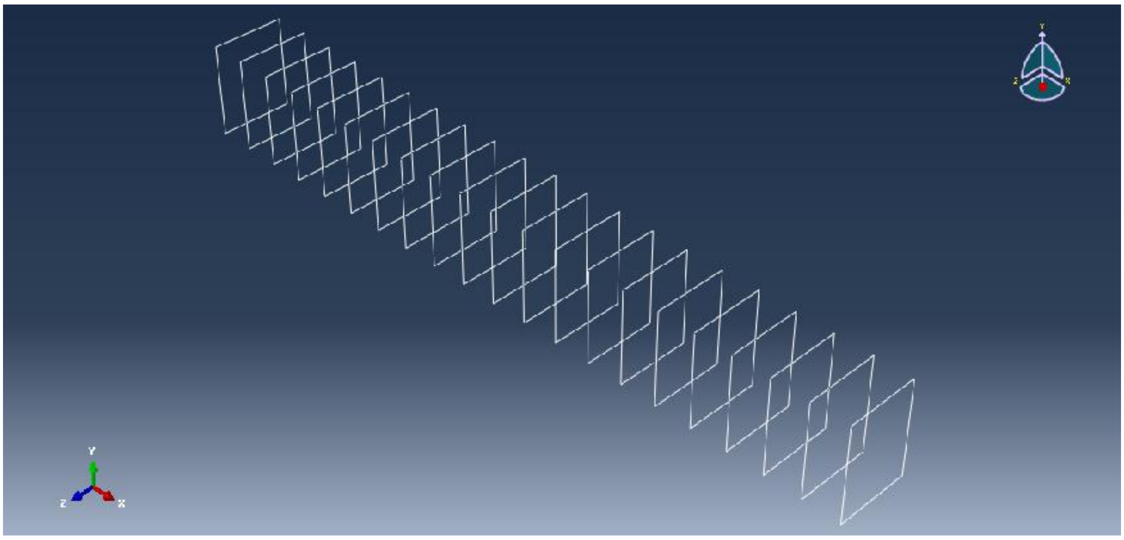

Figure3. Mesh bar

MATERIALS DEFINITION

We defined 5 behavior for concrete, CFRP/AFRP, Mesh bar, Rebar and resin epoxy. Definition for concrete is based on elasto-plastic behavior. For plastic behavior, we used concrete damage plasticity for both compression and tension region. The behavior for CFRP, Mesh bar, Rebar and resin epoxy was fully elasto-plastic.

Table1-values for inelastic behavior (concrete)

	f'c (N/m2)	Ec (N/m2)	fr (N/m2)	ε'c (εc in σc = f'c)
Concrete	2.50E+07	2.00E+10	2.50E+06	0.002

Table2–values for steel

	fy (MPa)	E (MPa)
Steel	400	2.00E+11

ASSEMBLY

At this step, we assembled 4 parts (Concrete Beam, CFRP/AFRP, Mesh bar, Rebar and resin epoxy).

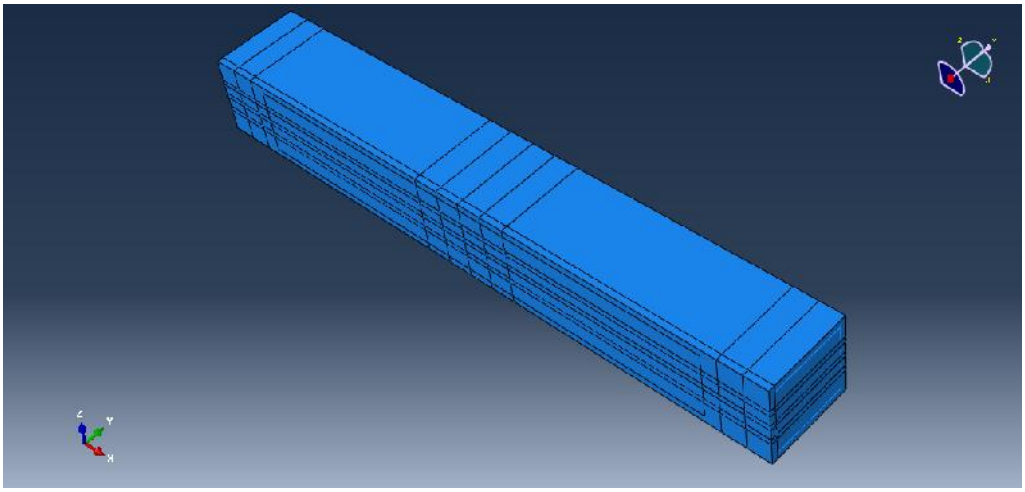

Figure4. Assembly sample

INTERACTION

In this level, we defined 3 behavior in interaction property part: 1-normal behavior, 2-tangential behavior, 3-cohesive behavior. In constraint menu, we embedded Mesh bar and tied CFRP/AFRP to bottom of concrete beam.

LOAD

Load definition is based on maximum displacement. We created 2 surface on the top of concrete beam and allocated maximum displacement on that surface.

BOUNDRY CONDITION

We created 2 type for boundry condition: 1-fixed support, and 2-hinged support and assigned them to left and right side of the concrete beam.

MESH

Mesh for concrete beam was hexagonal and technique of the mesh was structured. The name of mesh was C3D8R and the size of mesh was 0.02 m.

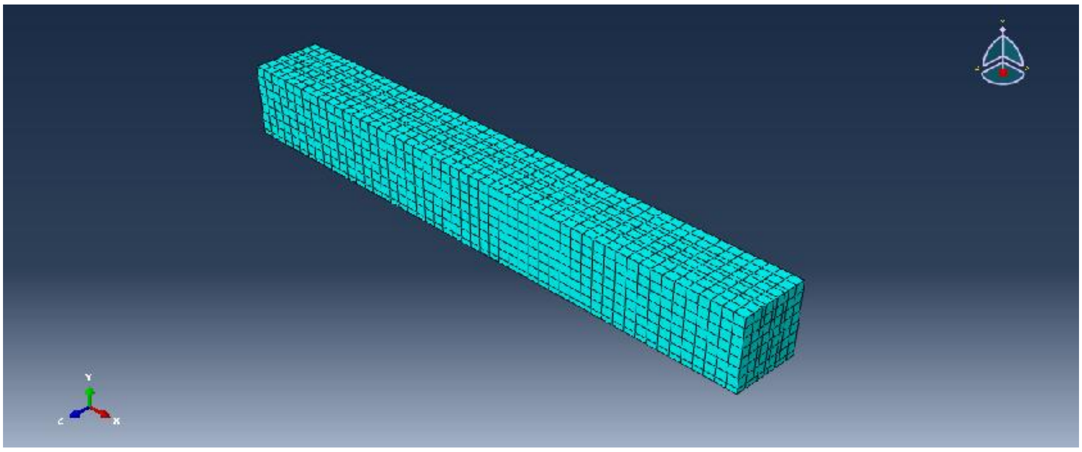

Figure5. Mesh for concrete beam

Mesh for CFRP/AFRP was Quadratic and technique of the mesh was structured. The name of mesh was S4R and the size of mesh was 0.02 m.

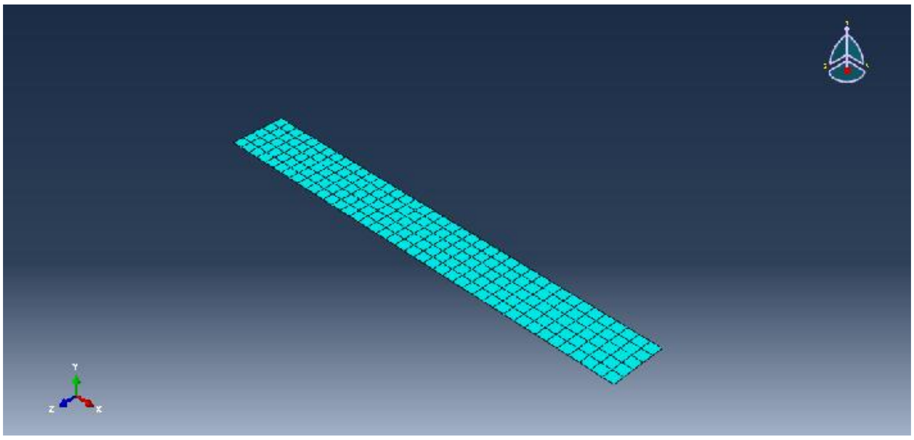

Figure6. Mesh for CFRP/AFRP

The name of mesh for Mesh bar was B31 and the size of mesh was 0.02 m.

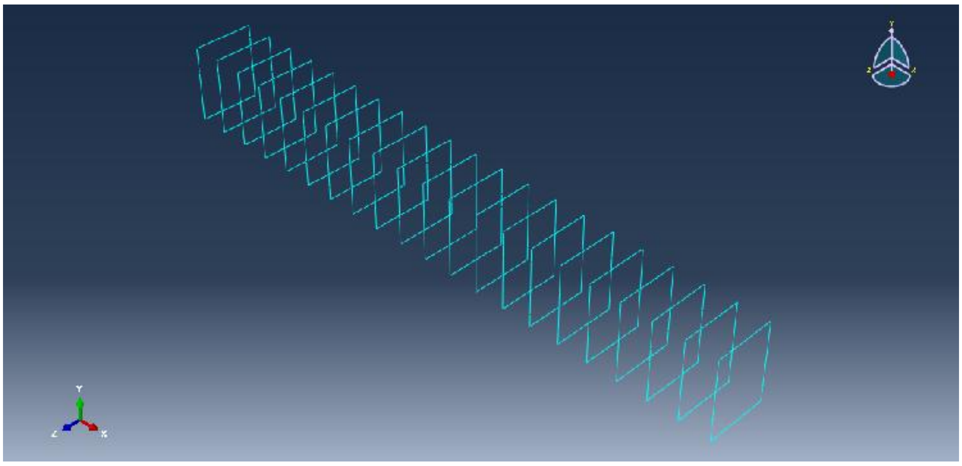

Figure7. Mesh for Mesh bar

STEP

We analyze this sample by Dynamic,Explicit method and we assigned time period=3.

RESULTS

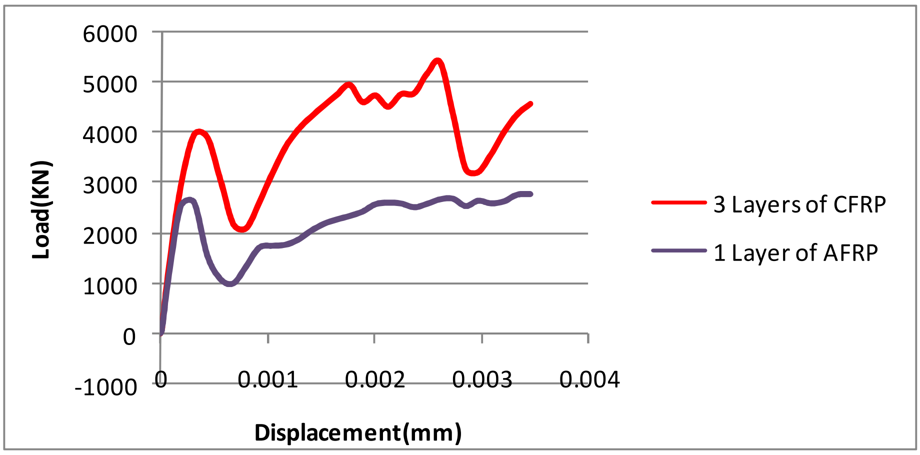

Diagram1. Load-displacement diagram for Multilayers of CFRP and One Layer of AFRP

CONCLUSION

1- Maximum value for loading capacity by using multilayers of CFRP is 5.5 KN and maximum value for displacement by using multilayers of AFRP is 3.3 mm.
2- Maximum value for loading capacity by using one layer of AFRP is 2.9 KN and maximum value for displacement by using multilayers of AFRP is 3.4 mm.
3- It is clear that the size of mesh between 0.005, 0.008, and 0.02 m not differences widely.
4- It is clear that loading capacity has increased when used multilayers of CFRP instead of using one layer of AFRP except some points at the end of analysis.
5- Finally, EBROG is one of the method for eliminating debonding and increasing the loading capacity. It is better to use this method when we use multilayers of CFRP.
6- The results shown that using 3 layers of CFRP is much better than one layer of AFRP. The rate of increment loading capacity is about 51.85 percent.

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