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ORIGINAL ARTICLE

Modeling of Ferroconcrete Beam's with High Resistance (HSC) are Reinforced by (AFRP) Under the Force of Bending

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ABSTRACT
Because of the very favorable properties of Synthetic polymers (FRP) using of these Composites is spreading day-to-day. So far the most usage of Synthetic polymers has been for reinforcing and Retrofitting the Structures. But these days we use them as the main reinforcement of concrete (instead of Steel bars). The FRP bars have many advantages over metal bars. In this study, a total of six high-strength concrete beam (HSC) which are reinforced by steel and AFRP have been Modeling and comparing their behavior under bending by a software which is called ANSYS. In addition to calibration software, in some cases the application results are compared with experimental results and their accuracy have been confirmed.
Keywords: *reinforced concrete beam with high strength (HSC) , AFRP , ANSYS, bending behavior.*

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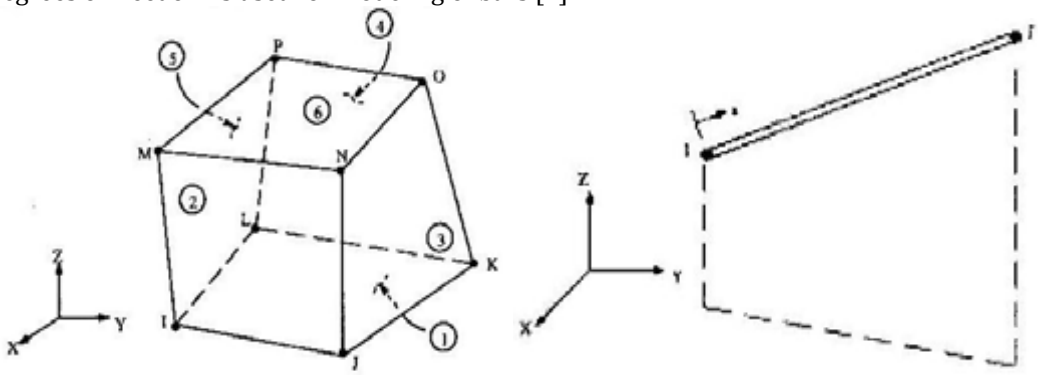
INTRODUCTION

Synthetic polymers are often used as either Steel Jacketing or the main reinforcement for retrofitting and reinforcing the Concrete. Although at the beginning these polymers were used only for Retrofitting but since they have overcome to steel jacketing, it changed people idea to use them as the main reinforcement of concrete. Although using of these polymers as a main reinforcement of concrete does not find its Position yet, but the very favorable properties of these reinforcement like their High tensile strength (about Three times stronger than steel) increase Engineers Enthusiasm to use them a lot [1].It is worth noting that the (FRP) bars have Linear behavior until the Moment of failure, which causes Beam to be frangible [2]. Using Synthetic polymers Whether as jacket or as bar, Include three types such as CFRP(Carbon-fiber-reinforced polymer), GFRP(Glass Fiber Reinforced Polymer), AFRP(Aramid Fiber Reinforced Polymer).Using Synthetic polymers Whether as main reinforcement or restoration or resistance , have Some Properties such as Lightweight , High resistance , High strength-to-weight ratio , Speed of operation , No need for machines and Special Equipment , Resistance to weathering and corrosion , being Economic , being a simple operations[3].Research conducted in the reinforcement of concrete with FRP has a life less than a decade. Cosenza and others in 1997 tried to research about reinforced Concrete Structures with FRP off -course in normal Concrete 'c < 41Mpa [4]. Grace and Masmoudi in 1998 have reinforced some concrete with 70 Mpa Resistance with FRP and finally the riault and Benmokrane examined the behavior of the Concrete with 100 Mpa Resistance which was reinforced by FRP under the flexural load [5]. However, all these studies were limited to the reinforcement of GFRP and CFRP. But in 2005, Rashid, Mansur and Paramasivam [2] did this reinforcement in some High resistance Concrete with AFRP And their flexural behavior were studied. In this article the Flexural behavior of beams that were reinforced by steel and the Flexural behavior of beams that were reinforced by AFRP have been compared.

MODELING WITH ANSYS SOFTWARE

ANSYS software is proper software for Nonlinear Analyzing. Analyzing with the ANSYS software includes three steps such as Preprocessor, Solution and Post processor [6]. ANSYS software 9 is used in this study. There are more than 100 types of elements for modeling. In this study for modeling of concrete, element of Concrete 65 is used which is a three-dimensional and eight-nodeelement and Three degrees of

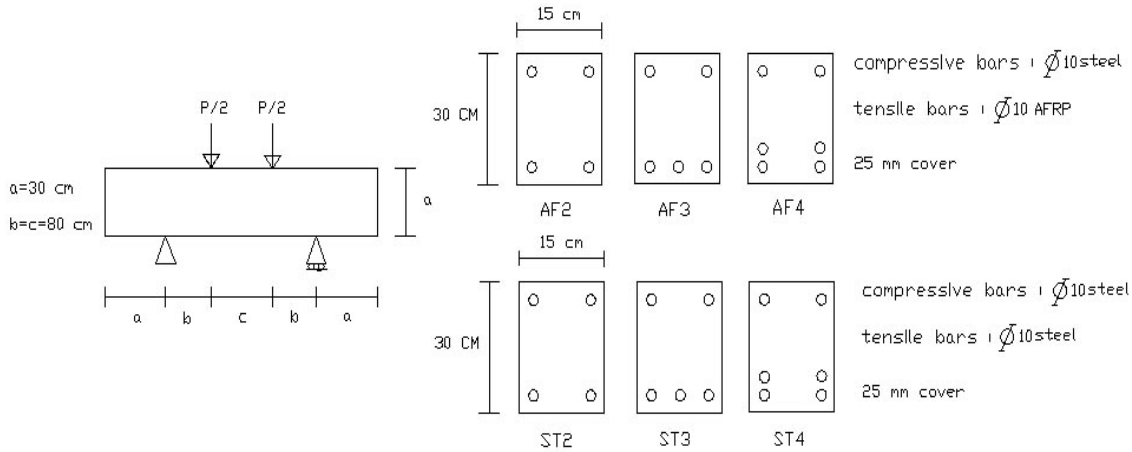
Freedom have been used in each node. also the element of Link 8 which is two-Node and each node has Three degrees of freedom is used for modeling of bars [7].



Picture 1- the elements of concrete 65 and Link 8

Modeled Samples

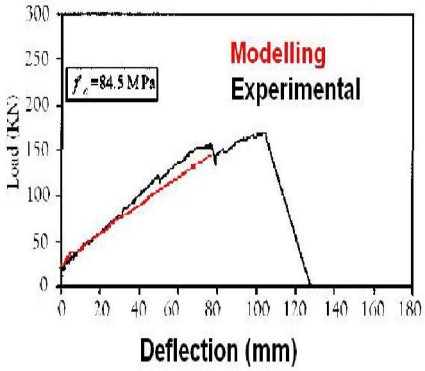
6 Samples of high-strength concrete beams (HSC) which have 6 meters length have been modeled. The flexural bars which have been used in the first 3 beams are made from AFRP with 35 Gpa of The modulus of elasticity and a 1760 Mpa of Tensile strength. These beams have been named AF2, AF3 and AF4 that first two letters of their names are retrieved from the tensile reinforcement of beam means (AFRP) and the number next to them shows the number of the flexural bars. These bars don't move and they will have perfectly linear behavior until the Moment of rupture. In the second three beams the flexural bars are made from steel with 2.1*105MpaofThe modulus of elasticity and 533 Mpa of yield Stress. These beams like previous beams have been named ST2, ST3 and ST4. That the first two letters of their names are retrieved from the tensile reinforcement means STEEL and the number next to them shows the number of the flexural bars. In all these beams the compressive bars are steel.26steelstirrups (A3) is distributed uniformly over the beams. Also all the steel beams and AFRP Have a diameter of 10millimeters.In all beams, the concrete compressive strength(f 'c) is 84.5 Mpa. Other detail of beams is given in picture 2.



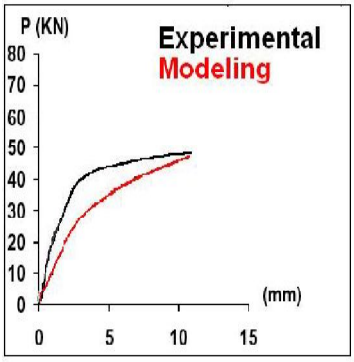
Picture 2 –The Information and name of the beams

Calibration of Software

Before studding the 6 main beams , To determine that if software works correctly, The conclusions of the analyzing of software and laboratory conclusions of two Beams which are under the flexural force are compared.(one beam is Reinforced by the steel and another one by AFRP). The first beam which is named ST-Control beam is a beam that has been Reinforced by steel and It's laboratory conclusions are presented (as a control) by sirs, Sadr Momazi , Ranjbar and Piraghvam[8]. picture 3 shows the second beam which is named AF-Control beam is a beam that has been Reinforced by AFRP and It's laboratory conclusions are presented(as DF3T 2) by sirs,Rashid, Mansur, and Paramasivam [2].picture 4 shows the comparison between laboratory conclusions and modeling with ANSYS.



Picture 4- AF Control Beam

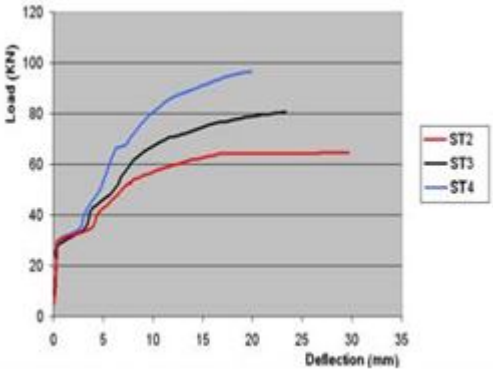


Picture 3- ST Control Beam

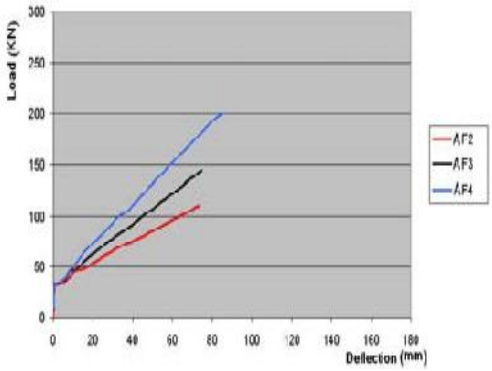
It is noted that software to reach of the ultimate strength of beam worked correctly. Of course about the HSC beams which are reinforced by AFRP, software could not converge the Equations after creation of large cracks in the tensile zone, so the end of the diagram is not found.

Comparison of the Behavior of the 6 Main Samples

High-strength concrete beams (HSC) that are reinforced by AFRP have perfectly linear Behavior until the Moment of rupture. Picture 5 shows the behavior of AF2, AF3 and AF4 beams. But those beams which have steel bars, from a segment have become nonlinear. Picture 6 shows the behavior of ST2, ST3 and ST4 beams.

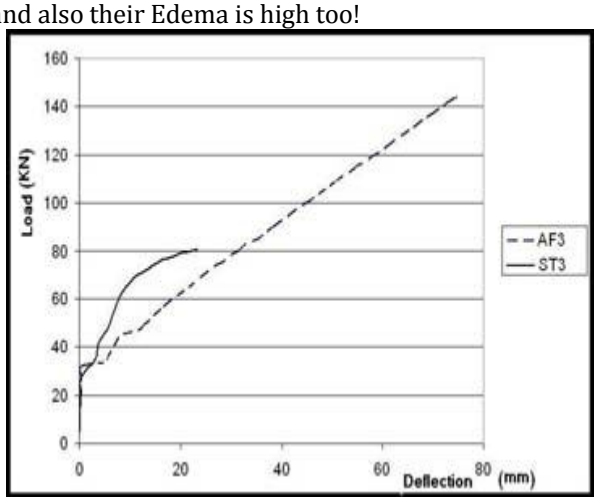


Picture 6

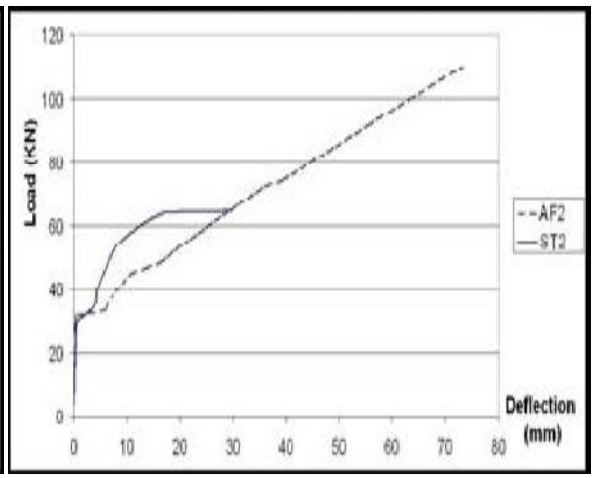


Picture 5

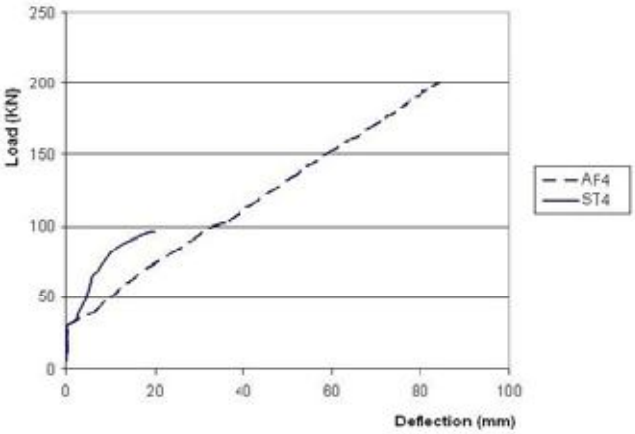
In the pictures 7, 8 and 9 the behavior of each beam that is reinforced by AFRP, has been compared to their steel Corresponding. In all cases the Cargo capacity of beams Are which Reinforced by AFRP is high and also their Edema is high too!



Picture8



Picture 7



Picture 9

Table 1 shows other information and conclusions of Analysis of samples

row	name of the beam	Genus of the Tensile bars	Number of the tensile bars	Compressive strength of concrete Mpa(f 'C)	Tensile strength of reinforcement	The maximum Edema of beam	force of Rupture of beam	Increasing the number of Tensile bars in order to Increasing the Resistance
1	ST2	STEEL	2	84/5	533	29/69	64/6	-
2	ST3	STEEL	3	84/5	533	23/35	80/5	24
3	ST4	STEEL	4	84/5	533	19/88	96/5	20
4	AF2	AFRP	2	84/5	1760	73/37	110	-
5	AF3	AFRP	3	84/5	1760	74/78	144	30
6	AF4	AFRP	4	84/5	1760	85	200	39

DISCUSSION AND CONCLUSION

A - High-strength concrete beams (HSC) which are reinforced by AFRP, under the bending load will have the linear behavior until the Moment of rupture. Also because of having Linear behavior (AFRP) these be beams are frangible that this can be the Weakness of these beams. Also the high Edema of these beams can be a warning of Fracture of these beams.(but High-strength concrete beams (HSC)which are Reinforced by Steel have nonlinear behavior).

B –balance of the final Edema of (HSC) beams that are reinforced by AFRP, under the bending load in all beams is more than the final Edema of (HSC) beams that are reinforced by steel. In the beams that are Reinforced by AFRP, by Increasing the number of Tensile bars, their edema Increases too but in beams that are Reinforced by steel, by Increasing the number of Tensile bars, their edema decreases.

C - The final rupture force of the High-strength concrete beams (HSC) that are reinforced by AFRP is more than the final rupture force of the High-strength concrete beams (HSC) that are reinforced by steel. Also the percent of the Increasing. The final rupture force by Increasing the number of tensile bars in the beams that are reinforced by AFRP is more that the beams that are reinforced by steel.

D –Because of the High tensile strength of (AFRP) HSC beams that are Reinforced by AFRP ,Maintain their performance in strain that is on top of the Reinforcement and in the Edema that is on top of the beam and until the Moment of rupture can Increase the force which is effective on them, But the concrete beams that are Reinforced by steel ,after the submission of Reinforcement, do not have performance and under a little load, the beam will have so much Edema and will have so much Strain and in fact , these beams will be effective only until the moment of Submission of reinforcement.

F – The more usage of the Tensile bars, the more difference between the Ultimate Resistance of HSC Concrete beams that are reinforced by AFRP and the Ultimate Resistance of HSC beams that are reinforced by steel.

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