Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 2 (10) September 2013: 135-139

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com

ORIGINAL ARTICLE

Reviewing the Usage of FRP Plates in Reinforcement of Built Beams

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ABSTRACT
In the past years, reinforcement and resistance of structures is widely discussed in engineering society. In this field, according to the structure and aim of strengthen, different methods have been offered. One of these methods that are generally used is the usage of FRP plates. In this topic, the usages of CFRP plates have been numerically studied. In these studies, reinforcement of built beam by locating CFRP plates on elasticity wing of iron beam and web was done and incoming results were comprised with other numerical and laboratory results. In this research impact of CFRP plates by different sizes and thickness by centric loading was studied and the results show that by using CFRP plates,the strength of built beams can be increased so much.

Received 01.07.2013 Accepted 06.09.2013

INTRODUCTION

Increasing the life time of structures, increasing the weight of cars, traffic increasing on bridges, bad environmental impacts, lack of control on structures, is the first reasons that cause load capacity deduction in main beams in these kinds of structures like bridges. Repairing and strengthening these kinds of structures to increase their life time is more economical and they take less time to be done, which cause less secondary problems. Connecting steel plates to the elasticity wing is a common way for strengthening steel plates which beside high cost, cause heaviness of structure. FRP system is consisting of flax and resin connector of lower surface and keeping surface. Tensile strength, elasticity module, high fatigue strength, resistance against corrosion and having low weight are its benefits in strengthening beams and uprights. Between different FRP plates, CFRP plates are in order to strengthen steel beams. In the past years various researches have been done about usage of CFRP plates for strengthening reinforcement concrete but there is less about strengthening steel beams by CFRP plates.

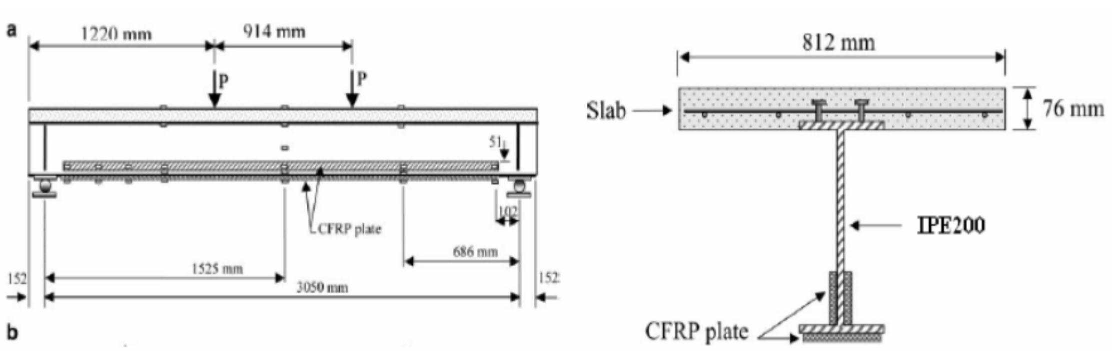


Figure-1-parts of built beam with reinforcement design

In this review, by different type and different thickness of CFRP plates, we will face with the impact of CFRP plates on ultimate load capacity of built beams. In studying process, plates deboning from steel surface with strain control have been studied.

Presentation

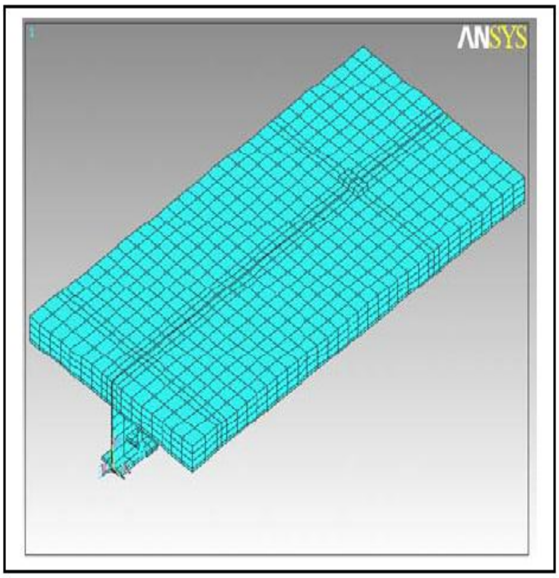
In order to caliber the numerical module, the main laboratorial built beam is as a numerical control beam, which is introduced in Figure 1.Built beam is consisting of a IPE200 steel beam with 3400 length, 200mm height, and a concrete slab with 812mm width, 76mm thickness. Sectional roaches are prepared for sectional connecting between slab and beam, which become true in numerical module by Merge Nodes. Steel plates with 100mm×20mm×50mmdimensions in loading location and bearer are placed. Bearer is simple one and loading is centric. Laboratorial control beam which is strengthening by CFRP plates is modulating as S1 and S2. In S1 just elasticity wing is strengthen and in S2 beside this, web is strengthen too. 28 day cylindrical resistance of concrete is 35MPa. Other information is in table 1.

Table 1- materials specification

Materials	Pressure Strength (MPa)	Tensile Strength (MPa)	Yielding stress Strength (MPa)	Elasticity Module (GPa)
Concrete	35	3/7	-	28
Steel	-	496	364	200
CFRP	-	2480	-	200

Studying and comparing the numerical and Laboratorial results

By cal bring the software before each research with numerical method we can trust the test result, so by modulating the laboratorial beam number and comparing the results, the one that has the fewer error and the nearest one to the laboratorial model was choose as a numerical control beam. To reduce the accounting and make the process faster, half of symmetrical beam is modulated and the results are known for the whole beam. Adaption standards are dislocating middle of span, yielding point of steel beam, amount of strain in CFRP plates, tension and strain in concrete. Figure-3 is an acceptable adaption between numerical control beam and laboratorial beam.



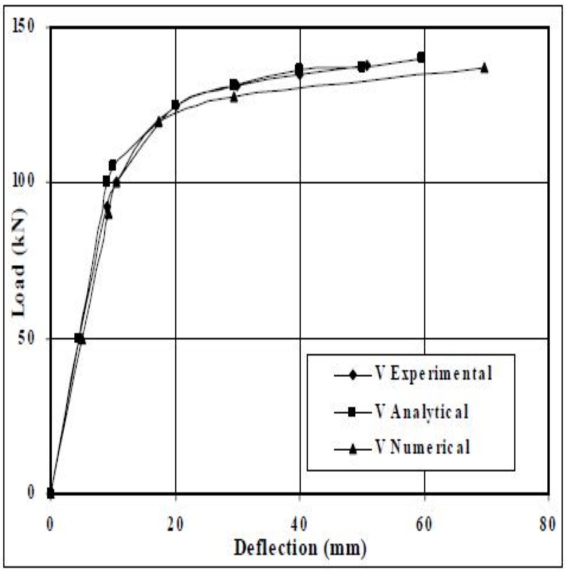


Figure-2-Half of built beam numerical module   Figure3-middle span shifting in numerical control beam, laboratorial, calculating

This research is according these theories:

1. Connecting slab concrete and steel beams, andalso steel beam and CFRP plate completely and without any separation.
2. Tension-strain diagram is taken as elastic-perfectly -plastic
3. Strain changes in the whole beams section are linear.
4. Tension-strain changing in CFRP plates is linear until its failure.
5. Tension-stain concrete diagram follow simple Ban gash curve.

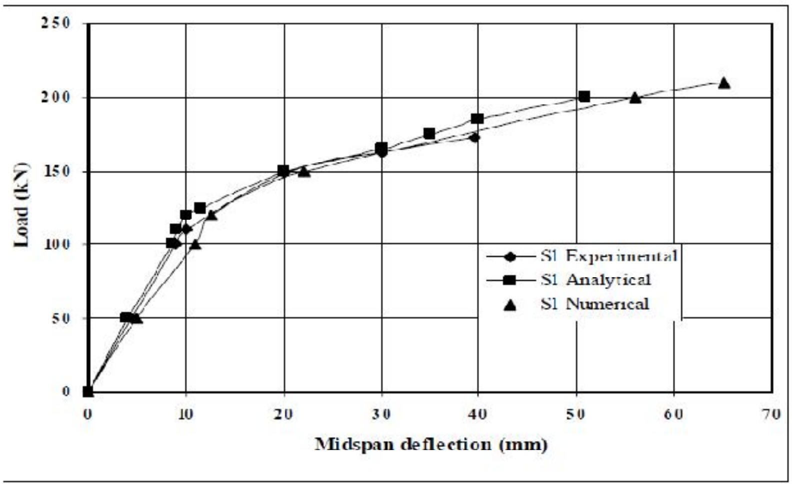


Figure-3-Comparing middle span shifting in S1 numerical module with laboratorial module and calculating formula

Next, S1 and S2 reinforcement beams by using modulating soft wares and laboratorial results become caliber. Adapting the results in shape 4,5 are given for comparing. Height of reinforcement web in S2, 50mm and thickness of plate in each module is 1.4mm.As it's shown the numerical module in these diagramshas acceptable adaptation. This way of reinforcement of beams extremely depend on plates bonding with its inferior surface, in a way that mostly because of not complete connection or deboning due to too much strain in reinforcement plate, the incoming result is not acceptable.

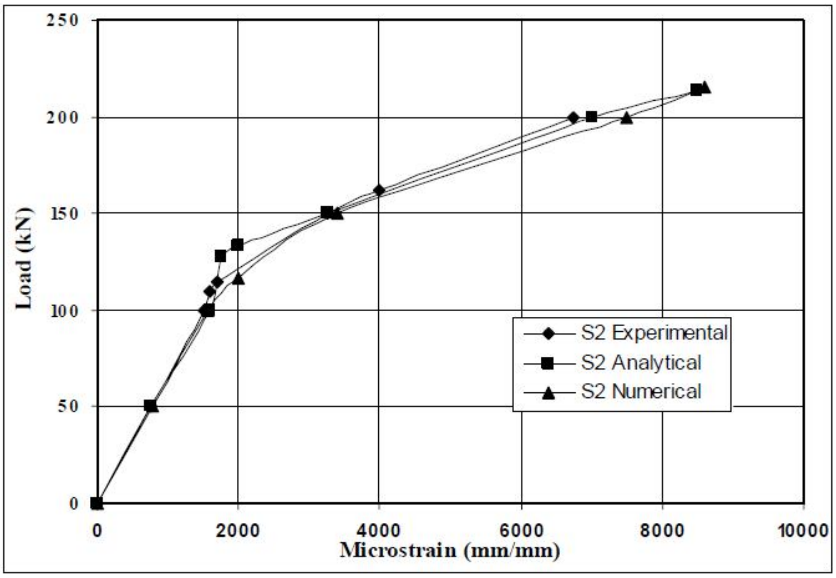


Figure-4-Comparing strain in CFRP plates in middle of span of numerical module and laboratorial module

To control this matter, ACI have suggested some ways like making some limits in plates strain. In the studied case because of customer willing the last strain in plates is limited to 1.6% and in concrete due to ACI rules is limited to 0.003. In shape 6 in addition to strain in CFRP plates, observance the limits are given.
Although connecting CFRP to the web directly wouldn't cause increasing in strengthen but it would reduce the tension and strain between inferior plate and wing surface of steel beam and this would increase loading of beam.

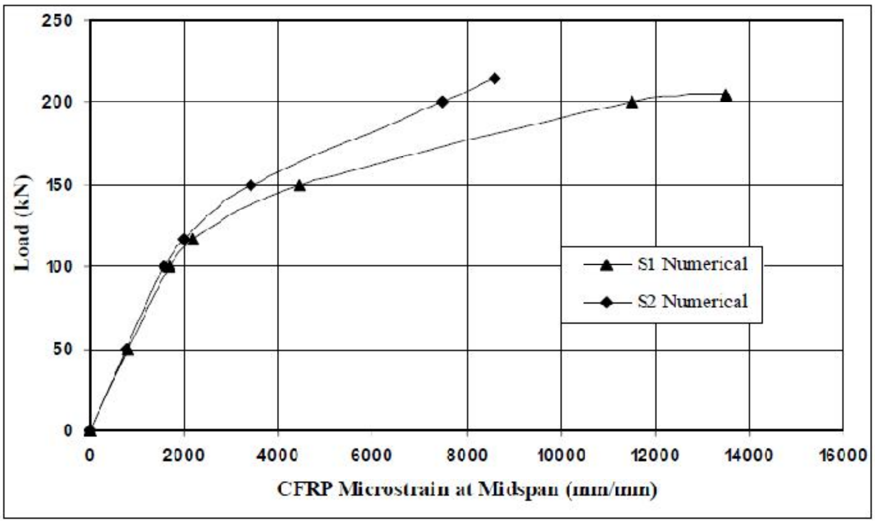


Figure-5-Comparing CFRP plates strain in numerical beams, S1 and S2

In these studies, reinforcement of built beam by locating CFRP plates on elasticity wing of iron beam and web was done and incoming results were comprised with other numerical and laboratory results. In this research impact of CFRP plates by different sizes and thickness by centric loading was studied and the results show that by using CFRP plates, the strength of built beams can be increased so much.

Table 2- Comparing numerical beam loading result with laboratorial module and calculating formula

Beam specification	Last load (KN)			Increasing loading capacity (%)			Failure mood
	EXP	ANL	NUM	EXP	ANL	NUM	
V	138	140	130-140	-	-	-	CC
S1	173	200	200-210	25	42	About 50	R
S2	200	213	200-220	45	52	About 50	R&CC

CC: concrete friability   R: CFRP failure

Parametric studying:
In this studying, the height of reinforcement plate in the web and thickness of it is two subjects to discuss. At first the height of CFRP plate is increased from 50mm to 100mm and next, reaches the whole height of web.

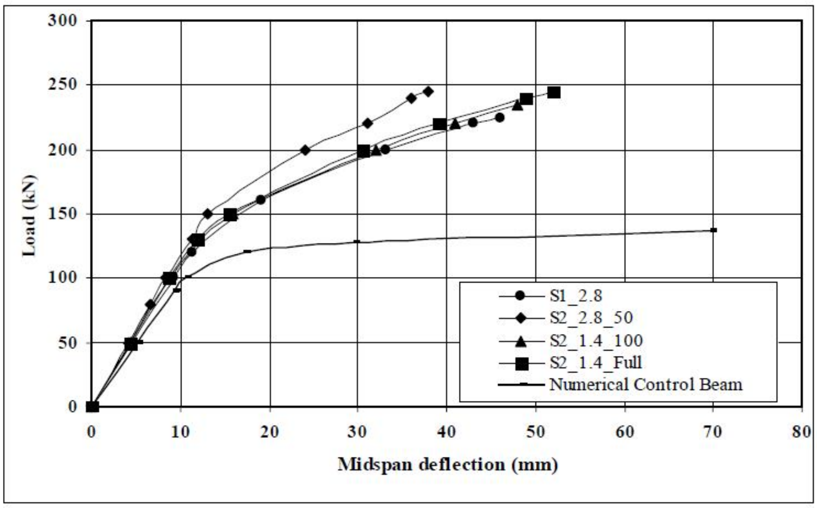


Figure- 6-Comparing last load of middle of span in parametric module an with numerical control beam

Then two S1, S2 beams with CFRP plate by 2.8mm thickness are reinforced. In the studied case because of customer willing the last strain in plates is limited to S1_2.8 and in concrete due to ACI rules is limited to S2_2.8. In shape 6 in addition to strain in CFRP plates, observance the limits are given.

CONCLUSION

Of these studying, these results would be refined:

1-Usage of CFRP plates in reinforcing built beams would increase sectional loading. This theory can be trusted up to 40%, 50%.

2-Usage of CFRP plates in reinforcing built beams would increase hardness and reduce rise of reinforcement beam. This reducing is up to 25%.

3-Connecting CFRP plates to reinforcement beams would reduce ductility.

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How to cite this article

Yousef Zandi and Amir Hossein Rezaeian. Reviewing the Usage of FRP Plates in Reinforcement of Built Beams. Bull. Env. Pharmacol. Life Sci., Vol 2 (10) September 2013: 135-139