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RETROFITTING OF T-SHAPE BRIDGE GIRDER USING FRP

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Abstract — *The aim of this research was to check the possibility of using Fiber-Reinforced Polymer (FRP) material for retrofitting of T-shape reinforced concrete (RC) non-pre-stressed Bridge girders. From last few decades, the use of innovative composite materials such as Fiber Reinforced Polymer (FRP) for strengthening, upgrading and rehabilitation of existing reinforced concrete structures. It is use because of their superior qualities such as light weight, easy to apply, high strength to weight ratio, and show efficient performance in strengthening and up gradation of reinforced concrete structure. Non-pre-stressed reinforced concrete (RC) T–shape bridge girder model was casted which dimensions were ¼ of the prototype bridge girder dimensions. After casting the girder they were tested and damage it to their ultimate strength. Girder model was failed only in flexural and flexural cracks developed only at four feet central span of the girders. Girder was retrofitted by externally applied of Fiber Reinforced Polymer (FRP) sheet with epoxy resin and also injected the epoxy resin into cracks. After retrofitting tested the girder under same protocol of loading as used before retrofitting and check the response of Fiber Reinforced Polymer (FRP) sheet under loading demand. Concluded from this research that externally bonded Fiber Reinforced Polymer (FRP) sheets with epoxy resin and injected of epoxy resin into cracks work effectively and increase the capacity of the girder from 1 times to 1.26 times of the original capacity of the girder before retrofitting.*

Keywords- *Retrofitting; Polymer; Fiber; Girder; Rehabilitation*

I. INTRODUCTION

In contemporary time bridges are considered life line and key element in transportation system. It is the main component of transportation network. Main components of typical bridge are Pile, Pile cape, Piers, Transom, Girder and slab Deck. Bridges some time fail as a whole or few of its components like pile, piers and girders etc. gets fail. In both the cases it must be retrofit before use. Damage in bridges is caused by different reasons such as Earthquake loading, Traffic loading, Fatigue Loading, Floods and Environmental Effects etc. Failure of any component of bridge may not warrant complete demolishing the bridge but an economical solution may be employed in the form of retrofitting.

In October 8, 2005 Earthquake at least 20 major bridges were damaged and not in serves condition as shown in figure – 1 because the absence of bridge design code in Pakistan (Ali, S.M., et al. (2011)). Similarly in 2010 Pakistan floods at least 150 bridges were damaged only in KPK Pakistan. Different materials and techniques are used for retrofitting and rehabilitation the reinforced concrete (RC) structures. The retrofitting and rehabilitation techniques includes fiber reinforced polymer, Grout injection, Shortcrete overlay, Repointing, stitching of cracks, and Ferro cement overlay etc. From last few decades, the use of innovative composite materials such as Fibre Reinforced Polymer (FRP) for strengthening, upgrading and rehabilitation of existing reinforced concrete structures composite (ACI 2007, Hollaway and Teng 2008). It also use to upgrade the deficient, deteriorate and damage reinforced concrete members by seismic activity or any other source because of their superior properties such as light weight, flexibility, easy to apply, resistance to corrosion, high strength to weight ratio, easy to transport, high alkali and fatigue resistance.

Figure 1. Shear failure of abutment at cold joint of Garhi Dupatta Bridge.

Fiber Reinforced Polymer (FRP) is composite material and available in different form such as Carbon Fiber Reinforced Polymer (CFRP) and Glass Fiber Reinforced Polymer (GFRP). Both CFRP and GFRP polymers available in fabric as well as in laminate form. The objective of this research was to retrofit the damaged T – shape bridge girder under monotonically increasing four points loading by externally applied of carbon fiber reinforced polymer (CFRP) with epoxy on the surface of the girders. The retrofitting of damaged girder was in such a way that it regain its original strength.

II. MATERIALS AND METHODS

This research was based on retrofitting of T-shape Bridge girder by externally applied Carbon Fiber Reinforced Polymer (CFRP) sheet with epoxy resin. But before retrofitting cast the girder model having dimensions ¼ of the actual dimensions of the bridge girders detail of girder dimensions and material properties were shown in table 1.

Table 1. Established dimensions and material properties of prototype and model bridge girders

T-Shape Girder	**Prototype**	**Model**
Scale	1	¼
Beam Length	44 ft.	11 ft.
Beam Depth	3.511 ft.	0.877 ft.
Flange Width	6.1 ft.	1.5 ft.
Flange Thickness	7.5 in	1.9 in
Stem Thickness	18.5 in	4.63 inch
Girder Long. Bar (Bottom) diameter	Ø 1 in	Ø 0.291 in
Shear Stirrups diameter	Ø 0.472 in	Ø 0.199 in
Flange Long. Bar (T&B) diameter	Ø 0.394 in	Ø 0.199 in
Flange Trans. Bar (T&B) diameter	Ø 0.63 in	Ø 0.199 in
Steel bar Yield Strength	60 ksi	60 ksi
Concrete Compressive Strength	2400 Psi	2400 Psi
Maximum Coarse Aggregate Size	2 in	0.5 in
Concrete Cover	2 in	0.5 in

To achieve the required strength of the concrete for girder model by performed the mix design and set the ratio for concrete mix as shown in table 2. Made the concrete cylinder and cured as per ASTM C192. After curing tested the specimens in laboratory as per ASTM C39 as shown in figure 2 which were approximately equal the strength of the concrete used in prototype bridge girder. Three steel bar of each diameter were tested under tensile load as per ASTM A615 to set the strength of the steel bars according to the steel bars used in prototype bridge girder.

Table 2: Set the compressive strength of the concrete

S. No	Mix Design	W/C Ratio	28 Days Compressive Strength Psi	Avg. 28 Days Compressive strength Psi
1	1:1.5:3	0.6	2457	2400
2	1:1.5:3	0.6	2101	
3	1:1.5:3	0.6	2642	

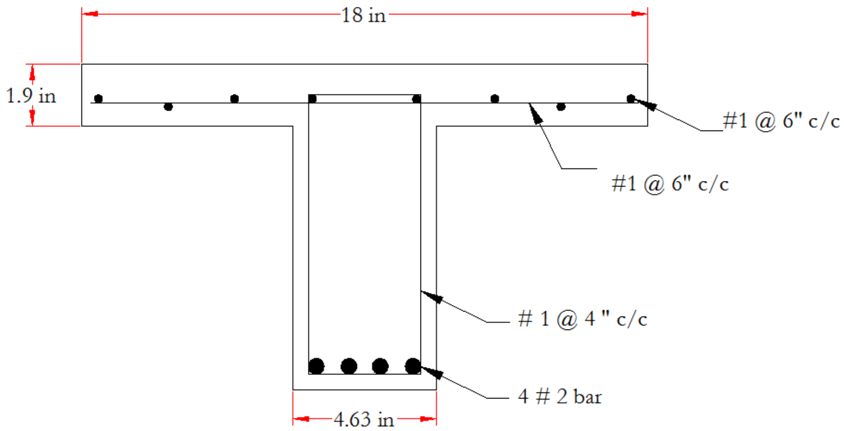

Figure 2. Reinforcement detailing of bridge girder

Figure 3. Testing concrete specimens in lab

III. FABRICATION AND RETROFITTING OF GIRDER MODEL

T-shape RC girder model was cast by using steel form work for good quality of work as shown in figure 3. After casting placed the girder for curing for 28 days that they achieved maximum strength, the girder was tested under monotonically increasing four points loading as shown in figure 4. The Girder was damaged only in flexural under the loading demand as shown in figure 5. Only flexural cracks developed at mid span of the girders. Girder were retrofitted only in flexural by externally applied the Carbon fiber Reinforced Polymer (CFRP) sheet with epoxy resin.

Figure 4. Pouring of concrete in girder form work

Figure 5. Test setup for T-shape girder model

After applied CFRP sheets on concrete surface of the girders also injected the epoxy into cracks with the help of pressure pump and steel packers. All retrofitted girder was tested under same loading protocol as the girder was tested before retrofitting. Retrofitted girder failed by delamination of Carbon fiber Reinforced Polymer sheet from the surface of the concrete which caused the development of shear flexural cracks in the girder as shown in figure 7.

Figure 6. Failure of girder before Retrofitting

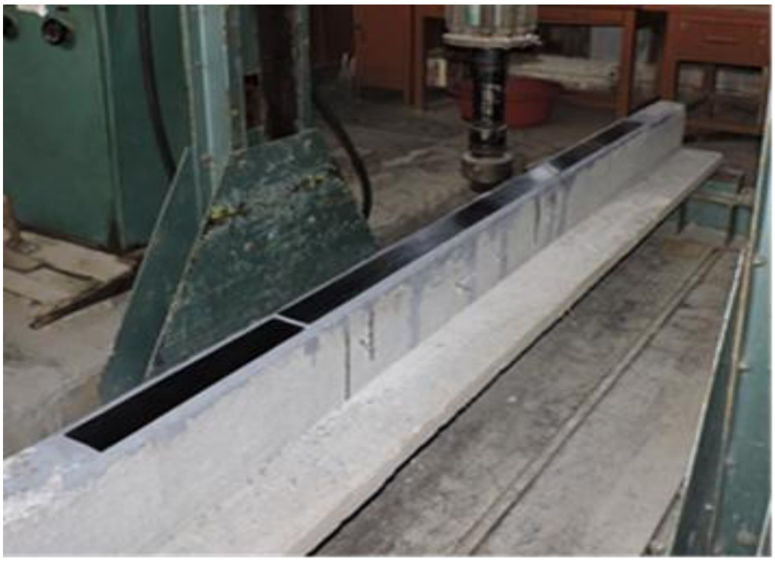

Figure 7. Application of CFRP sheet on bridge girder with bonding epoxy mortar

IV. RESULTS AND DISCUSSION

Girder was tested under monotonically increasing four points loading before and after the retrofitting. Before retrofitting the girder was tested to its ultimate strength and approximately failed at 31.312 KN load as shown in load deformation graph in figure 7. Maximum deformation which occurred at mid span of the girder was 47.2 mm. Retrofitted girder was tested under same loading condition as used before retrofitting. Retrofitted girder take 39.102 KN maximum load and 30.02 mm maximum displacement occurred as shown in load deformation graph in figure 8. CFRP retrofitted girder regains more than its original strength but ductility of the girder was decrease by delamination of CFRP sheet from the concrete surface.

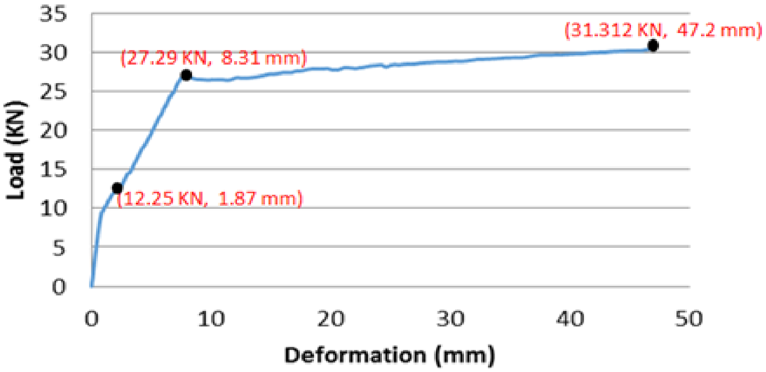

Figure 8. Load deformation curve for girder before retrofitting

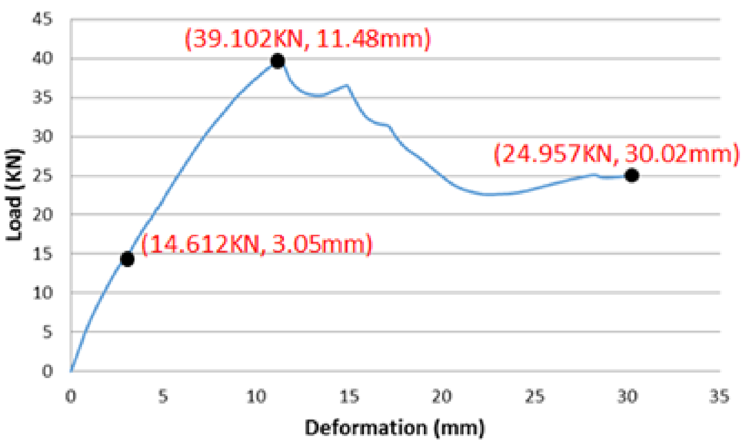

Figure 9. Load deformation curve for girder before retrofitting

V. CONCLUSION

Concluding from this research studies that:

- Carbon Fiber Reinforced Polymer (CFRP) material work effectively for retrofitting and rehabilitation of damage structures.
- It was founded that externally applied CFRP sheet with epoxy resin on RC girder work efficiently and increase the flexural strength from 1 to 1.26 time of their original strength.
- Poor and improper bonding caused the delamination of CFRP sheet from the concrete surface of the girder. which reduced the ductility and caused the brittle failure of the girder
- Also founded that externally applied CFRP sheet on RC girder shift the failure from flexural to shear.

VI. RECOMMENDATIONS

- Carbon Fibre Reinforced Polymer material also used for retrofitting and rehabilitation of damage structural elements in office, shopping malls and residential buildings.
- Developed the proper CFRP anchorage system between CFRP sheet and concrete surface of the structural elements can increase the ductility of the structural system.
- CFRP material also used for retrofitting the damage structures in earthquake prone area because its self-weight is very less and not increase the self-weight of the structures.

REFERENCES

[1] S. M., et al. "A Survey of Damages to Bridges in Pakistan after the Major Earthquake of 8 October 2005", 27(4), 947–970 (2011).
[2] Rabinovitch, & Frostig. "Experiments and Analytical Comparison of RC Beams Strengthened with CFRP Composites", 34, 663–677 (2003).
[3] Hosny, et al. "Performance of Reinforced Concrete Beams Strengthened by Hybrid FRP Laminates", 28, 906–913 (2006).
[4] Niemitz, et al. "Experimental Behavior of Carbon Fiber-Reinforced Polymer (CFRP) Sheets Attached to Concrete Surfaces Using CFRP Anchors", (April), 185–194 (2010).
[5] Pham, & Jirsa, "Development of Quality Control Tests", (July), 13–16 (2009).
[6] Smith, "Frp Anchors: Recent Advances in Research and Understanding. Asia-Pacific Conference on FRP in Structures", (d), 35–44 (2009).

