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Retrofitting of RC Beam Structure Member By Using CFRP

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Abstract:- The research has been lead relating the use of carbon fibre-reinforced polymer (CFRP) sheets in retrofitting and strengthening of the reinforced concrete member. The present research was conducted by using the epoxy to reinforced concrete beams retrofitted and strengthened for flexural strength by using CFRP sheet. The selected cross-section of the beam having 2400 mm length with 150 mm width and 225 mm height and the beam tension reinforcement on the bottom was set on 2#4bar@1.5" with the 38.1 mm clear cover was set to the main flexural reinforcement. The studied beam was focused on flexural behavior. The experimental study has shown that while the using of CFRP with epoxy will improve the rigidity and durability of the concrete beam. Their great deformability greatly improves the seismic properties of the beam structures. Under the reinforced RC beams showed a very large deflection by control beam before their failure. By using CFRP externally the rigidity of retrofitted and strengthened beams can be improved.

Keywords— CFRP, Epoxy, Flexural strength, Retrofitting/ Rehabilitation.

I. INTRODUCTION

One of the most important and significant challenges in civil engineering has become the retrofitting and reinforcement existing structures. Generally encountered engineering issues such as increased in-service loads, structure usage changes, structural design and/or construction mistakes, and change in design codes, deterioration issues and the seismic retrofitting are some of the reasons for the need to repair/retrofitting of an existing structure. The most common solution is of rehabilitation and repairing is retrofitting for RC structures. This project has been chosen after the strong earthquake was felt with the M7.5 in Hindukush region on the 2015 October 26, with the epicenter of 45 kilometers, at the southwest of Jurm, Badakhshan Province Afghanistan. Above 280 persons were killed and 1,770 persons were injured and remarkable demolition about 109,123 building was recorded by that earthquake [1]. Earlier that on 8 October 2005 earthquake smash the northern Pakistan, Afghanistan, and India with the magnitude of 7.6. The epicenter city of the earthquake was the capital city of Azad Kashmir, named Muzaffarabad, throughout 19 days 978 shocks with ≥ 4.0 scale magnitudes shock were recorded in the region, 86,000 people were killed, 96,00 were hurt, 32,000 houses were demolished and 2.8 million peoples became emigrant [2, 3].

The modern rehabilitation techniques (ie expand current parts, add new structural components, glued steel plates etc.) encounter numerous shortcomings, e.g. problematic and slow application, and lack of durability [4]. A retrofitted beam with CFRP laminates can resist up to 170 % of the maximum load as compared to control beams [5]. Dong considered reinforced concrete beams longitudinal reinforcement with the different cross-section depths, thickness and concrete cover and different flexural properties. They determined that the retrofitted CFRP beam will increase the resistance by 41 to 125% and stated that the stiffness would not change with increasing of concrete cover thickness [6]. Kachlakev and McCurry confirmed that when the beam reinforced with FRP glass and CFRP laminate, respectively were enhanced in flexural and shearing, with maximum load increase to 150% [7]. In attempts to quantitatively increase the flexural and shear strength provided by externally bonded CFRP laminates [8, 9]. It has been confirmed that if FRP plates increase the stiffness, the capability of load and the cracks can be decreasing with on RC structures [10]. The consideration of retrofitted beams is smaller as compared to un-retrofitted beams due to the added toughness by FRP Sheets or plates [11]. With the increasing numbers of layers of the FRP, the sheet has significant effect toughness and an extreme load of the RC structure beam. The load capacity will increase as the number of CFRP sheets increases, up to 6 sheets [12]. The strengthened beam by using CFRP sheets to superior load the stiffness will be increase and the cracking tension will be delayed [13]. The initial load of resistance during amplification is a key factor that affects the maximum strength of the RC retrofitted beam with FRP. A retrofitted beam lover level ultimate strength will produce a higher level of the load than a beam retrofitted with lover level of load [14]. On the continuous beams, the FRP can be used in the positive torque zone or the negative torque zone. Previous research studies confirm that the growing toughness and supreme carrying load carbon fiber reinforced polymer laminate can be used to RC beam, because the CFRP sheet increases the rigidity of the RC member, furthermore; the number of CFRP sheet has a significant impact on the maximum load and rigidity of a beam. The results show that the load carrying capacity increases as the number of CFRP sheets increase up to six, the early load during the reinforcement is also a main influence to affects the maximum strength of reinforced beams with CFRP. CFRP has the potential to apply on continuous beams, the use of CFRP laminates can effectively reduce deflection and increase beam load capacity [15, 16]. Repair and reinforcement of EB-FRP can be performed in three types of applications: holding, bending and shear reinforcement [17, 18].

The main objective of this experiment to study the flexural behaviors of RC concrete beams by using CFRP. In this experiment has shown the find-out contrast among the flexural strength of control and strengthen and retrofitted beams. The specimen cast in this experiment is to compare the retrofitted beams and non-retrofitted beams. Static load reactions of the RC beams structure under the two-point loading method was evaluated as a function of flexural strength, observation of crack, composite amongst concrete and CFRP, and the related failure approaches. Comparisons are made between the controlled beam and strengthened and retrofitted beam experimental results. excellent style manual for science writers is [7].

II. EXPERIMENTAL PROGRAM AND STRENGTHENING TECHNIQUES

In the present research work beams samples are tested under two-point loading situation. The beams were tested after 28 days of curing. The beams were tested in separately two groups. 1st group of beams are focused on flexural behavior and 2nd group of beams was focused on the shear behavior. The first group of beams in the experiment were labelled as control beams, and the other group was preloaded up to flexural cracks performed and after that strengthened these beams with CFRP. Lastly, the load was applied on the strengthened beam until they failed and the obtained results were matched with additional beams. In the total of two beams were cast in the 2nd group as control beams. Two beams were cast in 2nd group as well as two beams cast in control beams, and pre-loaded two beams until shear cracks appeared and after that the pre-loaded beams were retrofitted and lastly tested until their failure.

A. *Manufacturing of Beams*

The beams cast having the cross-section area of 1960 mm length, 150 mm width, with the depth of 300 mm. The beams are considered to having insufficient bending strength to attain the pure bending failure, with compression reinforcement of (2@10) and tension reinforcement of (2@10) and along with the 8 mm strips c/c 100 mm are used to tie the steel bars together as shown the Figure 1. In all beams, the clear concrete cover of the central flexural bar was used to 25 mm. The reinforcement and geometry are shown in "Figure 1". All beams were tested after curing of 28 days. The laminate used in this research had 1.4 mm thickness, with the width of 50 mm and according to the manufacturer the elastic modulus 165 GPa.

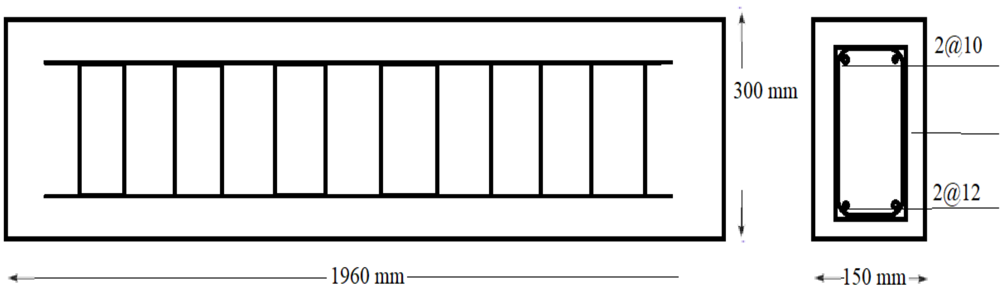

Figure 1. Beam Manufacturing with reinforced dimensions

The reinforcement geometry of beams shown in Figure 1. and the during the testing of control beams was tested by using the two-point bending load method. This load ratio was taken in the present the current study because it delivers a maximum force and as well zero cross-sectional shears between the loads, and delivers the maximum shear force among the load and supports. The beam supports span was kept 1560mm and the load was applied into equal parts as shown in Figure 2. over the width of the beams steel plates were used to distribute the load equally. The jacking machine in this test equipment has used the capacity of 1400 KN. To find out the deflection at the middle of the beam span, Linearly Variable Differential Transducer (LVDT) is used, as shown in Figure 2. the test arrangements of a beam.

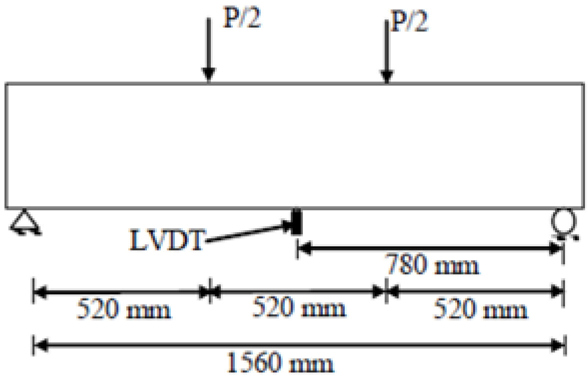

Figure 2. Loading, Position and Supports of LVDT

III. Methodology

In the present experiment, we will study about the CFRP as a building retrofitting material that used in RC beam structure member. The beams having the cross-section area of 1960 mm length, width were 150 mm and 300 mm height, with the tension reinforcement 2#4bar@1.5" as shown in Figure 1 and the bottom of the beams, the main flexural reinforcement clear cover was set 38.1 mm. in this experiment two beams cast by using 1:2:4 mix ratio as well as cured for 28 days. The grinder machine were used to make rough the surface of the beam and after that by using the surface cleaner the beam surface was cleaned to make it rough and level. After making the beam surface rough and clean mixed form of epoxy glue was applied to the rough and cleaned surface of the beam into two layers and then placed the CFRP sheet on the glued beam and kept on room temperature for 24 hours to get the strength. After 24 hours the bending test was scheduled for retrofitted beams and strengthened beam and the load was recorded until the failure of the beam.

A. Testing of Control Beams

In the present study, the two-point bending test is carried out. This loading situation is selected because it provides a maximum shear force and zero shears in the cross-section between the loads. These moments vary linearly between the supports and the load. The load was applied at two positions that equally divided beams into three parts as shown in Figure 3. under the load steel plates were used to distribute the load equally over the beam width. The testing device of 200 KN capacity jack was used in this experiment. A linear variable differential transducer, LVDT was used to find out the deflection of the central span of beams. Load and Deflections were recorded throughout the examination.

B. Testing of Retrofitting Beams

The grinder was used for rough surface of beams to coated CFRP sheets, applied CFRP sheets to the bottom of the entire beam as shown in the Figure 3. after that all the specimens were being exposed to negative moment allowing to its weight. This represents a minor pre-stressing effect; it can be found through a jack in the condition of onsite maintenance.


Figure 3. The surface of the beam roughened afore put on CFRP and applied CRFP Sheet on beam

IV. Results and Discussion

In this experimental study, CFRP externally bonded was used to repair a reinforced beam structure. The reinforced beam structure deformation capability performance against the seismic was improved by using CFRP, by using CFRP is easy to apply with epoxy as a construction material. The CFRP with epoxy has shown an improvement in strengthening the current construction practice results.

A. Load Deflection Analysis

The current assessment used data is obtained from the dialed reading which is attached with data logger placed at the middle span of the examined beam models and from the load chamber (applied load). At the load of the control beam as opposed to the deflection curves of the beam in the middle as shown in Figure 4. The beams performance in a yielding behavior and beam has shown large deflection before the final failure. RC structural beams should retrofit by using CFRC to meet the revised specification and change in the function of structures. Adsam et al. [19] investigated RC structural beams by using CFRC the retrofitted samples showed an increase in maximum load capacity and rigidity up to 53% and 61% respectively. They concluded that the CFRP laminates strengthened RC beams.

At the load of 1.7 tons, the first crack has appeared on retrofitted beam and middle span deflection curvature was noticeable the non-linearity of the cracking of reinforced beam. After 2.1 tons of load, flexural cracks found and became broad and open by increasing applying load. The maximum load of 2.7 tons was recorded.

The strengthened beam load versus middle span beam for strengthening beam load-deflection curves are shown in Figure 5. In the strengthened beam at the load of 3.4 tons, the first crack has appeared on strengthened beam and middle span deflection curvature was clear the non-linearity of the cracking of strengthened beam. The maximum load of 6.3 tons was recorded.

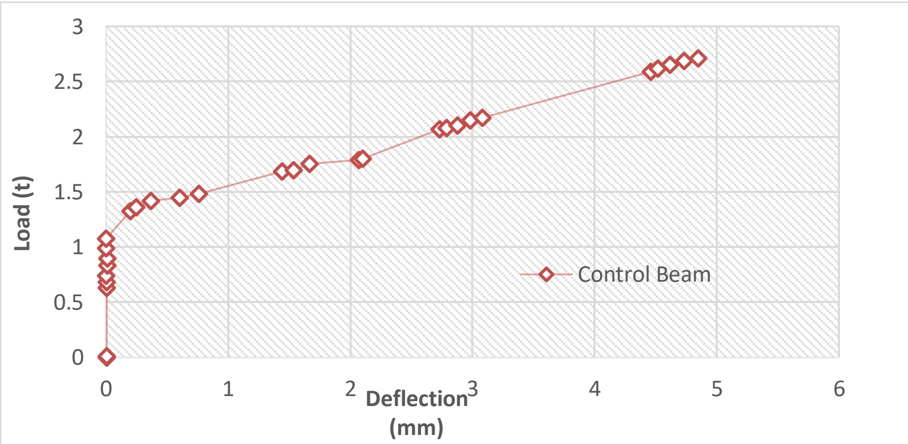

Figure 4. Control beam load vs. deflection

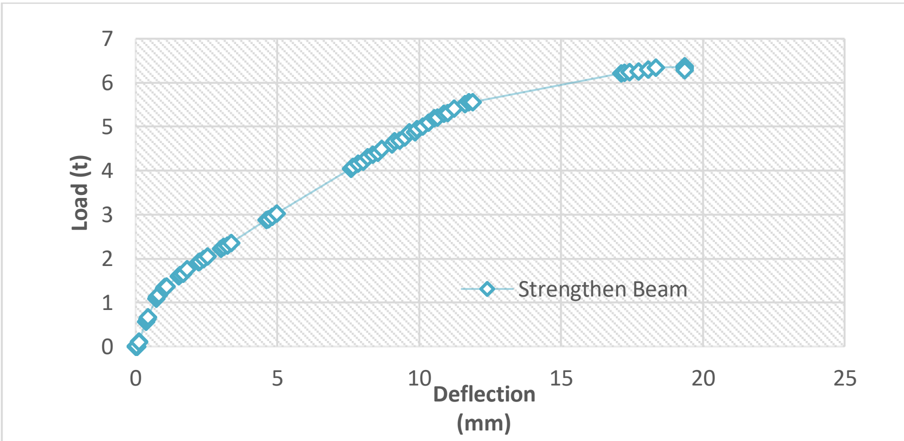

Figure 5. Strengthen beam load verse deflection

B. Comparison Between Control and Strengthen and Retrofitted Beams

The rigidness of the CFRP-reinforced (retrofitted) beam and strengthened beam was improved as a contrast to the control beams. By using the externally bonded CFRP results shown increases in the focused load of the CFRP-reinforced beam as well as strengthened beam specimens when contrasted to the control beams as shown in Figure 6.

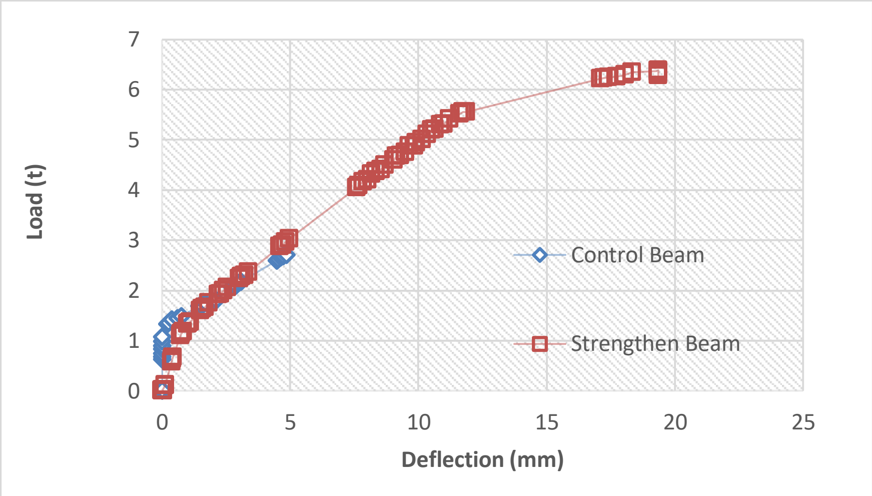

Figure 6. Comparison between control and strengthened and retrofitted beam

CONCLUSION

The purpose of this study is to investigate the rehabilitation performance of flexural strength by using CFRP retrofitting techniques. Experimental results have shown an increase in the length of CFRP in strengthened and flexural retrofitted can create the CFRP extra active in repairing and strengthening of concrete. This founds that unsatisfactory strengthening length does not yield the desired strengthening effect.

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