Investigation of Shear Response for RC beam with TRM

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Abstract – *The carbon Fiber sheet is more effective and innovative technique to improve the shear strength of RCC component has been investigated. In this paper we are going to compare the properties of CFS reinforced concrete with conventional concrete based on experiments performed in the laboratory. This research includes testing of beam for shear response of reinforced concrete beams strengthened with Carbon fiber sheet and compared with the same sized conventional beams. This research also proposed study on the strength of the M50 grade reinforced concrete cubes strengthened with Carbon fiber sheets and making variations in the stirrups. The cubes and beams have been subjected to 7, 14 and 28 days of curing and the results for compression tests are noted. It was found that the cubes subjected to 28 days of curing period showed effective increase in strength gain than the conventional cubes. Results of the beam testing demonstrated that the shear strength gain caused by strengthening was in the range of 80% to 90% depending on the amount of internal stirrups and number of jackets of CFS.*

Key Words: Carbon Fibers sheet, M50 Concrete, Shear strength analysis, curing.

1. INTRODUCTION

The carbon fiber sheet are used to increase the shear resistance of RC members is investigated in this study [1]. CFS can be considered as an alternative to fiber reinforced polymers (FRP), which provides solutions to many of the problems associated with application such as latter without compromising much the performance of strengthened members [2]. Based on the experiment, we can say that Carbon textile jacketing makes it better in shear resistance; also the shear strength increases with the number of increasing layer [4]. As the layers applied are sufficient to transform shear failure to flexural failure [3]. The CTRM layer is a combination of an anticorrosion carbon fiber reinforced polymer fabric and an efficient mortar [6].

In this paper, the strengthening method and the experimental results obtained by applying a thin layer of Carbon Fiber sheet on detoreated structure can improve the shear response of RC structure has been investigated [5].

AIM AND OBJECTIVES OF THE STUDY:

The project aims to investigate shear response of RC beams strengthened in shear with CFS and through the conclusions of provide recommendations for future studies in the field. The overall objective is to investigate the shear response of RC structure strengthened in shear with CFS. The detailed objectives are listed below:

- To study the physical properties of CFS by conducting durability tests on M50 Grade TRM concrete cubes
- Examine the viability of using CFS strengthening system to improve the shear response of RC structure
- Demonstrate the application of CFS for the strengthening of existing structures.

2. EXPERIMENTAL PROGRAMME:

2.1 Test specimens and investigated parameters:

The main objective of this study was to study the effectiveness of CFS in shear strengthening of RC beams and cubes. A total of eighteen rectangular RC beams (cross-section dimensions of 150 x 150 x 700 mm.) were constructed and tested as simply supported in (non-symmetric) three-point bending as shown in Fig. 1. The total length of the beams was equal to 700 mm, whereas the effective flexural span was equal to 600 mm (Fig. 1b), providing adequate anchorage length to the longitudinal reinforcement.

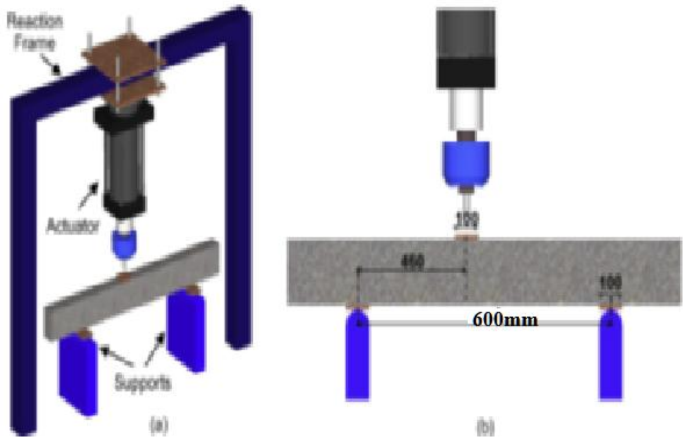

Fig -1: Test set-up: (a) Overall 3D view; (b) front view

Strengthening was applied only at the critical shear span aiming to increase its shear resistance. By design, the shear force demand in order to develop the full flexural capacity of the (un-retrofitted) beams was targeted to be 3 times their shear capacity.

The key investigated parameters of this study comprise: (a) the strengthening system (CTRC), (b) the strengthening configuration, and (c) the number of layers. One beam was tested as-built without receiving strengthening and served as control specimen

Fig -2: Application of Hakson's High glass epoxy resin

Out of eighteen beams the specimens are varied as: (a) the first group received one layer of CTRC sheet, (b) the second consisted of two layers of CTRC sheets. Both these arrangements are repeated with beams having different stirrups and longitudinal reinforcements.

Prior to the beam tests, cube tests were conducted to determine the mechanical aspects of the M50 grade concrete cubes covered with textile fiber sheets on two sides. These cubes are then compared with conventional M50 grade cubes and the difference in the results is presented further. Nine cubes for strengthening were casted and nine conventional cubes were casted for study with 7, 14 and 28 days curing periods.

2.2 Materials Properties:

Materials used in Concrete:

Carbon Woven Reinforcement Fabric- Technical Data:
240 GSM – 2X2 Twill Woven Carbon Fabric given in fig 2

Table -1: Specification of carbon Woven Reinforced Fabric

Characteristic	Specification	Tolerance	Test Method
Areal Weight (g/m2)	240	± 3%	ASTM D3801
Width* (mm)	1000	-0/+10mm	ASTM D3774
Dry Fabric Thickness(mm)	0.23	± 0.03mm	ASTM D1777

Fig-3: Carbonized textile fiber sheet (Purchased for experiment)

Table -2: Specifications of Carbon Woven Reinforcement Fabric

WEFT		WARP	
Carbon Fiber	50% by weight	Carbon Fiber	50% by weight
Standard Modulus 3K		Standard Modulus 3K	
15.24 ends/inch		15.24 picks/inch	

Table -3: Properties of Fiber

Density (g/cm3)	1.8
Filament Diameter (µm)	7
Tensile Strength (MPa)	3450
Tensile Modulus (GPa)	230
Elongation (%)	1.5
Sizing	Epoxy Compatible

3. EXPERIMENTAL RESULTS:

3.1 Results:

Specimens, who received one TRM layer, reached an ultimate load of 57.1 and 74.3 kN. The corresponding increase in their shear capacity was equal to 9% and 51%. The failure of these specimens was associated with damage of the CFS sheets. The first Specimen exhibited a diagonal-tension mode of failure where one major inclined shear crack initiated within the shear span at the peak load. Due to the absence of stirrups, the shear crack extended rapidly through the beam depth. The failure occurred suddenly without warning.

The second specimen with stirrups experienced minor inclined flexural-shear cracks close to the load point at a load value that corresponded to approximately 30% of the peak load. The first visible principal diagonal shear crack developed in the mid of the shear span was observed at a load that corresponded to approximately 65% of the peak load. As the load progressed, more shear cracks developed adjacent to the principal diagonal crack then extended towards the load and support points. The beam failed by formation of longitudinal cracks at the top and bottom surfaces of the beam causing separation of the side concrete covers.

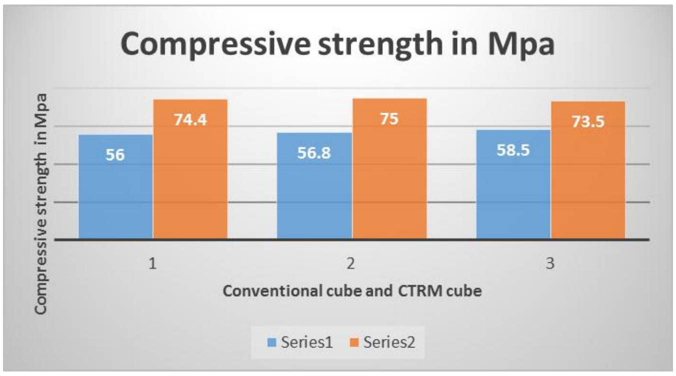

Fig -4: Compressive strength of CTRM and conventional cubes.

Specimens with double CTRM sheets failed in shear at a load of 88.7 and 120.2 kN, respectively. Compared to the control specimen the increase in the shear resistance was equal to 71% and 132%, respectively.

Table -4: Testing Results

Sample type	Sample No.	Compressive Strength (MPa)	Average compressive Strength (MPa)	Standard deviation (MPa)
CTRM Cube (150 × 150)	1	74.40	74.3	0.8
	2	75.0		
	3	73.5		
Conventional Cube (150 × 150)	1	56.0	57.1	7.0
	2	56.8		
	3	58.5		

Fig -5: compressive testing

In The third specimen with double layer of CTRM sheet first visible principal diagonal shear crack in was developed at the middle of the shear span at a load value that corresponded to approximately 66% of the peak load. This crack slightly extended in length as the load progressed. Some cracks also initiated within the end region of the shear span closer to the load point. At about 92% of the peak load, many shear cracks developed in the lateral triangular portion below the principal diagonal crack. Failure of this specimen involved separation of the two side concrete covers of the beam's lateral face.

Fourth Specimen exhibited the first visible principal diagonal shear crack in the mid of the shear span at a load value that corresponded to approximately 76% of the peak load. As the load increased, the principal crack extended towards the load point and additional diagonal shear cracks developed above it. Prior to reaching the peak load, some flexural-shear cracks developed below the load point forming a triangular portion. Eventually, the beam failed by detachment of the side concrete covers of the beam's lateral faces

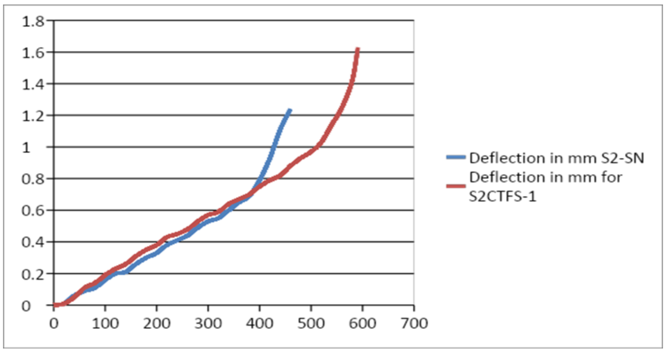

Fig -6: Load vs deflection graph

The load versus deflection response for 09 (nine) beams is presented in the graph showing the difference in load-deflection response with respect to shear reinforcement and strengthening layer. It is clear from the above graph that the deflection and load carrying capacity of beam increases with increase in the layer content and the deflection reduces with decrease in the layer ratio while load carrying capacity increases with decrease in no of layers.

Fig -7: Application of CFS on the cube

Two dial gauges were assigned to note the deflection. The graphs above are plotted by considering the mean value of the dial gauges, the detail of both dial gauge reading and graphs are mentioned above along with detail calculation of results obtained.

4. CONCLUSIONS OF CTFS STRENGTHENED BEAM TESTING:

The shear response of RC beams strengthened in shear with CTFS has been investigated in this research. The work comprised experimental testing. It is important to note that the results derived in this study are only applicable to the fabric and matrices/adhesives used and should not be extrapolated to other strengthening systems. A variation in the size of the specimens, amount and/or distribution of steel/CTFS reinforcement, properties of materials, and loading conditions would change the structural response before and after strengthening.

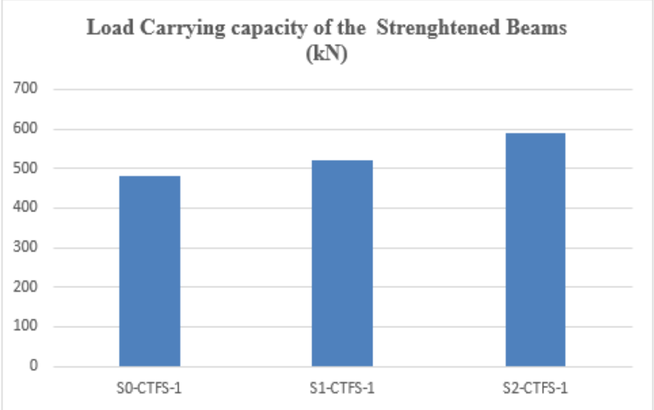

Fig -8: Load carrying capacity of strengthen beams

A total of 9 tests conducted on RC beam specimens were included in the beam tests. The variables for the beam test included; strengthening and no strengthening; minimum and maximum shear reinforcement and no. of CTFS layer. Based on the results of the beam test the following conclusion are drawn.

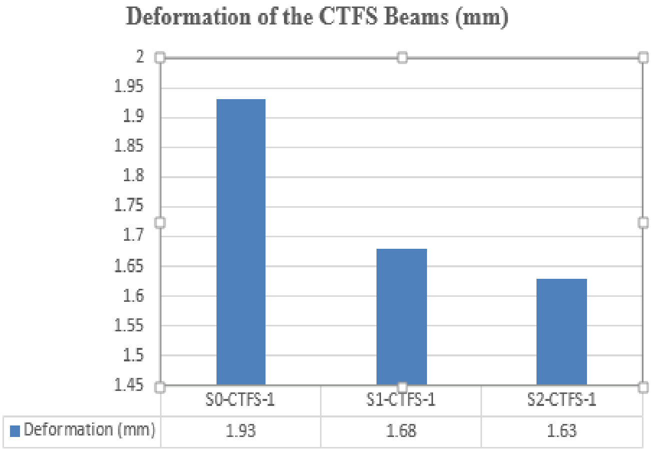

Fig -9: Deformation of the CTFS Beam

5. RECOMMENDATIONS FOR FUTURE STUDIES:

The present study provided insight into shear response of RC beams strengthened in shear with CTRM through an experimental testing. The following are recommendations for future studies in the field of shear strengthening of RC structures with CTRM:

Develop FE models for the specimens of the double-shear tests. Results of these FE models along with those of the corresponding experimental data can be used to study the bond characteristics between the CTRM and concrete presented in this study.

Perform a parametric study using the developed FE models to investigate the effect of a wider range of variables on the shear response of RC beams strengthened with CTRM.

Study the viability of using TRM in improving the structural response of pre damaged or corrosion-damaged RC beams. Investigate the durability performance of RC beams strengthened with CTRM under harsh environment conditions.

REFERENCES

[1] Manfred Curbach, Frank Jesse (1999) "High-Performance Textile-Reinforced Concrete" Structural Engineering International 4/99 Reports 2S9

[2] Alfred Strauss; Konrad Bergmeister; Simon Hoffmann; Radomir Pukl; and Drahomir Novák (2008) –"Advanced Life-Cycle Analysis of Existing Concrete Bridges" Journal of materials in Civil engineering /volume 20-issue 1- January 2008

[3] Christian Escrig, "Experimental and analytical study of reinforced concrete beams strengthened with different types of textiles", Journal Of Construction and building materials,2015.

[4] C G Papakonstantinou , C Kakae , N Gryllakis (2018) "Can Existing Design Codes Be Used to Design Flexural Reinforced Concrete Elements Strengthened with Externally Bonded Novel Materials" IOP Conf. Series: Materials Science and Engineering 371 (2018) 012031 doi:10.1088/1757-899X/371/1/012031

[5] Frederik Teworte, Martin Herbrand, Josef Hegger (2015) "Structural Assessment of Concrete Bridges in Germany— Shear Resistance under Static and Fatigue Loading" Structural Engineering International 3/2015 266 Scientific Paper

[6] Luciano Ombres "Structural performance of reinforced concrete beams strengthened in shear with cement based fiber composite material" Journal Of Composite Structures,2015.