APPLICATION OF CARBON FIBER REINFORCED POLYMER (CFRP) IN RETROFITTING OF MASONRY WALL

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ABSTRACT

This study explores the result of an experimental investigation for enhancing shear strength of masonry wall, strengthened with Carbon Fiber Reinforced Polymer (CFRP) strips. The dimensions of all masonry wall panels are kept same throughout the experiment. Experiments are conducted to study the shear strength of masonry walls with and without FRP using local available materials. For the experiment shear compression test was conducted. Deterioration of the specimens is done by using solutions of calcium chloride (CaCl2) with 3 mole ion concentrations. The experimental results demonstrated that the use of CFRP composite strips increases the shear strength of the masonry wall significantly by preventing the debonding of CFRP sheets, so that the full strength of the CFRP sheets get utilized. It can be concluded from the literature review that FRP is one of the efficient option for strengthening in either of the case like increasing the load carrying capacity of structures or to restore the original capacity of the structure after distress due to any means. The experimental campaign included a set of preliminary tests that allowed the design of the fiber reinforced grout, sustained with rheological parameters and mechanical characterization tests of the materials.

Finally, an experimental campaign was carried out in order to proceed to the mechanical characterization of the unidirectional fiber reinforced grout. The experimental results are presented and analyzed.

Keywords: *CFRP, CaCl2, Shear Compression Test, Strengthening.*

1. Introduction

Deterioration in structures is a major issue faced by the infrastructures industries all over the world. Since complete replacement of these structures requires high investment, strengthening has become the suitable solution to modify and improve the performance of the structures. The strengthening using FRP composites have become a popular structural strengthening technique, due to the well-known advantages of FRP composites such as their high strength-to-weight ratio and excellent corrosion resistance. This civilization depends upon the continuing performance of its civil engineering structures ranging from residential & industrial buildings to power stations and bridges. Structure is normal or special these are precious part and are promptly associated with living as well as nonliving things. During its whole life span, nearly all engineering structures face degradation or deteriorations. The main causes for those deteriorations are environmental effects including corrosion of steel, gradual loss of strength with ageing, variation in temperature, freeze-thaw cycles, repeated high intensity loading, contact with chemicals and saline water and exposure to ultra-violet radiations. This problem needs development of successful structural retrofit technologies.

To overcome this problem advanced composite materials such as carbon fiber reinforced polymer (CFRP) composites are used for retrofitting of structures. CFRP repair is a simple way to increase both the strength and design life of a structure. Because of its high strength to weight ratio and resistance to corrosion, these repair method is ideal for deteriorated concrete structure.

This work is focused on effects of CFRP wrapping for standard and deteriorated masonry wall panels with and without CFRP wrapping. The objective of study to carry out comparative study of the standard masonry wall with masonry wall wrapped with CFRP in terms of structural performance.

2. Geometry of Masonry Wall Panels

The geometry of all masonry wall panels is as per ASTM C1717-09. The sizes are 700 mm length, 700 width and 230 mm thickness. The bricks used are first class conventional bricks of size 230*110*70 mm. The dimensions of all masonry wall panels are kept same throughout the experiment. Experiments are conducted to study the shear strength of masonry walls with and without FRP using local available materials. All the masonry wall panels are gradually test loaded up to failure. Total 9 numbers of specimens were constructed. Specimens were tested for standard masonry walls with and without CFRP wrapping respectively.

Deterioration of Specimen:

The Specimens are deteriorated by using second class bricks instead of first class and also by using cement mortar grade 1:6 instead of 1:4. The specimens were exposed to weekly cycles of wetting and drying in water and in solutions of calcium chloride (CaCl2) with 3 molal ion concentrations, equivalent in ion concentration to a 7.5% solution CaCl2. The specimens were cured in solution for 7 days. After 7 days, they were removed from the solution and dried in air. Cycles were repeated for 5weeks. Nine Specimens were used to deterioration.

Design of CFRP wall panels:

Number of Ply: 1,
Type of Wrap: 150mm wide strips wrapped diagonally,
The strengthened specimen is capable of sustaining the new strength.

3. Experimental Program

All the specimens are tested in loading frame of the Applied Mechanics Laboratory. After curing for 7 days and 28 days, standard specimens are tested one by one applying load slowly up to failure load. The shear-compression test was performed in two steps. The in-plane shear on a masonry wall can be directly simulated by subjecting a wall to a vertical load and then subsequently to a static or dynamic horizontal load at the top of the wall. Because of the horizontal force, shear is applied on the brick masonry wall panel. The horizontal and vertical loads lead to tension and shear combined with compression in the masonry wall.

4. Test results and Discussion

This chapter interprets the results obtained from the experimental investigation which comprises of testing of eighteen masonry wall panels. The behavior of the masonry walls with respect to shear strength, crack pattern and deflection is studied throughout the test and their failure modes are described.

A. Test result of standard specimen without strengthening:

The standard specimen is not strengthened with CFRP composites. It is tested under the vertical and horizontal static loading system by applying the loads gradually. The average load at failure for 7 days specimen is 13 kN and the shear strength is calculated as 0.082 MPa, failure pattern is observed as diagonal shear failure. For 28 days test the average load at failure is 25 kN and the shear strength is calculated as 0.1532 MPa.

TABLE I
TEST RESULTS OF STANDARD SPECIMENS FOR 7 DAYS

Specimen	Failure Load (kN)	Maximum Displacement (mm)	Average Shear Strength (MPa)
Wall 1	12	4.3	0.082
Wall 2	15	5.4	
Wall 3	13	4.7	

TABLE II
TEST RESULTS OF STANDARD SPECIMENS FOR 28 DAYS

Specimen	Failure Load (kN)	Maximum Displacement (mm)	Average Shear Strength (MPa)
Wall 4	24	6.4	0.153
Wall 5	25	6.3	
Wall 6	25	6.7	

B. Test result of standard specimen without strengthening:

The specimens are strengthened with bidirectional woven CFRP strips of 1 layer bonded to the specimen diagonally with 2 strips of equal width of 150 mm. The testing of specimens is same as above. . The

average load at failure for standard specimen is 36 kN and the shear strength is calculated as 0.2215 MPa for 7 days and 75.33 kN and 0.432 MPa for 28 days respectively. The sliding failure is observed in the masonry wall with diagonal shear failure.

TABLE III
TEST RESULTS OF STANDARD SPECIMENS WRAPPED WITH CFRP FOR 7 DAYS

Specimen	Failure Load (kN)	Maximum Displacement (mm)	Average Shear Strength (MPa)
Wall 1	36	6.0	0.2215
Wall 2	35	5.3	
Wall 3	34	5.6	

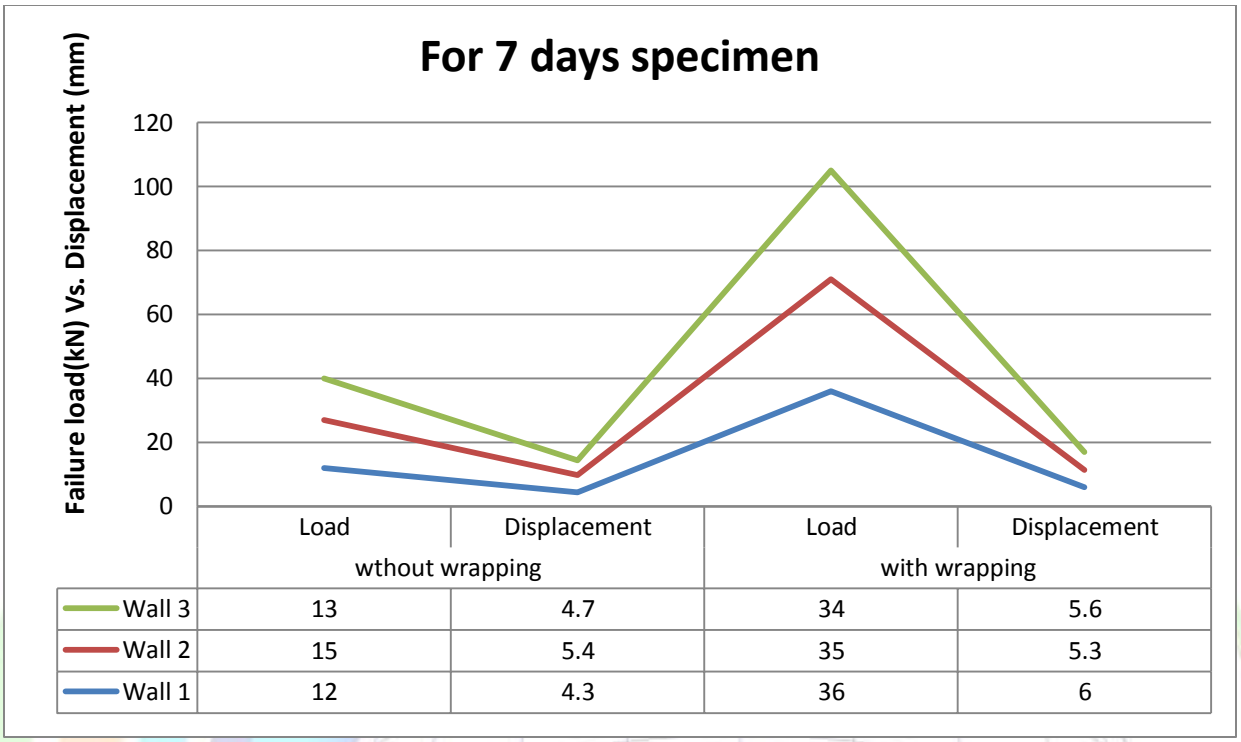
TABLE IV
TEST RESULTS OF STANDARD SPECIMENS WRAPPED WITH CFRP FOR 28 DAYS

Specimen	Failure Load (kN)	Maximum Displacement (mm)	Average Shear Strength (MPa)
Wall 4	73	7.1	0.432
Wall 5	76	7.6	
Wall 6	75	7.3	

C. Comparison of failure load and displacement for the specimen with and without wrapping:

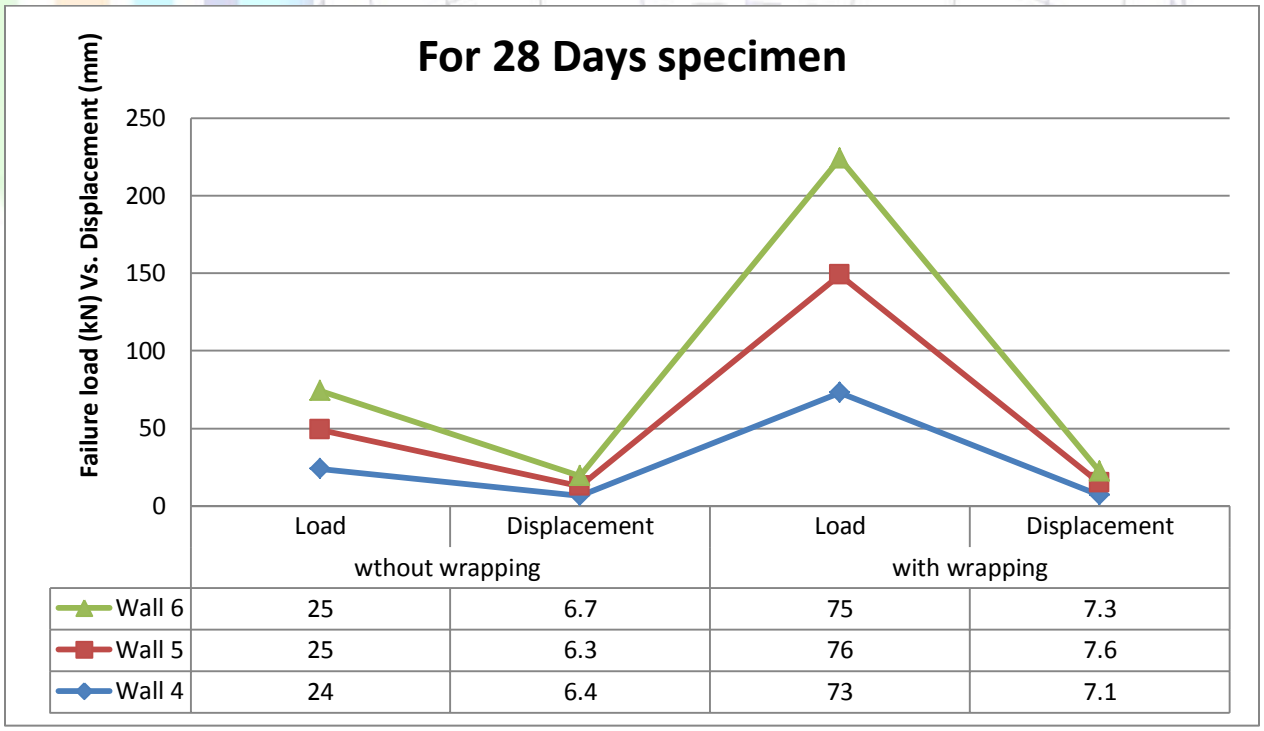
Specimens are tested after 7 days and 28 days curing in loading frame. The masonry wall panels are tested one by one by applying load slowly up to the failure load and deflection is measured by using gauge located at the top of a wall specimen.

The failure loads are compared in the graphical forms that are presented in the figures.



	Load	Displacement	Load	Displacement
	wthout wrapping		with wrapping	
Wall 3	13	4.7	34	5.6
Wall 2	15	5.4	35	5.3
Wall 1	12	4.3	36	6

Figure-1: Comparison of failure load and displacement for the specimen with and without wrapping for 7 days,



	Load	Displacement	Load	Displacement
	wthout wrapping		with wrapping	
Wall 6	25	6.7	75	7.3
Wall 5	25	6.3	76	7.6
Wall 4	24	6.4	73	7.1

Figure-2: Comparison of failure loads for the specimen with and without wrapping for 28 days,

D. Comparison of average share strength for the specimen with and without wrapping:

The average share strength is compared in the graphical forms that are presented in the figure for 7 days and 28 days.

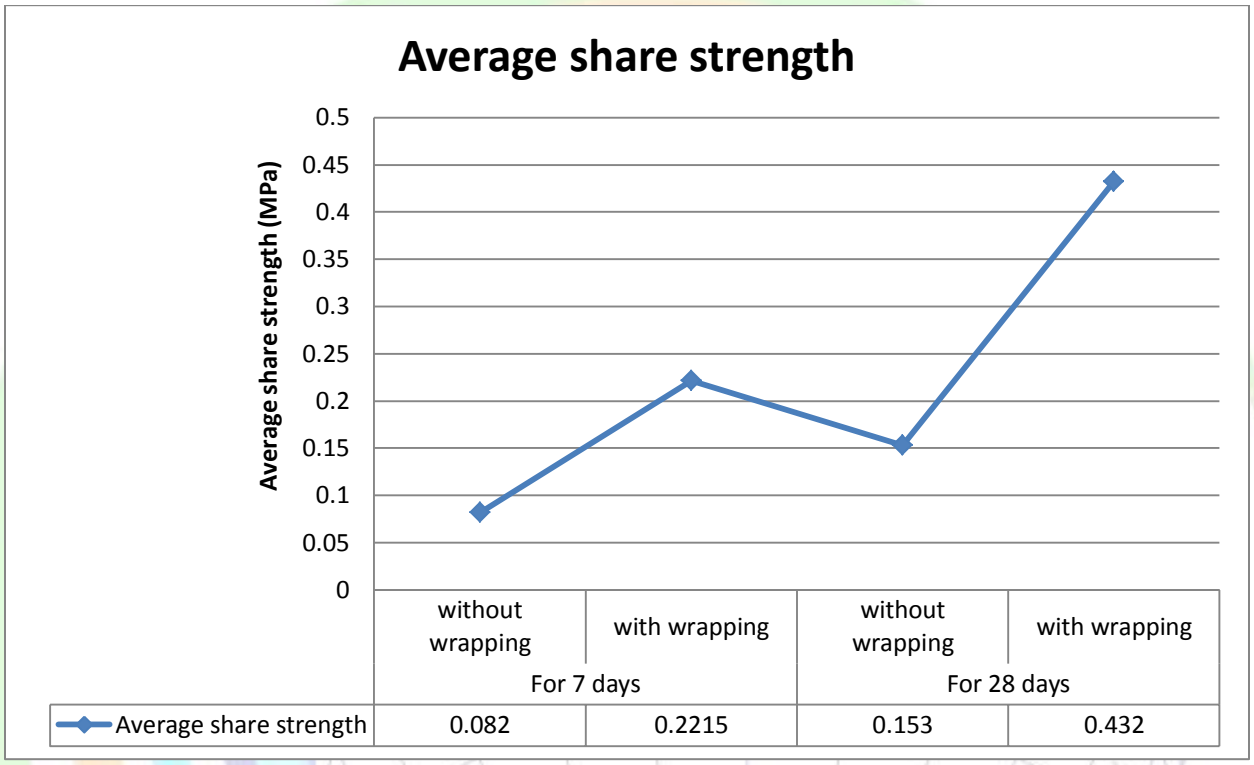


Figure-3: Comparison of average share strength for the specimen with and without wrapping,

5. Conclusion

i. After application of CFRP the shear strength of standard specimen is approximately increased by 62.97% in 7 days.

ii. After application of CFRP the shear strength of standard specimen is approximately increased by 64.65% in 28 days.

iii. The initial cracks in strengthened specimens are formed at higher load as compared to the standard specimens.

iv. Diagonal shear failure pattern is observed for standard specimens.

v. The diagonal crack & sliding failure patterns are observed for strengthened specimens.

6. References

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