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Performance Evaluation of RC Members using GFRP as Strengthening Technique

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***Abstract:-*Gradually most of the RC Structures are becoming structurally weak in their proposed life span; hence the structures are to be strengthened in order to increase the durability. There are many methods to strengthen the structure; however selecting the method of strengthening is also an important task.**
The strengthening of structure by GFRP sheet is a simple method comparative to other type of strengthening methods. Currently there is a no code of practice available in bureau of Indian Standard (IS) to recommend the strengthening procedure. This is relatively increasing the life span of the structures. This project includes the experimental study and also analytical study of RC members regarding flexural strength test and compression test. For the analytical study, ANSYS software is used, this software gives the results of above test which is almost similar to experimental study. So, this software may be use to study the behavior of heavily loaded structures.

Keywords: RCC Beams and Columns, GFRP sheets, Resin, Flexural strength, compression strength.

I. INTRODUCTION

The concrete structures have its own importance in recent days. Always the durability for this type of structure will be more, comparatively structures constructed by using other type of materials like steel, wood etc. and also the maintenance is very easy when compared to other type of structures.
Currently the "Rehabilitation and Restoration" of a structure is playing a major role in civil Engineering field, and also a very challenging task is to select suitable strengthening method which will exhilarate the strength and serviceability of the structures.
The structure can be strengthened for various requirements; it all depends upon the various situations.

- Improper maintenance.
- Increasing service loads.
- Modification works.
- Concrete related problems, and
- Natural disasters like wind load, seismic force.

There are different technique in retrofitting such as concrete jacketing, steel jacketing and FRP jacketing. Each of these methods has their own importance and is opted based on the requirement and case of application.
These retrofitting techniques are expensive; require skilled labors and its take more duration for applications. GFRP sheet will be one of the simplest method of retrofitting the exits structures. This has high strength ratio, high stiffness weight ratio, flexibility in design, non corrosiveness, high ultimate strength and less lower density. Due to lower density it is easier than steel to handling and installation process.

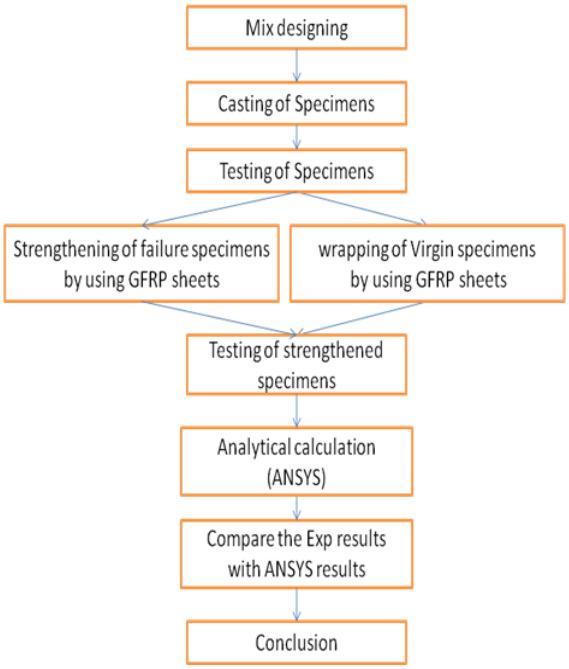
II. PRESENT INVESTIGATION

For conducting the experiment, 6 no's of specimens made of reinforced cement concrete in the form of beam and column were casted of size (700 x 150 x 150 mm) all having the same reinforcement detailing for all reinforced concrete members. The mix proportion arrived after mix design as per IS 10262-2009 was 1:1.8:3.33 for w/c ratio of 0.5. The mixing is done by hand mixing. Each trial cube were cured and tested for 7 and 28 days. All beams and columns specimens were tested to determine the flexural strength and compressive strength respectively after 28 days of curing.
Models of having same dimensions with similar reinforcement details are prepared in ANSYS software for analysis of RC members and comparing the results obtained from experimental studies.

➢ *In this paper we have studied on below;*

- The deformation of RCC Colum for ultimate load carrying capacity and failure partner with and without external straitening by GFRP wrapping.
- The flexural behavior of RC beams with and without external straitening by GFRP wrapping.
- To validate the experimental results with FEM tool (ANSYS).

III. METHODOLOGY



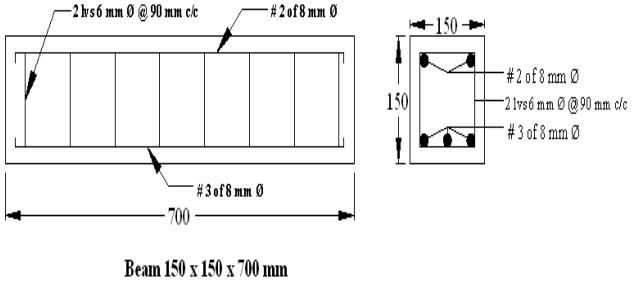
A. MATERIAL

Ordinary Portland Cement (OPC) of grade 43 was used; the initial time of setting time is 30 minutes and specific gravity of cement 3.15, standard consistency 33%. Fine aggregate used was clear sand passing through 4.75mm sieve with a specific gravity of 2.6. The grading zone of aggregate was zone III. Coarse aggregate used was angular crushed aggregate with specific gravity of 2.8. Design concrete mix of 1:1.8:3.3 is adopted to attend 20 N/mm^2. The water cement ratio of 0.5 is used. After several trials this mix design was finalized. 6 cub's specimens ware casted and tested after curing for 28 days. The average compressive strength of 28.8 N/mm2 is achieved. HYSD bar of 8 mm and mild steel bars of 6 mm diameter are used for shear reinforcement. GFRP sheet and vinyl-ester resin is used for strengthening of RC members.

B. COSTING OF SPECIMENS

1. RC Beam and RC Column

For conducting the experiment, 6 numbers of RC beams and RC Column. The size of the beam and column is 700 X 150 X 150 mm. Mix design proportion is 1:1.8:3.3 and water cement ratio of 0.5. Beam and column Reinforcement details are shown in Fig 1 and Fig 2 respectively.



Beam 150 x 150 x 700 mm

Fig 1

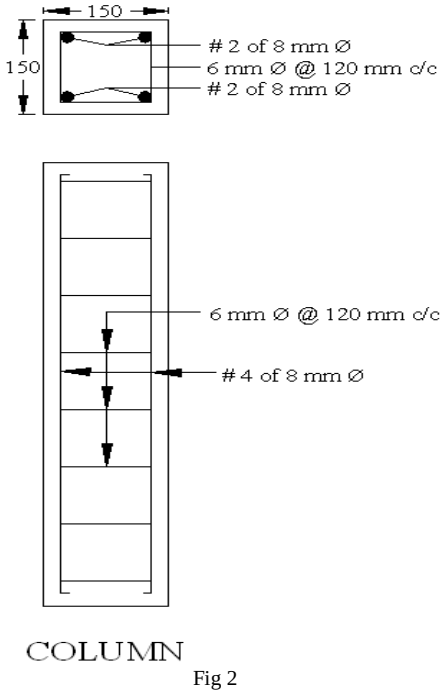


Fig 2

C. STRENGTHENING OF SPECIMENS

The surface of the failed RC members should be cleaned with water and air to remove the dust and other impurities presence on the surface of the member and for clearly visibility of cracks. They are allowed to dry completely. Apply the vinyl-ester resin on surface of the member with the thin layer as shown in Fig 3. The fiber sheet is placed on the specimen surface by stretching on either side and again apply resin on the sheet and rolled with steel rod by applying uniform pressure on the sheet so that all air bubble inside get expelled out as shown in Fig 4. Then keep it for 24 hours for air drying at room temperature.

Fig 3

Fig 4

D. TESTING OF SPECIMEN

1. Flexural strength test of RC Beam

The testing is done for each specimens after curing period of 28 days. The surface of members is cleaned for visibility of cracks. The most commonly used load arrangement for testing of beams will consist of two points loading. The specimen was placed over the steel rollers by leaving 50 mm bearing on either side of the beam. Then the remaining 600 mm beam was divided into 3 equal parts i.e. 200 mm. loading was done by

UTM of capacity 1000KN, and the dial gauge is placed at the center of the beam used to record the deflection of beam.

The above procedure is repeated for failed beam after strengthening the member by GFRP Sheet shown in Fig 6 (a). After getting the results load V/S deflection graphs have been plotted.

Fig 5 - Experimental setup

Fig 6 - Failed RC Beam

Fig 6 (a) Failed RC Beam wrapped with GFRP

2. Compressive strength test of RC column

The testing is done for each specimens after curing period of 28 days. The surface of members is cleaned for visibility of cracks. The most commonly used load arrangement for testing of RCC column will consist of compressive loading. The specimen was placed vertically as shown in Fig 7(a) and loading was done by UTM capacity 1000KN, and the dial gauge is placed at the center of the beam used to record the deformation of the RCC and PCC column.

The above procedure is repeated for failed RCC and PCC Column after strengthening by GFRP Sheet as shown in Fig 7(b).

After getting the results load V/S deformation graphs have been plotted.

Fig 7 (a) – Experimental test setup and crack pattern.

Fig 7(b) – Failed RC Column strengthen by GFRP.

IV. MODELLING IN ANSYS

The following elements are used during the modeling for ANSYS solutions.

- For concrete solid 65 elements is considered.
- For reinforcement link 8 elements is considered.
- For GFRP shell 41 elements is considered.

The mesh use essential to the analysis of model in this software, so the mesh is provided to the surface of RC members before analysis is carried.

The beam is simply supported at the both end, gradually applying two point load on RC beam, Failed RC Beam strengthened by GFRP, and RC beam strengthen by GFRP. The application of load is as shown in Fig 8(a), Reinforcement details shown in Fig 8(b) . Deflection of beam is as shown in Fig 8(c). Failed RC beams strengthened with GFRP and RC beam strengthened with GFRP. After getting the results load V/S deflection graphs have been plotted.

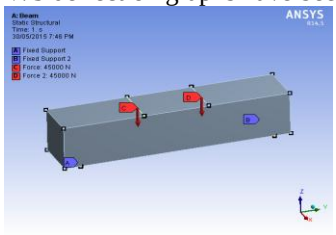


Fig 8 (a)

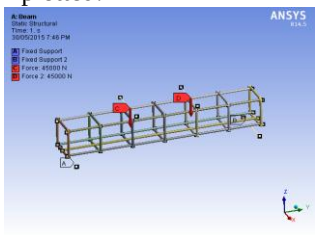


Fig 8 (b).

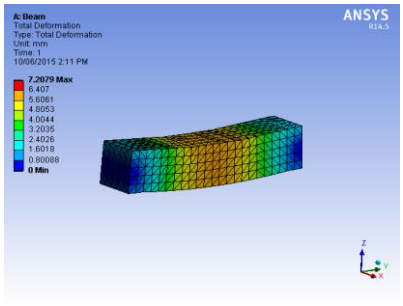


Fig 8 (c) Deflection of beam.

The compressive load is applied on the RC column, failed RC column strengthened with GFRP and RC column strengthened with GFRP. The application of load is as shown in Fig no 9(a), Reinforcement details shown in Fig no 9 (b). Deformation of Column is as shown in Fig no 8 (c). After getting the results load V/S deformation graphs have been plotted.

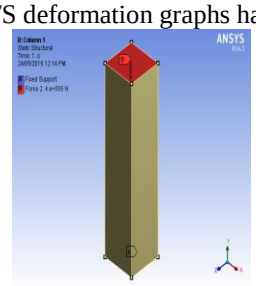


Fig 9 (a)

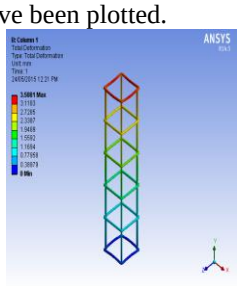


Fig 9 (b)

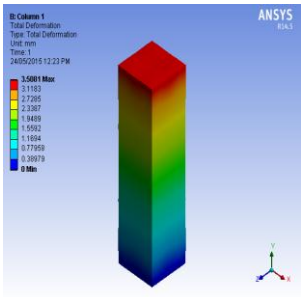


Fig 9(c) Deformation of column

V. Results

1. RC Beam

- Experimental Results for flexural strength test of RC Beam with and without strengthening by GFRP sheet as shown in Table no 10(a) and Fig 10(b).

Table 10 (a)

	RC Beam (1)	Failed RC beam strengthened With GFRP (2)	RC Beam strengthened with GFRP(3)
Load (KN)	95	90	105
Deflection (mm)	8.07	5.5	4.4

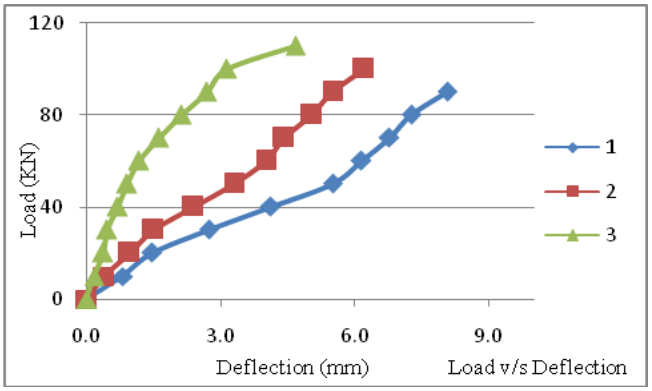


Fig 10 (b)

- Analytical Results for flexural strength test of RC Beam with and without strengthening by GFRP sheet as shown in Table 10(c) and Fig 10(d).

Table 10 (c)

	RC Beam (1)	Failed RC beam strengthened by GFRP (2)	RC Beam strengthened by GFRP (3)
Load (KN)	90	100	120
Deflection (mm)	7.2	4.4	3.6

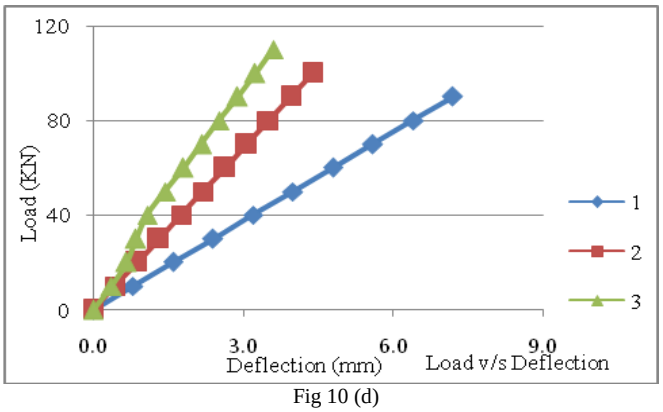


Fig 10 (d)

From the above results and graph it is observed that the deflection of RC strengthened beam was much lower than the RC beam of without strengthening. By addition of fibers the modulus of elasticity of members was increased and this resulted in increase of stiffness and further leading decrement in deflection. Inspire of rate of loading being same the elastic criteria of fiber's helped in controlling the deflection in a controlled manner.

2. RC Column

- Experimental Results for compressive strength test of RC column with and without strengthening by GFRP sheet as in Table 11(a) and Fig 11(b).

Table 11(a)

	RC column (1)	Failed RC Column strengthened With GFRP (2)	RC Column strengthened with GFRP Sheet (3)
Load (KN)	450	600	650
Deformation (mm)	4.1	5.4	5.2

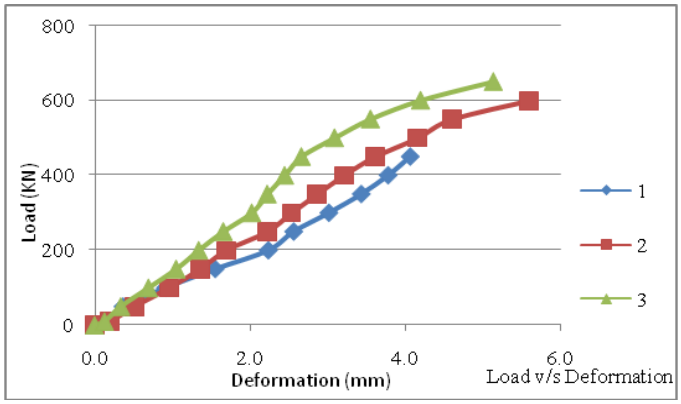


Fig 11 (b)

- Analytical results for compression test of RC column with and without strengthening by GFRP sheet as shown in Table 11(c) and Fig 11(d).

Table 11(c)

	RC column (1)	Failed RC Column strengthened by GFRP Sheet (2)	RC Column strengthened by GFRP Sheet (3)
Load (KN)	400	600	750
Deformation (mm)	3.5	5.7	4.67

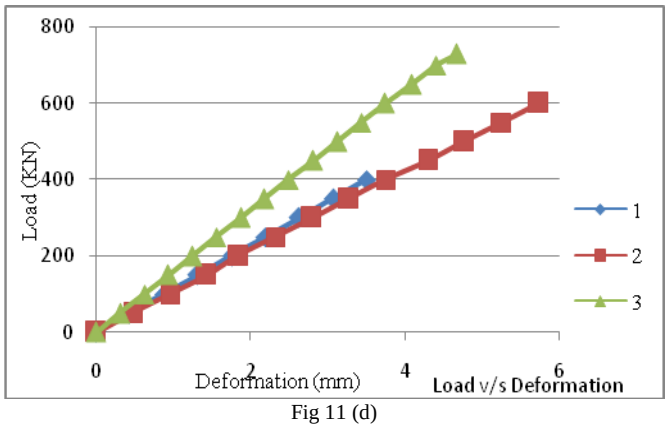


Fig 11 (d)

From the above results and graph it is observed that the deformation of RC strengthened column was much lower than the RC column of without strengthening. By addition of fibers the modulus of elasticity of members was increased and this resulted in increase of stiffness and further leading decrement in deformation. Inspire of rate of loading being same the elastic criteria of fiber's helped in controlling the deformation in a controlled manner.

VI. CONCLUSIONS

1. Fiber's elasticity plays an important role in increasing stiffness and this has lead to decrease of deflection.
2. By using GFRP as strengthening material so that the load carrying capacity of RC member increases.
3. The strength carrying capacity is depending on bonding between GFRP and concrete surface.
4. For the analytical study, ANSYS software is used this software gives the results of above tests which is almost similar to experimental study. So, this software may be use to study the behavior of heavy structure.

VII. REFFERENCES

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