Experimental Study of RC Columns Strengthened With Glass Fiber Reinforced Polymer (GFRP) Sheets

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Abstract-*The main aim of the project work is to improve the load carrying capacity if the column by strapping the Glass Fibre Reinforced Polymer by using Epoxy. Already many experimental research works is carried by wrapping the Glass Fibre Reinforced Polymer in Columns and Beam. But the main problem in fully wrapping the column and beam will make the crack to invisible, due to this failure modes can't be identified in early stage. So, to avoid this, strapping method is suggested. And also from the results, the load carrying capacity of the column will be increase up to 15% in strapping of GFRP in column, which is significant increase of load carrying capacity of column. And also the materials used are reduced in strapping method, while compared with fully wrapped column. This makes the strapping method as cost effective also.*

Keywords*-*GFRP Wrapping, GPRP Strapping, Horizontal Strapping, Vertical Strapping, Epoxy

I. INTRODUCTION

This experimentation work has been carried out to check the increased load carrying of column when the column is strapped with glass fibre reinforced polymer. Usually for strengthening purpose the glass fibre reinforced polymer is wrapped fully on all faces of the column. By wrapping the column the load carrying capacity of the concrete is increased. But the efficiency required to withstand the estimated load can't be met. Because while wrapping the column the strength gained by the column will be much higher than the required strength. So that in fully wrapping excess amount of glass fibre reinforced polymer, epoxy and hardener are utilized. In order to minimise the material used for strengthening, strapping of the glass fibre reinforced polymer will much effective and efficient.

Need Of The Project Work

To find the efficient method for using of glass fibre reinforced polymer in concrete column element for the strengthening purpose, this experimentation work is needed to be conducted and the result are need to be analysed for identifying the effective use of glass fibre reinforced polymer.

Objective

The main objectives of the project work are pointed as follows:

- To find the effective method for strengthening of the concrete column using glass fibre reinforced concrete.
- To find the efficient use of glass fibre reinforced concrete, epoxy and hardener.
- To reduce the cost of glass fibre reinforced polymer strengthening techniques, so that this method can be adopted in a cost effective manner.

II. MODEL DETAILS

Conventional Type –I

The height of the Specimen will be 1000 mm and Cross Sectional Size will be 150mm X 150mm. M25 Grade of concrete and Fy500 Steel is used.

Conventional Type – II

The height of the Specimen will be 1000 mm and Cross Sectional Size will be 150mm X 150mm. M25 Grade of concrete and Fy500 Steel is used. After curing period, Column is fully wrapped by glass fibre reinforced concrete using epoxy.

Contemporary Type – I

The height of the Specimen will be 1000 mm and Cross Sectional Size will be 150mm X 150mm. M25 Grade of concrete and Fy500 Steel is used. After curing period, Column is horizontally strapped (Strap Size 600mm X 30.5mm) by glass fibre reinforced concrete using epoxy.

Contemporary Type - II

The height of the Specimen will be 1000 mm and Cross Sectional Size will be 150mm X 150mm. M25 Grade of concrete and Fy500 Steel is used. After curing period, Column is vertically strapped (Strap Size 30.5mm X 1000mm) by glass fibre reinforced concrete using epoxy.

Table-1: Dimensional Details

Dimensional Details	
Depth	150 mm
breadth	150 mm
Height	1000 mm
Concrete Grade	M25
Steel Grade	Fy500

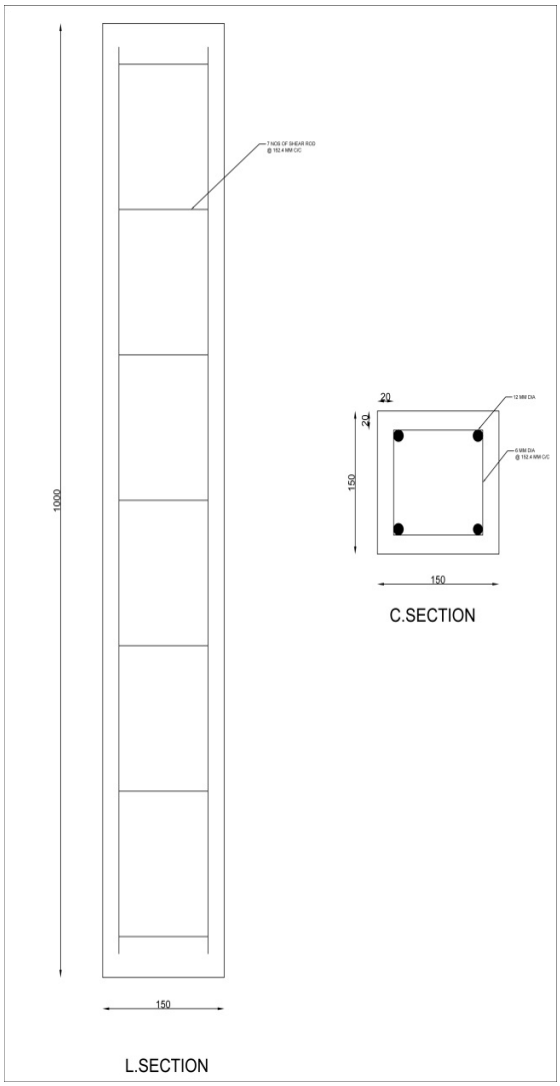


Fig-1: Sectional Drawing

III. TYPE OF COLUMN

In accordance with IS 456 it is necessary to identify the column member as short or slender column. With reference to IS 456, 25.1.2, it is stated that the ratio between the length of column to the breath/width should not exceed 12, so that it is consider as short column, if not it is consider as slender column. Thus in our model the ratio is 6.66, the value is less than 12. Therefore it is a short column.

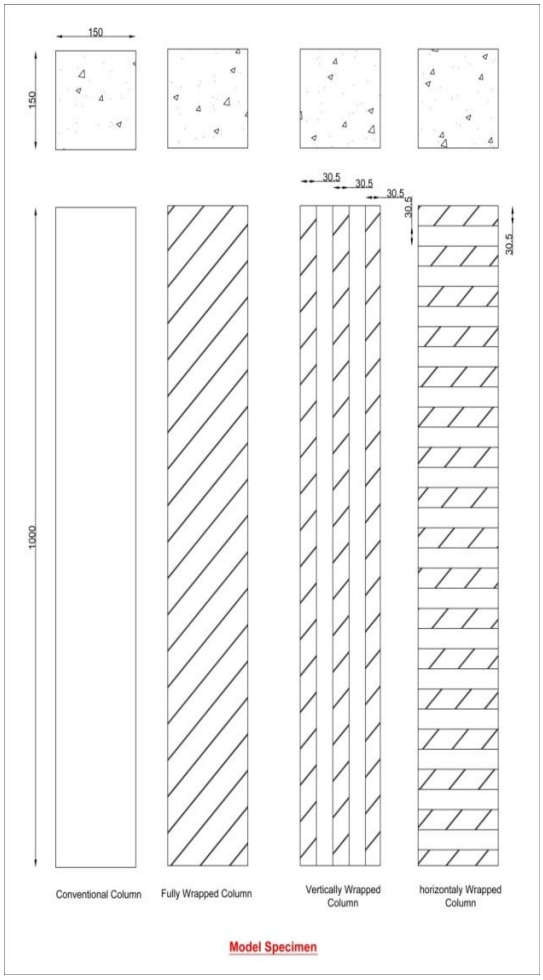


Fig-2: Model Drawing

IV. PROPERTIES OF PRIMER AND GFRP

The primer material properties are available from Hindustan Technical Fabrics Limited, Mumbai. The properties are given in below table.

Table-2: Properties of Primer

Properties of Primer	
Composition	**Two Parts**
Type of Resin	Epoxy Polyamine
Solid by volume	100%
Mixing Ratio	1:1 base and curing agent
Specific Gravity	1.08
Colour	Transparent
Pot Life	45 Min at 21 degree centigrade
Storage	18-24 degree centigrade

The GFRP is weaved in fabric form and unidirectional. The properties of GFRP are given in below table.

Table-3: Properties of GFRP

Properties of GFRP	
Type	E-Glass
Fibre Orientation	Unidirectional
Young's Modulus of Elasticity	75,900 N/Sq.mm
Effective Fibre sheet thickness	0.43 mm
Specific Gravity of fibre	2.56

V. PRELIMINARY TEST

Test on cement

For this project OPC 43 Grade cement is used. And the used grade of cement was test for its fineness, setting time, compressive test. All the result values are within the limit as stated in IS 8112.

Table-4: Preliminary Test on Cement – Result

S.No	Characteristics	Required as per IS 8112	Test Result	Method of Test, Ref to
1	Fineness, Sq.M/Kg, Min	225	232	IS 4031 (Part 2)
2	Setting Time			
	Initial, Min	30 Min	32 Min	IS 4031 (Part 5)
	Final, Max	600 Min	600 Min	
3	Compressive Strength, N/Sq.mm			
	28 Days, Min	43	47	IS 4031 (Part 6)
	28 Days, Max	58		

Test on Aggregate

For this project, 20mm Size aggregate is used as Coarse aggregate and natural sand is used as fine aggregate. And the size of aggregate both fine and coarse is within limits as stated in IS 383.

Table-5: Preliminary Test on Aggregate - Result

S.No	Test Name	Result
1	Specific Gravity of 20mm Aggregate	2.887
2	Specific Gravity of Sand	2.605
3	Water Absorption of 20mm Aggregate	0.97%
4	Water Absorption of Sand	1.23%

Strength Test on concrete

For checking the concrete strength with the nominal mix, cubes are casted separated for compression testing purpose.

Table-6: Test Result on Concrete Strength

S.No	Cube No	Test Result, N/Sq.mm
1	Specimen No 1	27.2
2	Specimen No 2	27.8
3	Specimen No 3	27.6

VI. TESTING SETUP

For the testing, we have used 500Kn Loading Frame and Proving Ring. The height of the column is 1000mm and therefore the height between the floor and jack is more than column height, so we have height adjuster to adjust the height. The weight of the proving ring is 10.5 Kg. this weight is added to the column load, by converting the values in KN.

Here is the picture of the column test setup which in taken while testing of the column.

Fig-3: Column Test Setup

VII. RESULTS & DISCUSSION

Reading in Proving Ring

Here the testing results are mentioned. All the values are in division and the values are needed to be converged with the calibration chart.

Table-7: Test Results, In Division

Testing Result, Proving Ring Reading					
S.No	**Type of Specimen**	**Specimen 1**	**Specimen 2**	**Specimen 3**	**Mean**
1	Conventional	78.6	79.2	76.8	78.2
2	Fully Wrapped	99.2	99.6	98.8	99.2
3	Vertical Strapping	87.4	87.2	87.4	87.33
4	Horizontal Strapping	88.6	88.8	89.2	88.86

Load Calculation

Therefore the ultimate load carrying capacity of columns are calculated by using the calibration chart and tabulated as follows.

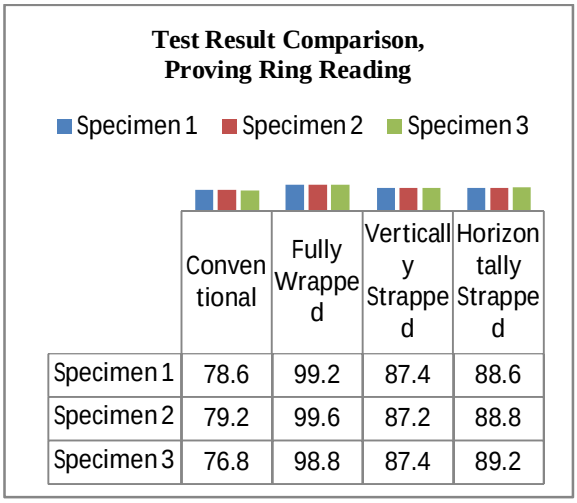
Table-8: Ultimate Load Carrying Capacity, KN

Ultimate Load Carrying Capacity		
S.No	**Type of Specimen**	**Ultimate Load, KN**
1	Conventional Column	94.31
2	Fully Wrapped Column	119.63
3	Vertically Strapped Column	105.32
4	Horizontally Strapped Column	107.16

Comparison of Test Results

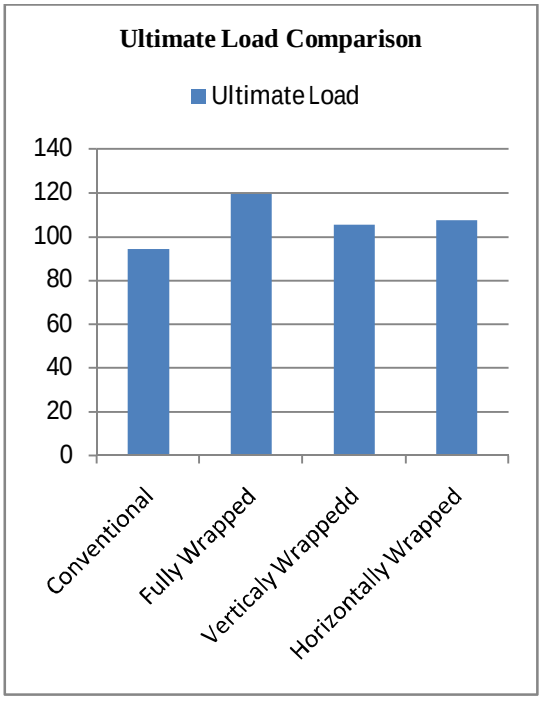
The test results are compared with the each other to understand the behaviour and capacity range of the various column types. To understand the difference of the load carrying capacity of the columns with one another the results are compared with one another.

In Graph-1, the test results are compared with all type of column.



Graph-1: Test Results Comparison

In graph 2, the ultimate load carrying capacity if the columns are compared will all. From the graph it is very clear that the fully wrapped column will carry much higher load. And the load carrying capacity will be increased up to 25% in fully wrapped column when compared with the conventional column. But for making the efficiency in the column load carrying capacity strapped column can be used in behalf of fully wrapped column. Because when the column is fully wrapped the load carrying capacity of column will be increased 25%. When there is no need to increase column strength by that much strapping can be done. In wrapping of the column failure modes can't be identified, but in strapping failure mode can be identified. So that in safety aspect, strapping is better option when compared with wrapping.



Graph-2: Ultimate Load Comparison

VIII. CONCLUSION

The experimentation work done successfully. When compared with the conventional column, strapped column carries 15% more load and in strapped column the failure mode (Initial Cracks) were identified. When compared strapped column with the fully wrapped column, fully wrapped column carries 10% more load than the strapped column, but in fully wrapped column the failure mode (Initial Cracks) can't be identified. By using the strapping method we can have advantage like identify the failure mode and we can reduce the costing of GFRP components. When compared with the fully wrapped column and conventional column, we can have an advantage like increase of strength by 15%. Thus by using this method we can achieve higher efficiency while using GFRP as strap instead of fully wrapped.

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