Retrofitting of Concrete Short Column Using Glass Fibre Reinforced Polymer

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Abstract:- The experimental investigation is carried out on cubes retrofitted with glass fibre reinforced polymer. In this experimental study the concrete with target a mean strength of 20MPa grade is utilized. The experimental study is carried out on a short column with the specimen of sizes 100 x 100 x300 and 100 x 150 x 300 mm with aspect ratio of 1 and 1.5 respectively. The specimens were singly and doubly wrapped with glass fibre.Thus the mechanical properties of short column specimen with varying aspect ratio were tested under compression testing machine. From the test result it is observed that short column specimen with double glass fibre wrapping gives better performance as compare to single wrapped and conventional concrete specimen. All the obtained result were tabulated and graphically presented in this paper.

Keywords- *Compressive strength Glass fibres, Single wrapping,Double wrapping,Rretrofitting.*

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I. INTRODUCTION

All the residential structures are designed for a certain design life depending on the type of structure. Generally the design life of residential building is considered to be twenty five to thirty years whereas for the public building it may vary from fifty to sixty years etc. Elements of most of these structural are constructed with RCC. Now a day's various factors affect the durability of concrete and thereby the life of structure. The most important factor is aggressive environment such as saline and chemicals. Due to these the reinforcement gets rusted thus reducing its life. The other important factors are frequent heavy loading, impact and disaster of various types. Retrofitting means action taken to upgrade the seismic performance of an existing structure so that it achieves intended seismic performance level. It includes adding of the members, shear walls, bracing, reducing loads, strengthening of structural elements and increasing ductility of members etc.

In this experimental work Glass fibre was used as a retrofitting material. Glass fibers have high strength, considering their relatively low cost. E-glass is the most commonly used glass fibers available in the construction industry. Wherever the conventional methods of strengthening of various element of RCC are not useful, there Fibre Reinforced Polymer (FRP) can be used because of its lower cost of labour and equipments though the constituent of FRP are costlier compared to steel and concrete.

II. MATERIAL USED

In the concrete mix the materials usually are cement, fine aggregate, coarse aggregate and water. The materials used in this study for concrete mix are,

A. Cement

Cement used throughout the experimental work is ordinary Portland cement 53 grade conforming to IS 269-1967, manufactured by Ultratech Company. The properties of cement are given in table 1.

TABLE 1 Properties of Cement

Property	Average value	Standard value
Specific gravity	3.11(standard)	3.15
Fineness(%)	4	<10%
Consistency (%)	31	-
Initial setting time (min)	80	>30
Final setting time (min)	389	>600

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B. Coarse Aggregate

Crushed stone aggregate has been used. It is a locally available with sharp, angular aggregate, with maximum size of aggregate 20 mm. The properties of coarse aggregate are given in table 2.

TABLE 2 Properties of Coarse Aggregate

Sr No	Property	Average value
1	Specific Gravity	2.80
2	Water absorption	1.53%
3	Moisture content	1.92%
4	Type	Crushed
5	Maximum Size	20 m

C. Fine Aggragate

The sand used for the experimental work was locally procured and conformed to grading zone III. Sieve Analysis of the Fine

Aggregate was carried out in the laboratory as per IS 383-1970 [11]. While the fine aggregate shall conform to the grading zone III. The properties of fine aggregate are given in table 3.

TABLE 3 Properties of Fine Aggregate

Sr no	Property	Average value
1.	Specific Gravity	2.72
2.	Water absorption	4.05%
3.	Moisture content	5.09%
4.	Fineness Modulus	4.87
5.	Type	Natural Sand
6.	Grading Zone	III

D. Water

Fresh and clean water is used for casting the specimens in the present work. The water is relatively free from organic matter, silt, oil, sugar, chloride and acidic material etc as per Indian standard.

E. Primer

The material and their properties are available from Hindoostan Technical Fabrics Limited. Mumbai. The properties of primer are given in table 4.

TABLE 4 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 kg
Color	Transparent
Pot life	45 min at 21 degree centigrade
Storage	18-24degree centigrade

F. Saturant

Epoxy saturant is the name of the saturant. Various properties of saturant are given in table 5.

TABLE 5 Properties of Saturant

Color	Pale yellow to amber
Application temperature	15 – 40 degree centigrade
Mixing ratio	1.5 : 1
Viscosity	Thixotropic
Density	1.12 – 1.16 g/cm^3
Pot file	2hrs at 30 degree centigrade
Cure time	5days at 30 degree centigrade
Storage condition	Under normal ware house condition < 35 degree centigrade

E. *Glass Fibre Reinforced Polymer (GFRP)*

GFRP is weaved in fabric form and unidirectional. The properties of GFRP are given in table 6.

TABLE 6 Properties of GRPF

Type	E-glass
Fiber orientation	Unidirectional
Young's modulus of elasticity	75,900 N/mm^2
Effective fiber sheet thickness	0.43mm
Density of wrap	900 g/cm^2
Specific gravity of fiber	2.56
Tensile strength in uni-direction	2060MPa

III. EXPERIMENTAL WORK

Initially all the constituent of concrete such as aggregate, cement, water, sand were duly tested in the laboratory in accordance with the Indian Standard. Then the procedure for mix design for M20 grade was adopted as per the Indian standard specifications (IS 10262-2007) [10]. Also after fix the proportion various test were carried out on fresh and harden concrete. For good quality of cement concrete works; testing plays a vital role.

- Compressive Strength Test

It is most common to identify the quality of concrete by its compressive strength measured on standard cubes at various curing period on Compression testing machine

The compressive test was carried out on specimens rectangular in shape. The column specimen is of the size 100 X 100 X 300 mm and 100 X 150 X 300mm. The concrete is filled into the mould in layers approximately 5cm deep. Total 18 specimens are tested in compression testing machine Three control specimens, three with single layer of GFRP and three with double layer of GFRP are tested. Two aspect ratios are taken as 1:1 and 1:1.5.

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IV. TEST RESULT AND DISCUSSION

The compressive strengths for various specimen are given in table 7 for control (conventional), singly wrapped and doubly wrapped.

TABLE 7 Load Carrying Capacities of Various Layer

Specimen size for M20	**load in kN at which specimen fails**					
	Control specimen		Single layer		Double layer	
100×100×300	220	215.16	317.1	312.6	380.3	388.8
	225.6		309.2		398.9	
	199.9		312.7		385.4	
100×150×300	314.6	324.86	457.9	454.07	568.4	563.8
	325.2		442.8		571.3	
	334.8		461.5		551.7	

TABLE 8 Strength of column in N/mm^2

		Ultimate compressive strength in N/ mm^2.			
Grade of concrete	**Layers of GFRP**	**Aspect ratio 1**	**% increse in strength**	**Aspect ratio 1.5**	**% increse in strength**
M20	Control specimen	21.51		21.65	
	Single layer	31.27	43.40%	30.26	39.80%
	Double layer	38.9	75.80%	37.58	73.60%

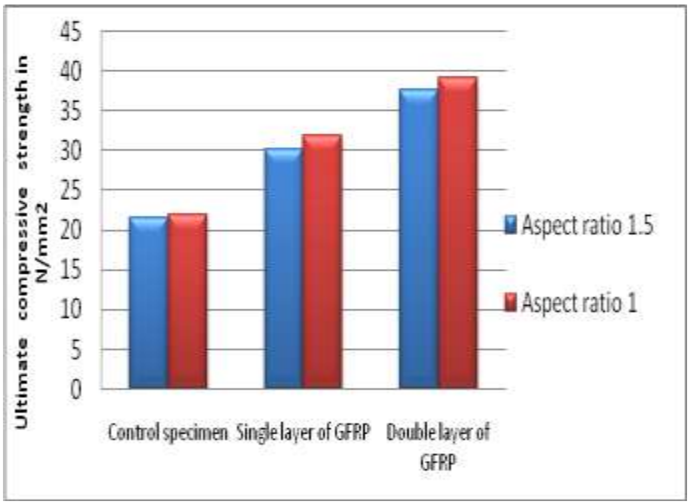

Fig 1 Effect of aspect ratio.

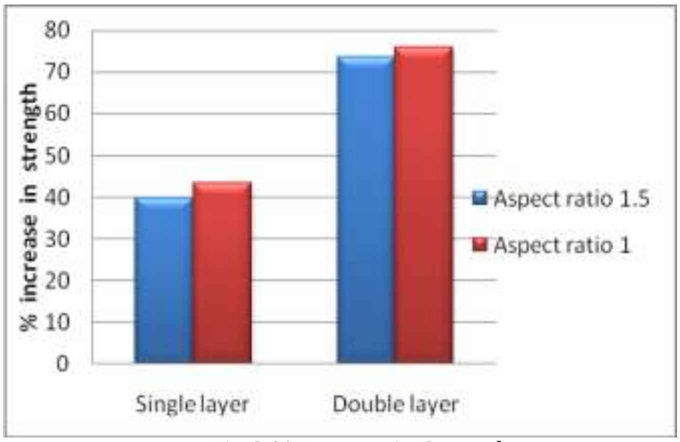

Fig 2 % Increase in Strength

For single layer specimens, the maximum percentage increase in strength achieved for square specimens (aspect ratio 1) and rectangular specimens (aspect ratio 1.5) with respect to control specimens were 43.4% and 39.8% respectively.

Similarly for double layer specimens, the maximum percentage increase in strength achieved for square specimens (aspect ratio 1) and rectangular specimens (aspect ratio 1.5) with respect to control specimens were 75.8% and 73.6% respectively.

TABLE 9 Load Carrying Capacities of Retrofitted Specimen

Specimen size for M20	load in kN at which specimen fails					
	Control specimen		GFRP wrap specimen		Retrofitted specimen	
100×100×300	220	215.16	317.1	312.6	246.2	261.1
	225.6		309.2		274.6	
	199.9		312.7		261.5	
100×150×300	314.6	324.86	457.9	454.07	387.2	388.36
	325.2		442.8		392.2	
	334.8		461.5		385.7	

TABLE 10 Strength of Retrofitted Column in N/mm^2.

		Ultimate compressive strength in N/ mm^2.	
Grade of concrete	Layers of GFRP	Aspect ratio 1	Aspect ratio 1.5
M20	Control specimen	21.51	21.65
	GFRP wrap specimen	31.27	30.26
	Retrofitted specimen	26.11	25.89

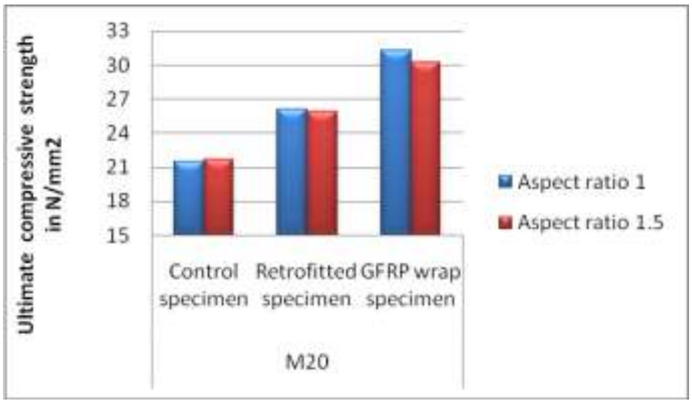

Fig 3 Effect on damaged concrete column retrofitted by GFRP wrap

From above figure, retrofitted specimens are more effective than control specimen and less effective than GFRP wrap specimens. Also it can be seen that the GFRP retrofitting is more effective for aspect ratio 1 than aspect ratio 1.5.

V .CONCLUSION

1. The experimental results clearly conclude that GFRP wrapping can enhance the strength of concrete columns under axial loading.
2. Confinement by GFRP enhances the performance of rectangular concrete columns. GFRP wrapping is more effective for aspect ratio 1 than aspect ratio 1.5, i.e. for M20 grade of concrete, percentage increased in strength are 43.4% and 39.8% respectively for column with single layer of GFRP
3. As the aspect ratio increases from 1 to 1.5, the strength gain in confined concrete columns decreases.
4. Compressive Strength of the Concrete Columns increases with increase in the number of layer of GFRP. For M20 grade of concrete, percentage increase in strength from single layer to double layer of GFRP are 24.4% and 24.19% for aspect ratio 1 and 1.5 respectively.
5. It is concluded that the retrofitting columns will have significantly better performance compared with the unwrapped columns, i.e. for M20 grade, retrofitted specimens have taken 21.38% and 19.67% more load than control specimens for aspect ratio 1and 1.5 respectively.

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