Comparative Study of Fibre Reinforced Polymer Composite Wrapped on Various Shaped Columns

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Abstract

The main objective of this paper is to study the shape effect of concrete columns confined with FRPC on strength parameters. The experimental programme wills includes number of specimens which will consists of unwrapped and wrapped various shape. The shape effect study will be established through results in terms of the ultimate axial strength. The experimental results will show that for concrete specimens the shapes significantly increase the confinement effectiveness when compare with wrapped concrete column specimens. Experimental results will be compared to Ansys software to find out strength performance of unwrapped and FRPC wrapped concrete columns that are affected by change in shape.

Keywords —

Compressive strength, UTM; FRPC wrapped and unwrapped specimens, Ansys.

I. Introduction

FRCs have two component, matrix and fibre, thermosetting resins like epoxy or polyethylene are used as matrix, while aramid, carbon and glass fibres reinforce the matrix and lend strength to the composite. The resin coheres and gives shape to the object, while fibres reinforce it. The result of such combination is a light, flexible and strong composite material.

Unlike conventional materials, composites are not homogeneous. Their properties are dependent on position and angle under consideration. Generally, composites are elastic up to failure and exhibit no yield point or region of plasticity. The properties are dependent on fibre and matrix, their relative quantity and orientation of fibre. If all the fibbers are aligned in one direction then the composite becomes very stiff and strong in that direction but it will have low strength and low modulus in the transverse direction.

Due to their malleability, fibre reinforced plastics are easy to fabricate. Recent development in this field has indicated that they can be used as highly efficient construction materials in various civil engineering activities. Fibre reinforced plastic composites (FRPC) have already been successfully used in industries like aerospace, automobile and shipbuilding. Recently, civil engineers and construction industry have begun to realize that these materials have potential to provide remedies for many problems associated with the deterioration and strengthening of infrastructure. Effective use of these materials could significantly increase the life of structures, minimizing the maintenance requirements.

Existing reinforced concrete columns may be structurally deficient for several reasons: substandard seismic design details, improper transverse reinforcement, flaws in structural design, and insufficient load carrying capacity. Reinforced concrete columns need to be laterally confined in order to ensure large deformation under load before failure and to provide an adequate load resistance capacity. In the case of a seismic event, energy dissipation allowed by a well-confined concrete core can often save lives. On the contrary, a poorly confined concrete column behaves in a brittle manner, leading to sudden and catastrophic failures. With the development of technology, the use of high-strength concrete members has proved most popular in terms of economy, superior strength, stiffness, and durability. With the increase of concrete strength, the ultimate strength of the columns increases, but a relatively more brittle failure occurs. The lack of ductility of high-strength concrete results in sudden failure without warning, which is a serious drawback. Previous studies have shown that addition of compressive reinforcement and confinement will increase the ductility as well as the strength of materials effectively. Concrete, confined by transverse ties, develops higher strength and to a lesser degree ductility.

In the recent years, the composite materials, by their non-corrodibility, high stiffness and strength to weight ratios, have quickly appeared as innovative solutions adapted to the strengthening and the repair of civil engineering structures. The composite materials usually used are unidirectional carbon or glass fibre externally retrofitted to concrete by bonding. The resins used are epoxy. The confinement of reinforced concrete columns is thus an application where external wrapping by glass or carbon fibre reinforced polymers is particularly effective. This innovative technique is used for reinforcing old structures in civil engineering field. Another attractive advantage of FRP over steel wraps as external reinforcement is its easy handling. Thus, minimum time and labour are required for implementation. The application of FRP in the construction industry can eliminate some unwanted properties of high strength concrete, such as its brittle behaviour. FRP is particularly useful for strengthening columns.

Advantages of FRPC:
FRPCs offer many advantages over other materials used in construction and rehabilitation and they are as follows.

- FRPC's are non-metallic. Therefore, FRPC's are resistant to corrosion.
- FRPC's are light, flexible and strong composite material.
- FRPC's are chemically inert.
- FRPC's are available in rolls of very long length.
- FRPC have short curing time.
- FRPCs have high ultimate strain therefore they offer ductility to structure and they are suitable for earthquake resistant applications.
- FRPC have low thermal conductivity.
- FRPC are bad conductor of electricity and are non-magnetic.
- Due to their lightweight prefabricated components they can be easily transported. FRPC encourage prefabricated construction; reduce site erection, labor cost and capital investment requirement.

II. Materials Used

1) Cement-
Ordinary Portland cement of grade 53 was used. The Initial setting time of cement is 30 minutes and the specific gravity of cement is 3.15.

2) Fine Aggregate-
Fine aggregate used in this research work was conforming to IS and was clear sand passing through4.75mm sieve with a specific gravity of 2.68. The grading zone of aggregate was zone II.

3) Coarse Aggregate-
Coarse aggregate used in this research work was conforming to IS and was angular crushed aggregate with a specific gravity of 2.70.

4) Water-
Potable water available in the laboratory with the pH of 7.0 ± 1 and conforming to the requirement of IS: 456-2000 was used for mixing concrete and also for curing of specimens.

5) FRPC Material-
FRPC is available in two component matrix and fibre matrix consists of thermosetting resins like epoxy and poly ethylene.

III OBJECTIVES:

1. To compare behaviour of unwrapped conventional concrete columns to FRPC wrapped various shaped concrete columns.
2. To study the effects of shapes on enhancement of strength of FRPC wrapped concrete columns.
3. To find out most economical wrapped pattern of column having maximum axial strength
4. To find physibility.
5.

IV CONFINING PRESSURE VARIATION DUE TO CHANGE IN SHAPE OF COLUMN

I Confining pressure of circular column: In case of cylinders the whole cross sectional area is effectively confined because the confining pressure is uniformly distributed along the perimeter as shown in fig 4.9 The behaviour of confined cylinders is similar to a thin walled cylinder. The equation (1) for confining pressure is given as,

$$f_1 = \frac{\rho f_{rp} E f_{rp} \varepsilon f_{rp}}{2}$$

Where,

Efrp = Young's modulus of FRP wraps
ε frp = strain in FRP wraps at failure
ρ frp = FRP volumetric ratio

$$\rho f_{rp} = \frac{\pi d n t f}{\frac{\pi d^2}{4}}$$

where,
d = diameter of cross section
n = no of layers
tf = thickness of FRP wrap

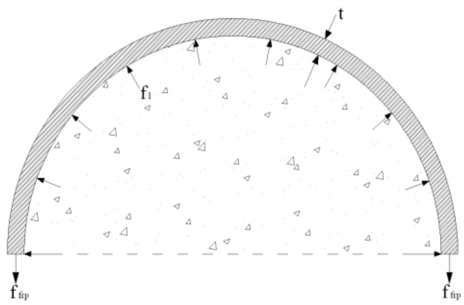


Fig no.1 Lateral confining pressure in cylinders

II Confining pressure for non circular cross sections

In case of non circular cross sections the confining pressure is affected by the sharp edges. The dilation in non circular cross section is effectively contained by the FRP wraps only at the corners due to stress concentration as shown in fig 4.10 The effective confined area is reduced because stress concentration causes arching of concrete core along the sides. The equation (3) for confining pressure for non circular cross section is given below,

$$f = \frac{\left(k_a \rho_{frp} E_{frp}\right)}{2}$$

In order to account for the reduced effective confined area, the confining pressure is reduced by a shape factor *ka* and is given by the following equation,

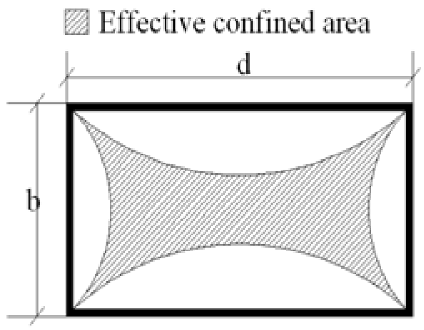


Fig no.2 Effective confined areas of sharp edged

V Experimental work plan

As per methodology, test matrix was decided of different shapes keeping area of all the shapes approximately equal and also height of all the specimens was 300 mm. The maximum height of column sample that can be tested in existing 200 ton capacity compression testing machine was limited to 450 mm and hence the maximum height of sample column was kept 300 mm. The grade of the concrete was M20. Before casting of Concrete columns of each shape like square, rectangular, circular, lamellar L shape, lamellar T shape and lamellar plus shape, concrete cubes of standard dimension (150x150x150) was casted as per mix design of M20 and tested under 200 ton compression testing machine and same batch of concrete was used for all 36 casting of Concrete columns. As per the following test matrix moulds of different shapes like square, rectangular, circular, lamellar L shape, lamellar T shape and lamellar plus shape etc were made and casted 6 specimens for each shape. Later on out of 36 specimens 18 specimens were wrapped with one layer of GFRP. Total 14 sq. m. of GFRP was used to wrap all the specimens and test were taken of all the specimens using 200 ton compression testing machine.

TABLE NO.1

TEST MATRIX

Shapes	Dimensions (mm)				Area (mm2)
	d	a	b	h	
Circular	220			300	38013.27
Square		195	195	300	38025
Rectangular		160	240	300	38400
Lamellar(L-shape)		226	113	300	38307
		113	113		
Lamellar(T-shape)		226	113	300	38307
		113	113		
Lamellar(+ shape)		88	264	300	38720
		88	88		
		88	88		

All specimens were wrapped with one layer of GFRP. Glass fibres had an ultimate strength of 2400 mpa elastic modulus of 72 KN/mm^2.Resin epoxy was used as a matrix. All specimens were pre-treated with resin primers in order to achieve a surface & good bond between FRP & specimen surface. Compression test was carried out on the entire specimen on a 200T compression testing machine (CTM) under a load of 2.5KN/sec.

MIX DESIGN PROPORTION FOR CONVENTIONAL SPECIAMENS

TABLE NO.2

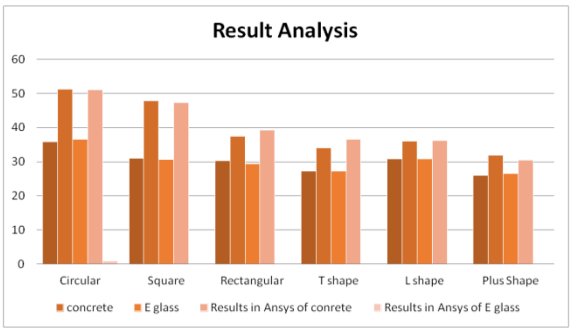
	Water	Cement	Fine Agg.	Corse Agg.
By weight	38.15	79.47	119.22	238.44

VI Results and Observations:

FIG NO.3 GFRP WRAPPED SQUARE COLUMN WITH SHARP EDGES FAILURE OF FIBRE AT CORNER DUE TO STRESS CONCENTRATION

TABLE NO.3
Results

Sr. No	Shape	concrete	E-glass	Results in Ansys of conventional concrete	Results in Ansys of E-glass Fibre wrapped
1	Circular	35.91	51.31	36.65	51.15
2	Square	30.99	47.88	30.65	47.23
3	Rectangular	30.35	37.45	29.42	39.2
4	T shape	27.26	34.01	27.2	36.56
5	L shape	30.81	35.99	30.81	36.14
6	Plus Shape	25.99	31.99	26.6	30.4



VII CONCLUSION

Based on the results obtained from the experimental investigation following conclusions have been drawn.

From the data available on confinement of FRPC to building columns (low concrete strength & use of Conventional concrete column) are found to be responsible for total collapse or partial damage of buildings during recent earthquakes. The use of glass fibre polymers for ductility and durability enhancement of deficient columns has gained. So it is important to use of glass fibre composites having high strength, high ductility, high durability etc. to enhance strength parameter.

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