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GFRP CONFINED CONCRETE UNDER UNI-AXIAL LOADING

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ABSTRACT

Compression members primarily take compressive loads and prove to be the important member in the structural framework. Compression members under confinement provide better load carrying and energy absorption capacity which in turn provides better resistance of the member to unexpected lateral loads. Confinement can be provided by several means but in this paper the work is limited to glass fibre wraps. For determining the amount of confinement 150 X 300 mm cylinders are considered. To get a better analysis in terms of confinement several parameters were considered such as Single layer, two layers and a Central band in terms of the Fibre wraps. The results of these specimens are tested under uni axial loading. In addition the experimentally obtained results are analytically verified using ANSYS and with standard experimental results.

Key words: Confinement, Glass fibre wraps, Single layer, two layers & Central Band

1. INTRODUCTION

Concrete is a material which is generally used for almost all sorts of construction and has certain areas of shortcomings such as strengthening them post construction or in other terms rehabilitating concrete structures. Several techniques are available to resolve this demerit of concrete. The most commonly used technique is Jacketing by conventional Reinforced Concrete but does have many shortcomings such as bond, placing of bars and so on. Hence forth the use of FRP (fibre reinforced polymer) has been on the increase in the past two decades. FRP is generally used for repair works or for additional strengthening of the member. The most commonly used fibre materials are glass, carbon and aramid fibres and the commonly used resins are epoxies and polyesters. Lam and Teng [7] a total of 27 Concrete cylinders of diameter 152 mm and height 305 mm and both GFRP and CFRP were used and one layer and two layer of wrap were carried out with various thickness of fibre wraps and the fibre wrapped specimens failed by the rupture of fibre wrap outside the overlapping zone. Samaan et al [1] a total of 30 specimens of 152.5X302 mm were considered and three different concrete batches and three different E glass fibre plies such as 6, 10 and 14 were considered and most of the specimens were subjected to monotonic loading and results were used to propose a new model primarily based on dilation rate of concrete and hoop stiffness of the restraining member. In this paper the work is primarily confined to glass fibre wraps of one layer, two layers and a central band of 100 mm.

2. EXPERIMENTAL INVESTIGATION

For Experimental investigation 150X300 mm specimens are considered. The concrete used is of M30 grade concrete as conforming to IS10262:2009. The experimentally obtained results were primarily based on 28 day strength of the concrete.All the specimens were tested by Compression testing machine under monotonic loading. Three different wrappings of fibres are considered such as single layer, two layers and a central band. The fibre wraps are applied on the specimens using resins and hand lay up technique is used. The fibre wraps are primarily of E glass fibre wraps and their properties are

Table 1 GFRP Properties

Description	Thickness (mm)	Tensile Strength(N/mm^2)
E- Glass Fibre Wraps	0.35	200

Table 2 Composite Strength

S.No	Description	Compressive Strength in N/mm^2
1	Unconfined	30.8
2	Central band	33.7
3	Single layer	37.3
4	Two layers	38.2

Figure 1: FRP Confined Specimens

3. ANSYS MODELING

The specimens are modeled in ANSYS, the concrete specimens are considered as a solid element and the FRP jacket is considered as a shell element. The material properties such as Elastic Modulus and Poisson's ratio are given and elastic modulus of concrete is based on $5000\sqrt{f_{ck}}$. The composites are modeled and analyzed as shown in the following figures. Table 3 shows the comparison of results of experimentally obtained and the results obtained from ANSYS.

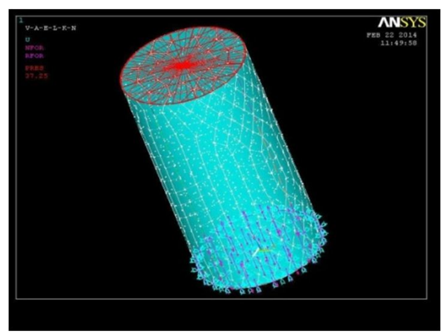

Figure 2: Modeling in ANSYS

Table 3 Comparison of Results

Description	Experimental Results (N/mm^2)	ANSYS (N/mm^2)
Central Band	33.7	32.23
Single Layer	37.3	37.4
Two Layers	38.2	38.5

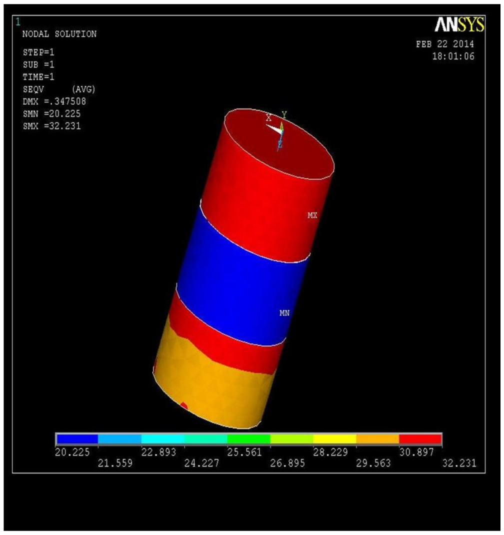

Figure 3: Central Band Stress

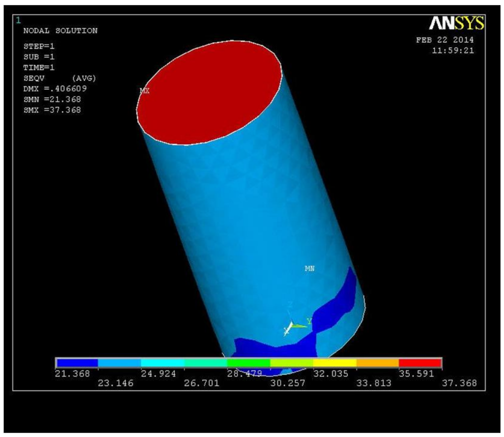

Figure 4: Single Layer Stress

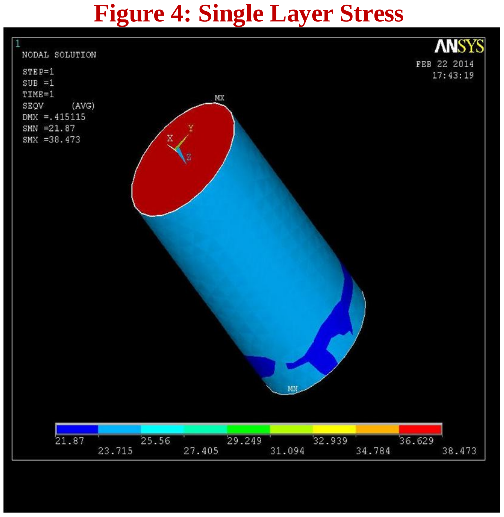

Figure 5: Two Layers Stress

From these results it is clearly evident that the deviation of results is within 5% and the experimental results are in close proximity with the ANSYS results.

4. REGRESSION ANALYSIS

It is a statistical procedure to obtain a relationship between variables, from these results it is found to be evident that there exists a linear relationship between the Confinement strength ratio (f_l/f_c) and strengthening ratio (f_{cc}/f_c). Hence a regression analysis is carried out between these variables. The lateral strength (f_l) due to FRP jacket is obtained using.

$$\rho = 4t / D \qquad \text{...Eq 1}$$

Where ρ refers to Confinement ratio, D refers to diameter of the specimen and t refers to the thickness of the FRP.

$$f_l = 2\, f_t\, t / D \qquad \text{...Eq 2}$$

Where f_t refers to the ultimate tensile strength of the Fiber wrap material substituting eq.2 in eq.1, lateral strength is determined by

$$f_l = \tfrac{1}{2}\, f_t\, \rho \qquad \text{...Eq 3}$$

The regression analysis carried out between confinement strength ratio and strengthening ratio produced a relationship as

$$f_{cc} / f_c = 1.1 + 3.23\, (f_l / f_c) \text{.Eq 4}$$

Where f_{cc} refers to the confined compressive strength of the FRP confined concrete specimen and f_c refers to the unconfined strength of the concrete specimen.

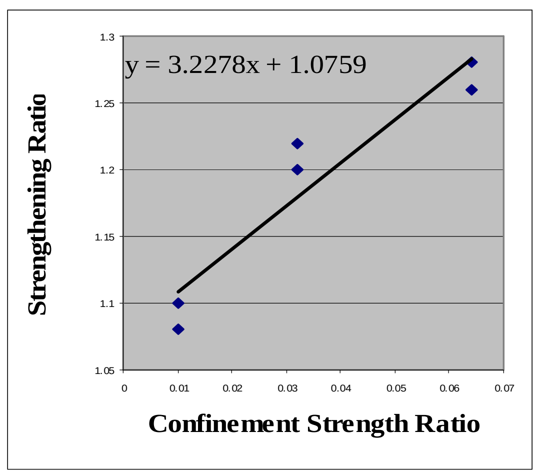

Figure 5: Confinement Strength ratio Vs strengthening ratio

The Eq. 4 obtained through regression analysis is validated with experimentally available results of standard authors. The experimental results which are considered are Abdollai et al, Lin and Chen, Nanni & Bradford, Silva and Rodrigues & Youssef et al. The following table shows the Validation of the results based on the above equations and the experimental results are considered based on different confinement ratio.

Table 4 Validation of Equation (4)

Paper	Specimen Dimension (mm)	Experimental (MPa)	Tensile strength of FRP, f_t (MPa)	ρ	Predicted by Eq.4 (MPa)
Abdollahi et al [3]	150 X 300	30	537	0.0135	28.03
Abdollahi et al [3]	150 X 300	55.5	537	0.0271	51.1
Lin and Chen [4]	120 X 240	66.3	743.9	0.03	72.0
Lin and Chen [4]	120 X 240	104.5	743.9	0.06	108.1
Nanni and Bradford [5]	150 X 300	46	583	0.008	47.46
Nanni and Bradford [5]	150 X 300	55.75	583	0.016	55
Silva and Rodrigues [2]	150 X 300	87.5	464.3	0.067	85
Silva and Rodrigues [2]	150 X 450	89.8	464.3	0.067	83.35
Youssef et al [6]	406.4 X 812.8	51.19	424.7	0.033	55.0
Youssef et al [6]	152.4 X 304.8	81.13	424.7	0.059	88.8

5. CONCLUSION

An extensive experimental investigation is carried out on specimens with three different confinement ratios such as central band of 100mm, single layer & two layers and it is found to be evident that there is an increase in the ultimate compressive strength of the composite. The increase in strength is found to be 9% in terms of central band, 21% in terms of single layer and 24% in terms of two layers. The experimentally obtained results are validated with FEM package ANSYS and the results are found to be in good correlation with experimentally obtained results. A regression analysis is done and the analysis is validated with standard experimental results.

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