Effects of Various Slenderness Ratio and Aspect Ratio on FRP Wrapped Axially Loaded RC Capsule Column

Saravanan S, Ruban Daniel V, Karuppasamy R

Abstract: ***This paper presents results of experimental investigation on the behaviour of axially loaded capsule shaped columns that have been strengthened with Glass Fibre Reinforced polymer and Carbon Fibre Reinforced Polymer with different wrapping patterns. Twelve capsule shaped columns were casted and tested under axial compression. One set of columns have been made with aspect ratio 2.53and with two different slenderness ratios. The second set of columns has been made with aspect ratio 2.1and with two different slenderness ratios. Eight out of twelve columns were confined with one layer and two layers of GFRP and CFRP wrap patterns. Based on the axial compression testing the columns it can be concluded that the lower the slenderness ratio and higher the no of layers and aspect ratio obtained the more strength and ductility.***

Keywords- CFRP, GFRP, confined, Strengthening, Axial compression.

I. INTRODUCTION

In recent years, the use of externally confined Fibre Reinforced Polymers in concrete columns and beams has become increasingly popular. Significant research has been devoted to circular and rectangular shaped columns retrofitted with FRP were proposed [1] Hadi M N S [1] tested six cylindrical plain and RC columns were wrapped with different no of layers GFRP and CFRP. The conclusion is that considerable gain in strength and ductility are obtained when reinforcing the columns with CFRP (vertical straps and horizontally wrapped). Kumutha R et al. [2] tested nine rectangular specimens were casted aspect ratio 1, 1.25, 1.66 and wrapped different no of layers of GFRP. The conclusion is that the effective confinement with GFRP composite sheets resulted in improving the compressive strength. Better confinement was achieved when the no of layers of GFRP wrap was increased. Pan J L et al. [3] tested six elliptical modified rectangular slender reinforced concrete columns wrapped with FRP with a slenderness ratio 4.5 and 17.5. The result shows that the strengthening effect decreases with increase of the slenderness ratio.

A. Scope and Objective

The Main Endeavour of this work is to experimentally scrutinize the effects of upgrading the load carrying capacity of Reinforced Concrete Capsule Shaped Columns subjected to axial compression by confining with GFRP, CFRP.

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The objectives of this study are as follows:

i. To evaluate the corner effectiveness of external GFRP and CFRP strip strengthening for Capsule shaped concrete columns.

ii. To evaluate the effect of number of FRP strip layers on the ultimate load of capsule shaped confined columns.

iii. To evaluate the effect of slenderness ratio and aspect ratio on the confined columns.

II. EXPERIMENTAL INVESTIGATION

A. Specimen details

A total of 8 FRP wrapped and 4 unconfined control concrete columns with dimensions of 150x 380x 600, 150x380x1000 with shorter face radius 75mm, 190x90x1080, 190x90x1250 with shorter face radius 45mm respectively were prepared and tested under axial compression loading. The specimen details are shown in table 1 and the specimen wrapping details are shown in fig 1-4.

Table 1 Specimen Details

Specimen ID	Slenderness Ratio(L/B)	Aspect Ratio (a/b)	No of Layers
CG 0	4	2.53	0
CG 1	4	2.53	1
CG 2	4	2.53	2
CG 3	6.67	2.53	0
CG 4	6.67	2.53	1
CG 5	6.67	2.53	2
CG 6	12	2.1	0
CG 7	12	2.1	1
CG 8	12	2.1	2
CG 9	14	2.1	0
CG 10	14	2.1	1
CG 11	14	2.1	2

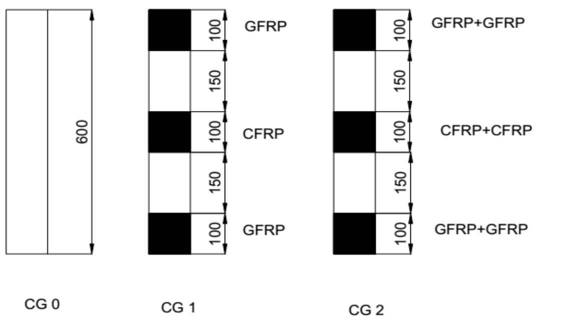

Fig. 1 Wrapping Pattern of Specimens Slenderness ratio 4

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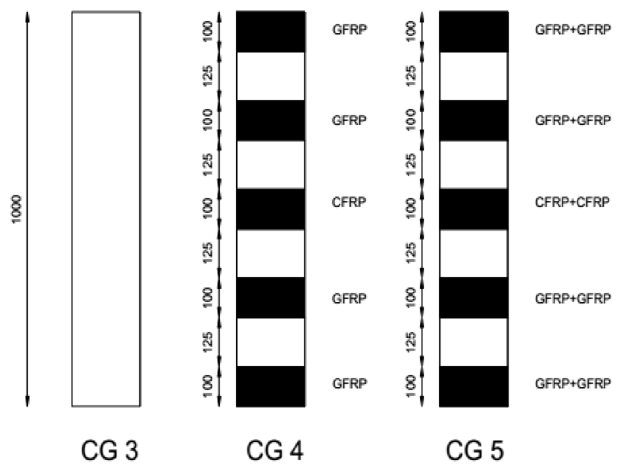

Fig. 2 Wrapping Pattern of Specimens Slenderness ratio 6.67

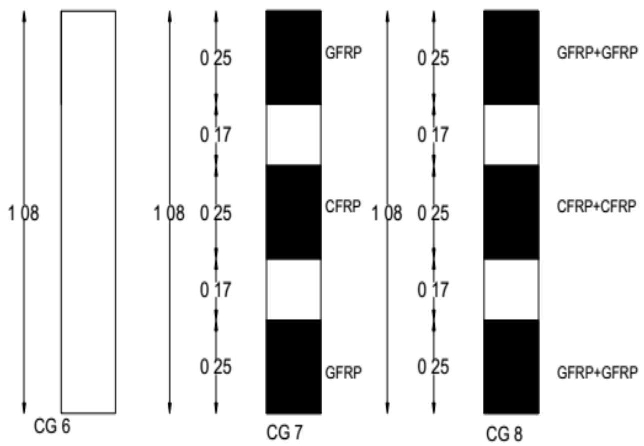

Fig. 3 Wrapping Pattern of Specimens Slenderness ratio 12

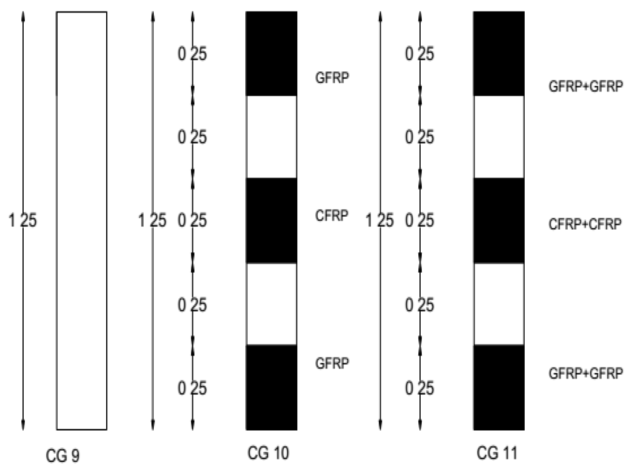

Fig. 4 Wrapping Pattern of Specimens Slenderness ratio 14

B. Material Properties

B.1 Internal steel reinforcement

The internal reinforcement 16mm dia 4 nos and 2nos of 12mm dia bars used as main reinforcement and 8mm dia bars used as stirrups 200mm C/C spacing provided in the specimen CG 0, CG 1, CG 2, CG 3, CG 4, CG 5. 12mm dia 4 nos used as main reinforcement and 8mm dia bars used as stirrups 150mm C/C spacing provided in the specimen CG 6, CG 7, CG 8, CG 9, CG 10, CG 11.

Fig. 5 Reinforcement cage

B.2 Concrete

Portland Pozzolana cement , natural sand (fine aggregate) and crushed coarse aggregate 20mm & 10mm size were used for the concrete mix. The mix proportion of M20 is 1:1.3:3.1 by weight of cement, sand, coarse aggregate and water cement ratio 0.5 was adopted.

B.3 FRP used

Glass Fibre Reinforced Polymer and Carbon Fibre Reinforced Polymer rovings were used as confinement reinforcement.

B.4 Strain gauge used

The strain gauge type was BICSA-10 with a gauge length of 10mm fixed in the longitudinal reinforcement.

III. RESULT AND DISCUSSION

A. Observed behavior

At the early stages of loading of the confined specimens, the noise related to the micro cracking of concrete core was evident. At the latter stages of loading, a plastic-like sound was produced by the stretching of the FRP rovings.

Table 2 Summary of Test Results

Specimen ID	Ultimate Load in kN	Max Axial Strain	Max Displacement in mm
CG 0	700	0.002940	0.69
CG 1	750	0.002120	0.77
CG 2	800	0.002030	0.80
CG 3	677	0.000210	0.92
CG 4	725	0.000200	1.20

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CG 5	784	0.000273	1.16
CG 6	399	0.000841	1.18
CG 7	550	0.000040	1.20
CG 8	600	0.000817	1.30
CG 9	350	0.000170	1.39
CG 10	500	0.000200	1.81
CG 11	550	0.000500	2.40

B. Effects of Slenderness Ratio

The variation of displacement with that of the no of layers was plotted for all the specimens as shown in Fig 6. From the displacement vs no of layers it is observed that the increasing displacement with increase in slenderness ratio.

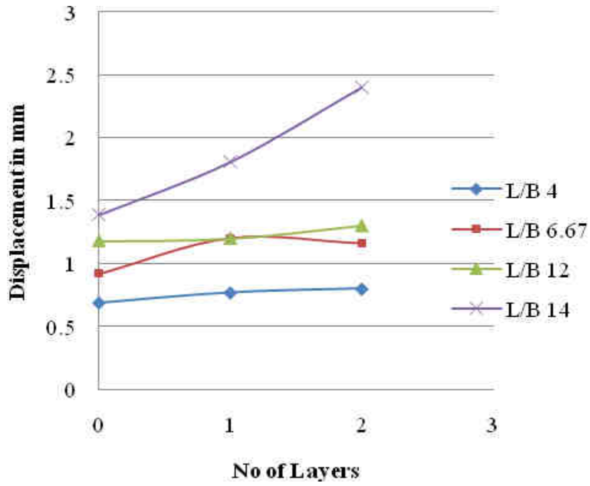

Fig.6 Displacement vs No of Layers

The slenderness ratio 14 has higher displacement compared to slenderness ratio 4 and other specimen.

C. Behavior of No of Layers vs Axial Strain

The behavior of No of Layers vs Axial Strain for specimens are as shown in fig 7.

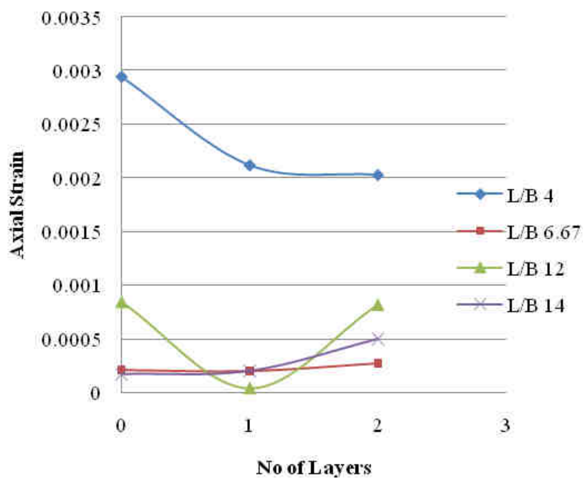

Fig 7 Axial Load vs No of Layers

D. Comparison of Compressive Strength

From the graphs shown in the Figures 8 it is found that due to the high tensile strength of the FRP confinement, the compressive strength of aspect ratio of column specimen 2.53 is increased by 7.15% (one layer) & 14.30% (Two layers) when compared with unconfined specimen. And also the compressive strength of aspect ratio of column specimen 2.1 is increased by 40.37% (one layer) & 53.78% (Two layers) when compared with unconfined specimen.

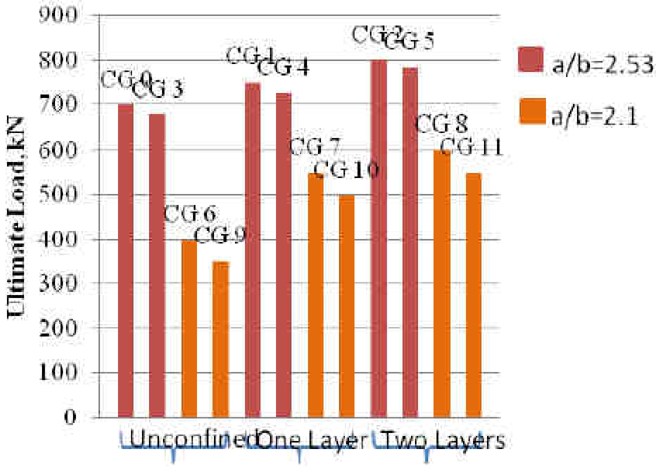

Fig.8 Comparison of Compressive Strength

IV. CONCLUSION

This research was aimed to propose and to investigate the new strengthening technique of strip pattern for FRP confinement of capsule shaped RC columns with different slenderness ratio and aspect ratios. The following conclusions can be drawn from the test results.

The wrapping of FRP has increased the compressive strength compared to the specimen without wrapping. The compressive strength of column specimen CG 2 is increased by 14.29% when compared with unconfined specimen CG 0 and the maximum strain was reached 0.00203 at the axial load of 800kN. The compressive strength of column specimen CG 5 is increased by 15.80% when compared with unconfined specimen CG 3 and the maximum strain was reached 0.000273 at the axial load of 784kN. The compressive strength of column specimen CG 8 is increased by 50.40% when compared with unconfined specimen CG 6 and the maximum strain was reached 0.000817 at the axial load of 600kN. The compressive strength of column specimen CG 11 is increased by 57.17% when compared with unconfined specimen CG 9 and the maximum strain is reached 0.0005 at the axial load of 550kN.

The FRP wrapping containing Glass and Carbon absorbs more strength than the unconfined specimens involved in this research. The wrapping procedure adopts capsule shaped columns because in the case a rectangular shaped column wraps rupturing in the circumferential direction [2]. There is enough literature available to justify the fact that rectangular shaped columns have damaged the column in the previous research studies. The capsule shaped column wrapping avoided stress concentration in corners and reduce the cost of the FRP materials involved in stripping the column.

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