EXPERIMENTAL INVESTIGATION ON RCC LONG HOLLOW CIRCULAR COLUMNS WITH FRP JACKETING

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***Abstract* -** In practice, most of the research studies are done in solid RCC columns. We tried to have a research study on hollow RCC circular columns. Since RCC hollow circular columns are economical and strength behavior is fine when compared with solid columns in case of bridge piers and massive concrete structures, reducing the usage of cement also an ecofriendly activity. From the past earthquakes, one of the most affected components of buildings is RCC Columns and also most of the damages are occurred in Piers. Nowadays hollow RCC column are also provided in the bridge structures. Hollow sections are used to reduce seismic masses, based on economic considerations the cost saving is associated with reduced material and design moments compared with increased construction complexity, and hence increased labor costs. Here in our project work, M20 concrete mix was used. After 28 days curing the columns were tested for compression test and the results were obtained. Confinement or Jacketing is one of the most frequently used techniques to strengthen reinforced hollow concrete columns. The study focus on the circular section of concrete hollow column strengthened with the confinement technique –External FRP winding. The study has been carried out for maximum load carrying capacity of columns.

The conventional RCC hollow Columns and confined hollow columns were tested under axial compression. The load deflection behavior, load carrying capacity of the columns has been studied. The load carrying capacity of confined RC Column is compared with conventional RC Columns.

Chapter-I

Introduction

Concrete is the most frequently used material in the construction material worldwide. High elevation bridges with very large size columns are constructed to accommodate high moment and shear demands. In particular, bridge piers designed in accordance with old design codes may suffer severe damage during seismic events, caused by insufficient shear or flexural strength, low ductility and inadequate reinforcement anchorage. Many parameters may influence the overall hollow column response such as: the shape of the section, the amount of the longitudinal and transverse reinforcement, the cross section thickness, the axial load ratio and finally the material strength of concrete and reinforcement.

This paper focuses on circular long hollow cross sections and investigates the columns behavior under a state of compression with frp composites. The experimental results have been compared with solid sections on the behavior of the hollow column strength of concrete M20 grade concrete mix designed as per I.S. 10262-1982 method.

The reinforced polymer (FRP) composite consists of reinforcing fibres embedded in a polymer matrix. The matrix may be polyester, vinyl ester or epoxy. The reinforcing fibres are generally carbon, glass or aramid. The fibres can be used in a variety of forms much as medium chopped strands, woven roving's and continuous roving's.

Other applications of FRP composites were confined either to aerospace and automotive industries or to marine enterprises. Construction uses were generally non-structural; renewal of civil engineering infrastructure has received considerable attention over the recent few years throughout the world. The civil engineers have been encouraged to replace ways and means of strengthening and upgrading existing civil engineering infrastructure to cater for changes in use and general deterioration. The search over years for an innovative solution triggered the development of FRP composites for the purpose. The beneficial attributes of FRP composites include high length–to-weight ratio, immunity to corrosion, grater case in site handling, reduction in minor costs, elimination of the need of scaffolding, large deformation capacity, minimum changes in geometrical dimensions, minimum interruption to existing services and availability of FRP in different sizes, geometry and dimensions.

Objective

- To find the behavior of ordinary RCC hollow column and columns confined with external FRP jacketing.
- To find the load carrying capacity, the buckling characteristics, the failure Pattern, compare the load carrying capacity, energy absorption of confined columns.

Chapter –II

Materials and Mix

- Concrete Type: Normal M20 strength Reinforced Concrete with Ordinary Portland cement, coarse aggregate of crushed rock with a maximum size of 12 mm, fine aggregate of clean river sand and portable water. HYSD bars of 8 mm dia were used as main reinforcement. HYSD bars of 8 mm dia were used as stirrups. Commercial available binding wires are used as steel fibres.
- Reinforced Cement Concrete Solid and Hollow Column
    - Outer size of column = 150 mm
    - Inner size of column = 90 mm
    - Height of column = 1200 mm
    - Reinforcement rods = 6 nos of 8 mm dia
    - Stirrups = 8 mm dia at 150mm C/C
    - Cover = 25 mm
    - Concrete mix = Grade M20

Chapter-III

Experimental program

The concrete mixes have been prepared as per the nominal mix 1:1 ½:3. The super plasticizer dosage of 1% by weight of binder is used.. The workability of fresh concrete has been determined by conducting the Slump test. The strength of hardened concrete has been determined by conducting Compression test on hollow circular cylinders at 28 days. The results are presented in the following articles.

Each specimen was tested under axial compression using hydraulic jack in the Structural Engineering Laboratory. The column of the test assembly was placed in a loading place. The column was centered accurately using plumb bob to avoid eccentricity. The bottom end was placed in the frictionless surface. In top of column mild steel plate was fixed. It’s used for applying axial load for column and also avoids the movement of column. To avoid local failure, the top and bottom side of the columns, steel caps were used. Dial gauge was used to measure the axial displacement. Two Dial gauges were used to measure the lateral displacements in the column at a distance of half height of the column.

Figure 1: Casting Process

TEST PROCEDURE

The column was loaded under constant compressive load by hydraulic jack at bottom of the column. The capacity of the hydraulic jack is 500 KN. The corresponding axial deflections, lateral deflections were measured by dial gauges. The arrangements are shown in Fig.

INSTRUMENT FOR MEASURING DEFLECTION

Dial gauge was used for measuring axial deflection at center point of the specimen. The position of dial gauge to measure the defection at the center point is shown in Fig. Dial gauge of least count 0.01mm was used to measure the lateral displacement in column at a distance of half the height of column.

LOAD MEASURMENTS

The increasing load was measured in a hydraulic jack available at the laboratory. The capacity of the machine is 500 KN. To avoid local stress failure, bearing plate of 15mm thickness was provided at the point of loading and bottom face of the specimen

Figure 2: Test Setup (Dial gauges)

Figure 3: Test Setup (Compresso Meter)

Chapter-IV

BEHAVIOUR AND MODE OF FAILURE

The Conventional RC Column was subjected to axial load expose the behavior of the column specimen. The failure pattern of Conventional RC Column is shown in figure. As the load increases the crack width is also increased. The concrete was crushed and spalling down.

Figure 4: Failure pattern for Conventional Column

Figure 5: Failure pattern for Solid Column

Figure 6: Failure pattern for Hollow FRP Column

Table1: Experimental Results of Conventional Solid RCC Column

Axial Load(KN)	Axial Deflection in concrete(mm)	Lateral Deflection concrete(mm)	Axial Deflection in steel(mm)
0	0	0	0
10	0.26	0.12	0
40	0.42	0.22	0
60	0.68	0.33	0
80	1.02	0.46	0
100	1.30	0.62	0
120	1.52	0.84	0
140	1.65	1.01	0.01
160	1.84	1.22	0.02
180	2.02	1.36	0.03
200	2.36	1.48	0.04
2200	2.57	1.65	0.06
240	2.88	1.80	0.08
260	3.14	2.05	0.10

LOADING AND LOAD DEFLECTION BEHAVIOUR

Experimental Results of Conventional Solid RCC Column

The consideration of the loading condition up to failure load of the specimen, that load is called as Ultimate Load of the specimen. The deflection (axial and lateral) reading was taken up to 260KN of each specimen. The average values of two specimen's deflection (axial and lateral) were taken into account. The load versus axial deformation diagram was presented in Figure.

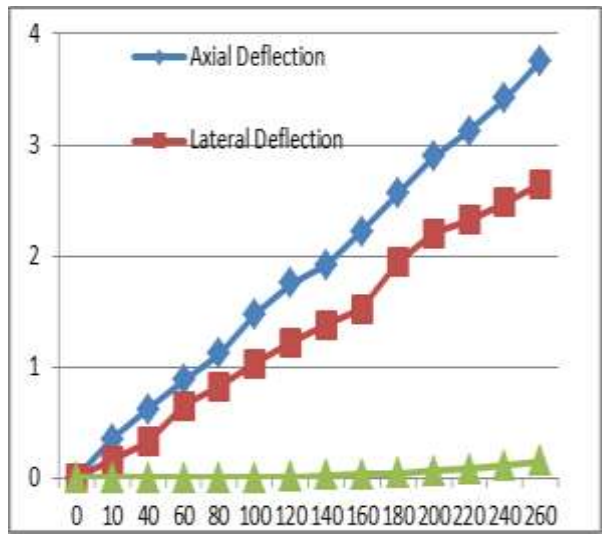

Figure 7: Load and Deflection Behavior of Solid RCC Column

Experimental Results of Conventional Hollow RCC Column

The deflection (axial and lateral) reading was taken up to 260 KN of each specimen. The average values of two specimen's deflection (axial and lateral) were taken into account. The load versus axial deformation diagram was presented in fig. The load versus lateral deflection diagram was presented in figure.

Table 2: Experimental Results of Conventional Hollow RCC Column

Axial Load (KN)	Axial Deflection in concrete(mm)	Lateral Deflection concrete (mm)	Axial Deflection in steel(mm)
0	0	0	0
10	0.35	0.16	0
40	0.62	0.32	0
60	0.88	0.65	0
80	1.12	0.82	0
100	1.47	1.03	0
120	1.75	1.22	0.01
140	1.92	1.38	0.02
160	2.22	1.52	0.03
180	2.56	1.94	0.04
200	2.89	2.20	0.06
220	3.12	2.32	0.08
240	3.42	2.48	0.11
260	3.76	2.65	0.15

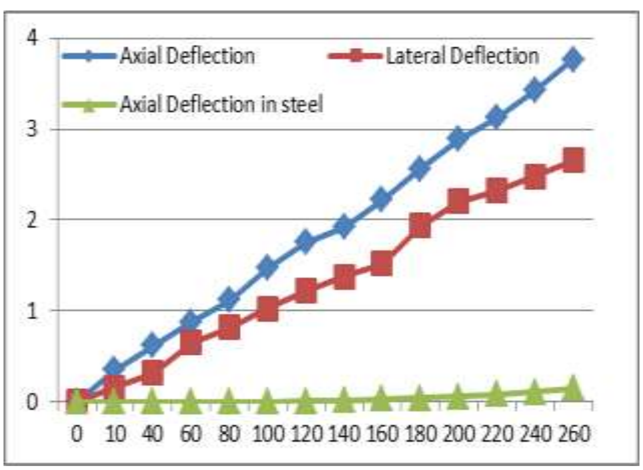

Figure 8: Load and Deflection Behavior of Hollow RCC Column

Experimental Results of Conventional Hollow RCC Column confined with External FRP Jacketing

Table3: Experimental Results of Conventional Hollow RCC Column confined with External FRP Jacketing

Axial Load (KN)	Axial Deflection in concrete (mm)	Lateral Deflection concrete (mm)	Axial Deflection in steel(mm)
0	0	0	0
20	0.22	0.08	0
40	0.32	0.14	0
60	0.46	0.26	0
80	0.54	0.32	0
100	0.72	0.46	0
120	1.02	0.62	0.01
140	1.22	0.71	0.02
160	1.48	0.92	0.03
180	1.72	1.02	0.04
200	1.98	1.19	0.06
220	2.24	1.24	0.08
240	2.42	1.31	0.11
260	2.65	1.48	0.15

The deflection (axial and lateral) reading was taken up to 260 KN of each specimen. The average values of two specimen's deflection (axial and lateral) were taken into account. The load versus axial deformation diagram was presented in Figure. The load versus lateral deflection diagram was presented in Figure.

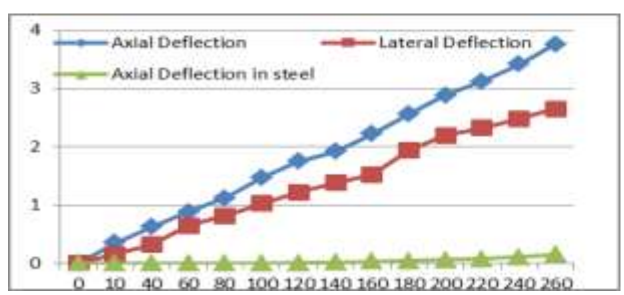

Figure 9: Load and Deflection Behavior of Conventional Hollow RCC Column confined with External FRP Jacketing

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COMPARISON OF TEST RESULTS AXIAL LOAD VS AXIAL DEFORMATION OF COLUMNS

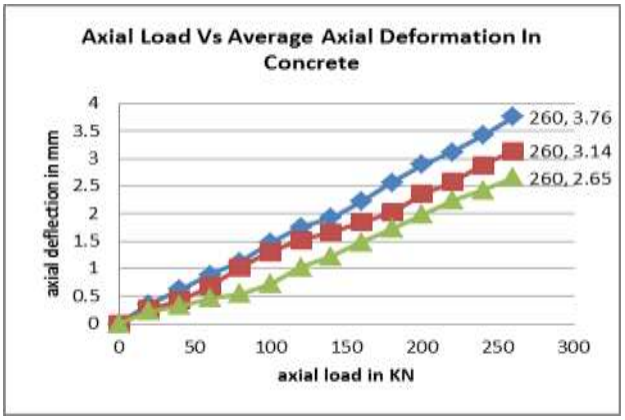

Figure 10: Axial Load Vs Average Axial Deformation in Concrete

AXIAL LOAD VS LATERAL DEFORMATION OF COLUMNS

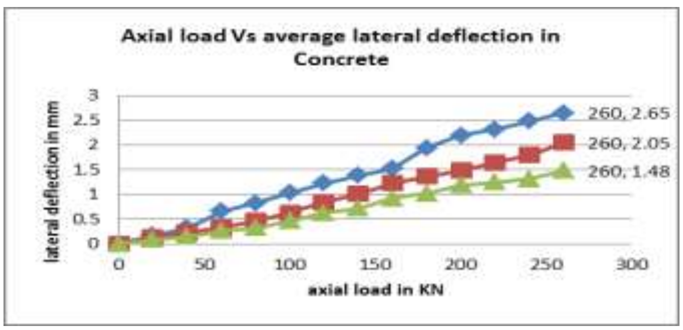

Figure 11: Axial load Vs average lateral deflection in Concrete

AXIAL LOAD Vs AXIAL DEFORMATION OF STEEL

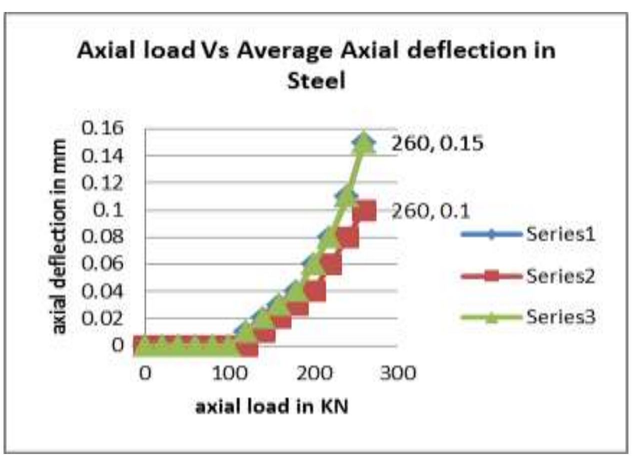

Figure 12: Axial load Vs Average Axial deflection in Steel

Ultimate Loads for All Types Of Column (Specimen Height 1200mm)

Serial No	Description	Ultimate Load in KN
1	Conventional RCC solid Column	350
2	Conventional RCC hollow Column	395
3	Conventional Column confined with External FRP jacketing	435

Average Axial Deflection for an Axial Load of 260KN (Specimen Height 1200mm)

Serial No	Description	Axial Deflection at 260KN (mm)
1	Conventional RCC solid Column	3.76
2	Conventional RCC hollow Column	3.14
3	Conventional Column confined with External FRP jacketing	2.65

Average Lateral Deflection in Concrete for an Axial Load of 260KN (Specimen Height 1200mm)

Serial No	Description	Lateral Deflection in concrete at 260KN(mm)
1	Conventional Column	2.65
2	Conventional RCC hollow Column	2.05
3	Conventional Column confined with External FRP jacketing	1.48

Average Axial Deflection in Steel for an Axial Load of 260KN (Specimen Height 1200mm)

Serial No	Description	Axial Deflection in Steel at 260KN (mm)
1	Conventional Column	0.15
2	Conventional RCC hollow Column	0.10
3	Conventional Column confined with External FRP jacketing	0.15

Chapter- V

Conclusions

- Ultimate load carrying capacity of the conventional RCC columns without confinement confirms to theoretical value.
- By confining with FRP Jacketing the load carrying capacity is increased by 35% compared to conventional RCC columns.
- The initial portion of the load-deflection curve of the conventional column is almost same for confined columns and FRP wounded columns. The later portion of the load-deflection curve of the conventional column clearly shows the effect of confinement.
- Compared to Hollow RCC conventional columns with FRP winding are increased in strength, durability, and also increased in ductility.

Chapter –VI

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