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Experimental behaviour of FRC Composite Columns

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Abstract: In composite construction the initial construction loads including the self-weight of the structure are supported by the bare steel sections. Later concrete is casted around or filled inside the steel section. The steel and concrete are combined in such a way that advantages of both the materials are effectively utilized. Higher strength and lighter weight enables the use of steel in smaller and lighter foundations. The subsequent concrete addition enables the building frame to limit the sway and lateral deflections. The objective of this study is to optimize the reinforcement in circular columns based on buckling. In this study the buckling behaviour of a circular column under axial load is examined. A loading platform is created and a concentrated axial load is applied to a conventional circular column so as to measure the buckling. Later same procedure follows with another sample of column in which reinforcement bars are replaced by a hollow GI pipe. Buckling is measured under the same axial load and these values are compared with the conventional method. Experiment is repeated by adding steel fibres for better results.

Keywords: Composite columns, Buckling, Conventional column, New material model, Hollow GI pipe, Stel fibres.

I. INTRODUCTION

A composite material in construction is nothing but the combination of both steel and concrete. There is a huge hike observed in the development of construction industry due to the impact of composite materials. In composite construction, the self-weight of the structure and all the initial construction loads are supported by the bare steel sections. Later concrete is casted around or poured inside the steel section. Steel and concrete are so combined in such a way advantages and abilities of both the materials are effectively utilized. Higher strength and lighter weight enables the use of steel in smaller all type of foundations. Lateral deflections and sway conditions are limited in building frames by subsequent addition of concrete.

In reinforced concrete columns subjected to seismic loads, failure is often initiated by buckling of the longitudinal bars. For a reliable solution of the nonlinear response of structures, a proper material model for replacing reinforcing bars with the effects of buckling is essential. The main objective of this study is to optimize the reinforcement in circular columns based on buckling.

Buckling can be defined as the sudden large deformation or sideways failure of a structure due to variation or increase in the existing load under which the structure had showed little, if any, deflection before the load was increased. In this study the buckling behaviour of a circular column under axial load is examined.

The optimization of reinforcement is to be done by replacing the reinforcement area by a hollow GI pipe. The buckling of columns with reinforcement and with hollow GI pipe is measured. Later the steel pipe is to be made hollow by partially removing the concrete inside the steel pipe. Again buckling value is compared with conventional technics.

Steel fibers were added along with the GI pipe and experiment was repeated for more relevant results and these values were discussed with conventional method. Performance and stability of columns were discussed.

II. METHODOLOGY

Selection of Columns

A. Conventional Circular Column

This is the normal circular columns recently used in construction. These columns are constructed by means of concrete and rebars. In this study the new material model introduced for replacing rebars are compared with the conventional circular column. Conventional column were casted by using M25 grade concrete and 6mm diameter rebars which is 1.17mm long. A clear cover of 15mm was provided at each end.

Rebars are connected each other at an equidistance of 45mm by using steel wires. Later it was kept inside the PVC pipe for casting. Cement,coarse aggregate and fine aggregates are mixed with water at 1:1:2 proportion for the preperation of concrete. Concrete was poured inside the PVC pipe and each layer is compacted with tamping rod. Later PVC pipe was removed and column was cured for 28 days before testing. Later PVC pipe was removed and column was cured for 28 days before testing

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Figure 1.Reinforcement arranged inside PVC pipe

B. Circular Column in which Rebars Replaced by Hollow GI Pipe

It was the new material model introduced in this study. Column was casted by using fresh concrete and a hollow GI pipe instead of rebars. GI pipe was adopted because of the easiness in availability and lesser cost compared to other forms of steel pipes. Corrugated GI pipes were chosen for better bonding of pipe and steel. Concrete was prepared with the same proportion of the conventional column. GI pipe was kept inside the PVC pipe and concrete is poured in between both the pipes. Inside portion of the GI pipe was kept empty. Each layer was compacted by using a tamping rod. Later PVC pipe was removed and cured for 28 days before testing.

Figure 2. Column concreting using Hollow GI pipe

C. Circular Column in which Rebars Replaced by Hollow GI Pipe with Addition of Steel Fibers

Steel fibres were added along with hollow GI pipe for better performance of the column.

Figure 3. Cincrete mixed with steel fibres

A minimum 0.75 percentage of total volume of concrete of fibre was added while concreting as per mix design. Hook end type fibres were used with 0.5mm x 50mm dimension. Column was cured for 28 days before testing and results were discussed.

III.EXPERIMENTAL INVESTIGATION

Loading platform

Circular columns were 1.2m long as it cannot be fit inside the UTM machine for the buckling measurement. Hence a loading platform was created by using ISMB300 sections with a clear distance of 1.5m. Load was applied by means of hydraulic jack and proper provisions for fixing the circular column were installed. Provision for fixing extensometer for measuring buckling were installed in the loading platform Columns were fixed inside platform and buckling of column were measured with the help of extensometer and total station.

Figure 4 Loading platform

Experimental Program

Both the columns were cured for 28 days before testing. Conventional column was tested initially and the buckling behaviour is compared with the new material model. Conventional column was fixed over the column shoe and a maximum of 300 KN was applied over the specimen until it fails. Buckling can be occur at any side of the column, Hence with the help of two extensometer and two total station buckling was measured. After fixing total stations and extensometer properly load gradually applied. Column started to buckle after certain time and it was measured in extensometer and total station. Load was applied till it fails and both failure load and maximum buckling was noted. After the failure of conventional column, the new material model or the circular column with rebars replaced with hollow GI pipe was kept over the loading platform. Again a maximum of 300KN was applied over the specimen until it fails. Similar to conventional column the buckling measurement was taken with the help of extensometer and total station.

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Figure 5. Extensometer connected over concrete column

Later Circular column with addition of steel fibres along with GI pipe was kept under the loading platform and buckling was measured by using the same technique that used for other columns. Readings were noted and the performance of the column were analysed.

IV. RESULTS AND DISCUSSION

Load Vs Buckling

A graph was plotted between Load and buckling for each columns. Both the failure load and maximum buckling was noted from the graph. Failure load corresponding to the maximum buckling is called as critical load.

A. Conventional Circular Column

Conventional column were casted by using M25 grade concrete and 6mm diameter rebars which is 1.17mm long. Clear covers of 15mm were provided at each end.

Table 2 Buckling of circular column with bar reinforcement

Load (KN)	Buckling(mm)
10	0.375
20	0.525
30	0.735
40	0.915
50	1.14
60	1.275
70	1.47
80	1.95
90	2.31
100	2.58
110	2.7
120	3

Buckling of the column with bar reinforcement with respect to load is given in table6.1.1 and graph is shown in fig6.1.1.1. There was a gradual increase in the buckling according to the load applied. A maximum buckling of 3mm was measured with a failure load of 120KN.

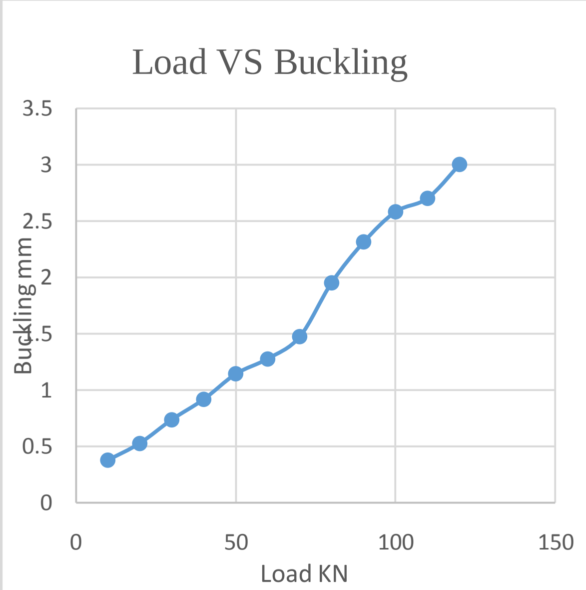

Figure 7 Load Vs Buckling graph of circular column with bar reinforcement

B. Circular Column in which Rebars Replaced by Hollow GI Pipe

The new material model or the circular column with rebars replaced with hollow GI pipe was kept over the loading platform. Again a maximum of 300KN was applied over the specimen until it fails. Similar to conventional column the buckling measurement was taken with the help of extensometer and total station.

Table 3 Buckling of circular column with with reinforcement replaced by hollow GI pipe

Load (KN)	Buckling(mm)
10	1.5
20	2.19
30	2.775
40	3
50	3.375
60	3.57
70	3.75
80	3.93
90	4.23
100	4.455
110	4.5
120	4.65
130	4.725
140	4.8

Buckling of the column with hollow GI pipe is given in table 6.1.2 and graph is shown in figure6.1.2.1. There was a gradual increase in the buckling according to the load applied. A maximum buckling of 4.8mm was measured with a failure load of 140 KN.

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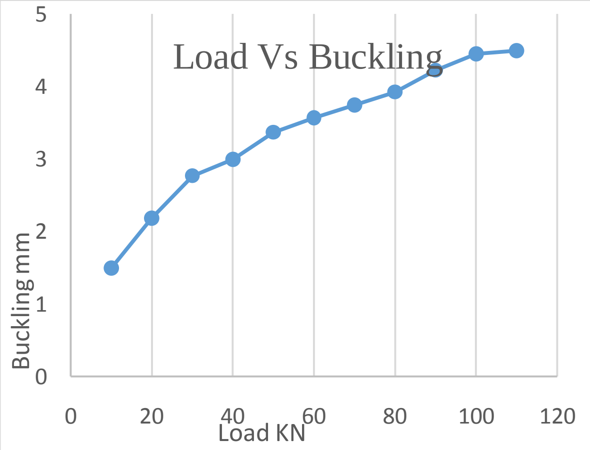

Figure 8 Load Vs Buckling graph of circular column in with GI pipe

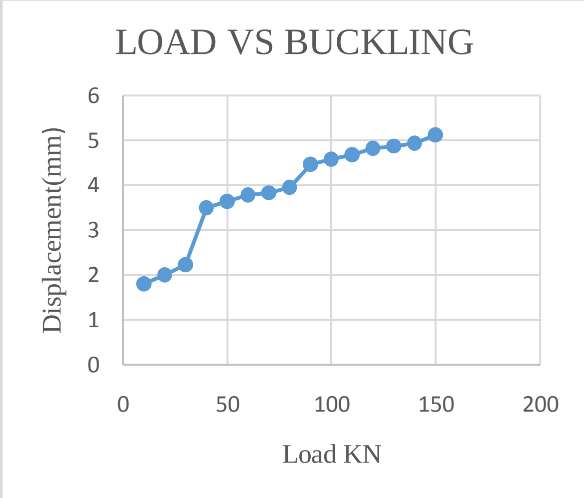

Figure 9. Load Vs Buckling graph of FRC column with hollow GI pipe

C. FRC Circular Column in which Rebars Replaced by Hollow GI Pipe

In this study Hooked type steel fibres are used with a dimension of .5mm x 50mm. Structural behaviour of steel reinforced concrete affects the modulus of repture, compressive strength and also compressive strength and tensile strength during fire conditions or at higher temperature conditions. Introduction of the new material model shows better buckling properties although addition of steel fibres along with the hollow GI pipe shows more structural rigidity.

Table 6.1.3 Buckling of FRC column with reinforcement replaced by hollow GI pipe

Load (KN)	Displacement (mm)
10	1.8
20	2
30	2.23
40	3.5
50	3.64
60	3.78
70	3.83
80	3.95
90	4.46
100	4.58
110	4.68
120	4.82
130	4.87
140	4.93
150	5.12

There was a gradual increase in the buckling according to the load applied. A maximum buckling of 5.12mm was measured with a failure load of 150 KN.

Comparison of all The Circular Concrete Columns

While comparing the test results of all the three columns, there is a drastic difference in performance. Figure 6.2.1 shows the comparison of all the columns. Blue curve denotes the conventional circular column. Red curve denotes the new material model without steel fibres and the last one green cure denotes the new material model with addition of steel fibres.

The new material model with addition of steel fibre showed better improvements in sustainability and performance. A maximum buckling of 5.12mm was measured with a failure load of 150 KN.Circular column with hollow GI pipe without steel fibres showed almost similar performance compared to the fibre reinforced concrete column. A maximum buckling of 4.8mm was measured with a failure load of 140 KN.A maximum buckling of 3mm was measured with a failure load of 120KN in conventional concrete column which indicates the new material model introduced was far better compared to conventional circular column.

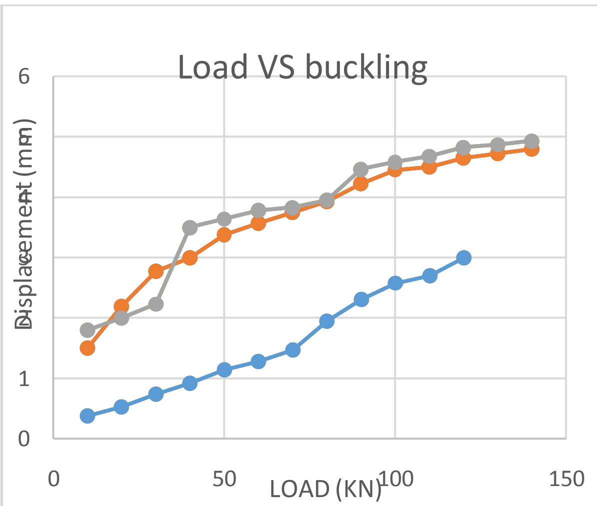

Figure 10. Comparison of all the columns

V. CONCLUSION

From the results obtained from both tests, it can be concluded that:

In conventional column a maximum buckling of 3mm was measured with a failure load of 120KN although in column with hollow GI pipe shows a maximum buckling of 4.8mm with a failure load of 140KN

The addition of steel fibers in concrete improves the mechanical properties of concrete such as tension, toughness and aslo structural rigidity. From the results a maximum buckling of 5.12mm was measured with a failure load of 150 KN.

Comparing the buckling behaviour of all the three columns it's observed that the column with hollow steel pipe shows more sustainability and structural rigidity compared to the conventional column and also economical in nature.

Addition of steel fibres enhances the properties of the new material model with maximum load carrying capacity and durability.

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