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BEHAVIOR OF HIGH STRENGTH REINFORCED CONCRETE SLENDER COLUMN UNDER BIAXIAL LOADING

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ABSTRACT

This paper aims at providing a brief experimental study and the behaviour of the bi-axially loaded reinforced concrete slender column with different percentages of longitudinal reinforcement ratio with biaxial loading and studies were carried out on the mechanical properties of concrete and to investigate the parameters for the reinforced concrete slender column. By the witnessing, the displacement happens at the centre of the column and to spotting out the location of the cracks and type of the crack occurred over the surface of the column. Totally four columns were tested with dimensions 2200x150x150 mm for testing of the bi-axially loaded column with eccentricities like 150mm and 300mm. All columns were tested under constant axially and bi-axially loaded conditions. In this paper, experimental results are presented and global behaviour of tested columns is discussed, particularly focused on the deflection, stiffness and ultimate loads because of the increasing the eccentricity.

Keywords: bi-axially loaded, slender column, deflection, stiffness, eccentricity.

1. INTRODUCTION

Columns are key structural elements for the seismic behavior of building. There special importance should be given to their structural response under load reversals. More ever earth quake effects generally required the inclusion of two horizontal components that are recognized more damaging than the both two direction actions. The interest in the inelastic response of axially loaded members under biaxial bending histories is relatively recent and the available experiments results are limited. This is possibly due to in part of the uncertainty of combining histories of bending moments in the two perpendicular directions, adding considerable applications to the problem. The practical experimental results shows that of the in elastic behavior of the reinforced concrete (RC) columns under biaxial cyclic moments is much behind than our understanding of the behavior under biaxial cyclic bending with axial load. Normally eccentricity loaded columns will fail to buckling. The eccentric load is one that applied away from the centroid axis of the cross section of the columns. Such load will apply bending in addition to the columns will cause that is resulting deflection shape. Normally it can be seen that one side of the column receives more compression than another. The column cross section will have the compressive stress, as long as the applied load remains within the central axis of the cross section of the section. When the applied load moves out of the core, tensile stresses are introduced. As the eccentricity increases, the extent of the bending moment that the section must also increases. The infinite eccentricity is an extreme case, resulting in the pure bending moment stress prism. For the sizing of the column, the awareness of the magnitude and distribution of the internal stress is very much important. In the case of the biaxial column loaded experiments are done under the effect of eccentrically loaded column.

Objective

To experimental study and behavior of bi-axially loaded reinforced concrete slender column with different percentages of longitudinal reinforcement.

Scope

a) Studies on the mechanical properties of concrete such as compressive strength, split tensile strength and modulus of elasticity.

b) Scope of work is to evaluate the effect of testing parameters on the strength of bi-axially loaded RC slender column

c) Parameters to be investigated:

d) Loadcarrying capacity at different percentage of longitudinal reinforcement with bi-axially loading.

e) Displacement at center.

f) Location& Type of the crack.

2. MATERIAL USED

Materials used in the experimental work are tested for their properties and the details are furnished. Raw materials listed below are used for preparing of the specimens; ordinary Portland cement (OPC) 53 grade, coarse aggregate with 20mm maximum size, Fine Aggregate as per Indian standards and results shown in Table-1.

Table-1. Mechanical Properties.

S. No.	Mechanical properties of dement	Experimental results
1	Fineness of Cement	9%
2	Specific gravity of fine aggregate	2.65
3	Specific gravity of coarse aggregate	2.70
4	Specific gravity of cement	3.15
5	Initial setting time	92 min
6	Standard consistency	29%

2.1 Concrete mix proportion

M50 grade concrete has been used for the casting of specimens. The method proposed in IS 10262-2009 used for the mix design and the mix proportion have given in Table-2.

Table-2. Mix proportion.

Mix	Cement (kg)	Fine aggregates(kg)	Coarse aggregates (kg)	Water content
M50	478.85	627	1188	0.35

3. MAKING OF COLUMN TESTING FRAME

Hence in order to apply uniaxial/biaxial a self - straining loading frame of 25 Tons capacityunder biaxial load for column testing has been conceptualized, fabricated and erected. The basic configuration of the loading frame consists of seven vertical steel box sections with two hexagonal shape box beam sections with two hexagonal shape box beam sections including cross beams is fixed rigidly to the top and bottom of the vertical members. The horizontal platform by the steel plate of 12mm thick is welded in the both top and bottom at the inner side of the frame and the applied loading point at the cross section of the column under biaxial loading. The maintenance department of SRM University has been carried out Fabrication and erection.

Test setup for RC column under eccentrically loading

The test program consists of casting and testing of four columns, all having size of 2200X150X1550mm length and designed as slender column with two different reinforcement is 4number of 12mm diameter and 4number of 12mm diameter rod as longitudinal reinforcement. The column was casting using M50 grade concrete and Fe415 grade steel. OPC cement, Fine aggregates and the coarse aggregates of maximum size 20mm were used. High yield strength deformed (HYSD) bars of 12mm and 8 mm diameter were used as the longitudinal reinforcement. After 28 days curing specimen were tested in UTM to determining the compressive strength, split tension strength. The column was tested under biaxial bending with different eccentricity and details shown in Table-3 from Centre gravity of column. Test setup shown in Figure-1 and Figure-2 shows the reinforcement detail of Bi-axial frame.

Table-3. Details of eccentrically loaded column.

Specimen details	Longitudinal reinforcement		Eccentricity in mm
	Steel details	Ratio	
Central Axial loading	6Number of 12mm Diameter	μ = 3.01%	0
C1			300mm(2d)
C2			150mm(d)
C3	4Number of 12mm Diameter	μ = 2.01%	300mm(2d)
C4			150mm(d)

Figure-1. Test setup for column biaxial and eccentrically loading.

Figure-2. Reinforcement detail for column.

4. RESULT AND DISCUSSIONS

4.1 Compressive strength

The result of compressive strength obtained for M50 grade concrete by conducting compressive test on all specimens and the results are presented in Table-4the comparison of compressive strength for 7,14 and 28 days.

Table-4. Average compressive strength for M50 grade concrete cube after 7,14 and 28 days curing.

S. No.	Ages (Days)	Average Compressive strength of concrete cube (N/mm^2)
1	7	22.04
2	14	38.93
3	28	51.2

4.2 Split tensile strength

The result of split tensile test obtained for M50 grade concrete by conducting test on all specimens and the results are presented in Table 5 the compression of split tensile test for 7, 14 and 28 days.

Table-5. Split tensile strength 7, 14 and 28 days curing.

S. No.	Ages,(Days)	Average Spilt tensile strength(N/mm^2)
1	7	3.07
2	14	4.32
3	28	8.016

5. RESULTS FOR RC SLENDER COLUMN UNDER ECCENTRICAL LOADING

The test specimen was a square reinforced concrete slender column. The overall height of the test specimen was 2200 mm. All specimens were subjected to eccentric loading. All specimens were subjected to eccentric loading in which the eccentricity like depth, and two times of depth (D, 2D). To apply the eccentric loading, rigid lower and upper steel plates were used. The specimen's cross section was 150x150mm. The longitudinal steel reinforcement consisted of four normal mild steel bars either 4number of 12diameter bars, 6number of12 diameter bars to account for the test variable of the ratio of the longitudinal steel bars "μ" which corresponding to steel reinforcement ratios of about 3.01%,2.01% respectively. The load displacement, stiffness and modulus of elasticity were studied and the graph is plotted and details of the specimen.

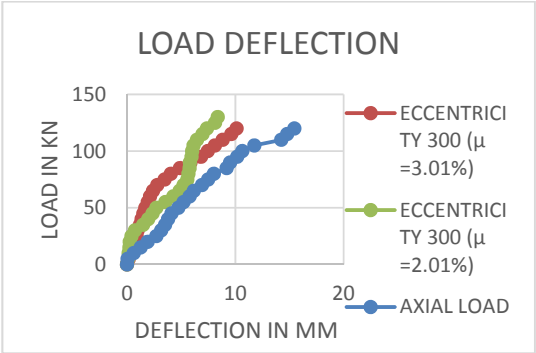


Figure-3. Load deflection curve for the specimen with different eccentric loading300mm and different longitudinal reinforcement.

In Figure-3 load deflection curve. In the plotted graph which represents the types C1, C3 for the eccentricity of 300mm as 6 number and 4 number of 12 mm diameter bars shows the values for the maximum deflections are 10.12mm for the C1 type and the 8.39 for the C3 typeas shown in Figure-3 following Figure-4 C2,C4 for the eccentricity of 150mm as 4number and 6 number of 12 mm diameter bars gives higher deflection values while comparing to C1, C3. The values for the maximum deflections 20.21mm for the C4 type and 10.36mm for C2 type which are shown in Figure-4.

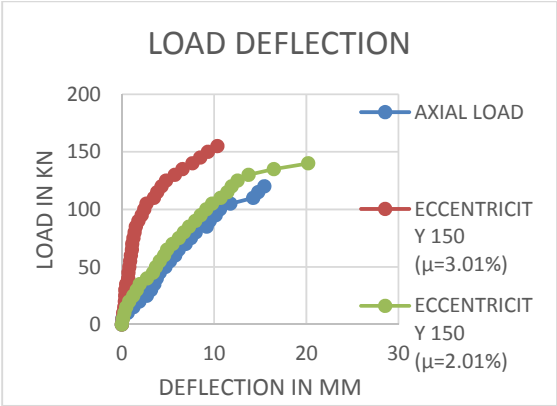


Figure-4. Load deflection curve for the specimen with eccentricity 150 mm.

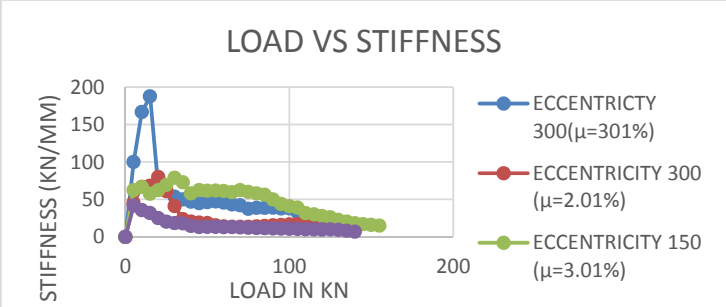


Figure-5. Load stiffness curve for the specimen with different eccentric loadingand different longitudinal reinforcement.

In Figure-4 load vs stiffness curve for bi-axially loaded column the highest value is 187.5kn/mm respectively. In plotted graph which represents the types C1,C3 for the eccentricity of 300 mm as 4number and 6 number of 12 mm diameter bars shows higher values. The values for the high stiffness are namely 80 for the C3 type and 187.5 for the C1 type for the following C2,C4 for the eccentricity of 150mm as 4 number and 6 number of 12mm diameter bars gives less stiffness values while comparing the C2,C4. The values for the maximum stiffness are 66.67KN/mm for C2 type and 41.67KN/mm for C4 type.

Ultimate load for biaxial specimen

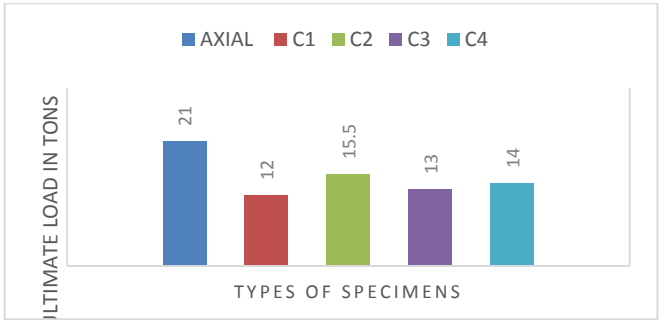
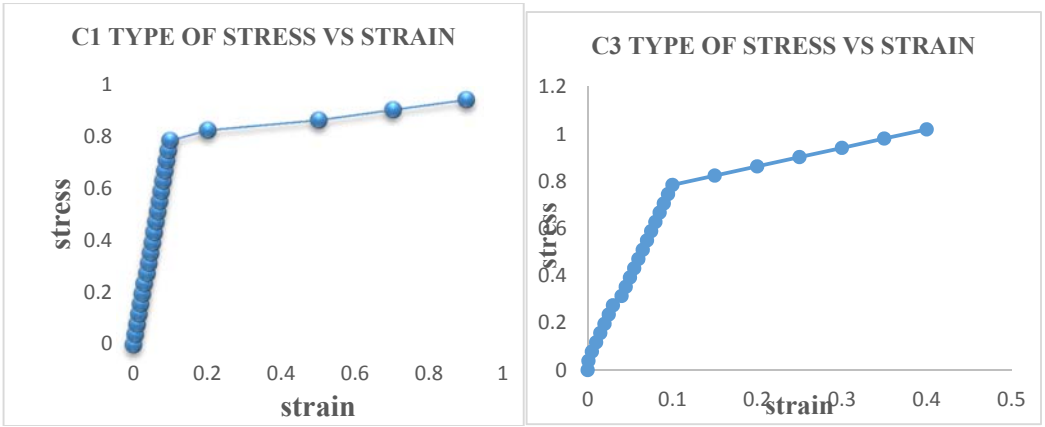


Figure-6. ultimate loads for the specimen with different eccentric loading and longitudinal reinforcement.

From the Figure-6 shown the ultimate loads of the columns was given shown in the Figure-6. The prepared specimen of the columns were casted are cured for 28 days after testing the specimens to performing the ultimate loads of the biaxialcolumn. First column axial load is 21 ton and comparing other the biaxial specimens C1 and C3 was casted reinforcement are the same 6 number of 12 mm diameter and tested the eccentricity 300 mm and getting ultimate load is C1 type is 12 and C3 type is 13 is respectively another two columns were casting the reinforcement with 4 number of 12mm diameter of C2 and C4 for the getting the ultimate loads are 15.5 for C2 type and C4 type is 14 tons respectively.

6. MODULUS OF ELASTICITY

The modulus of the elasticity as shown in the Figure-7 the graph indicate the comparison between the stress and strain curve. For the biaxial columns of the C1 and C3 type tested the eccentricity 300mm with percentage of the steel is 3.01% and 2.01% for 6 number of 12 mm diameter. In the graph indicates the X-axis is strain and the y-indicate the stress respectively.in the graph modulus of elasticity shows the ultimate value is C1 is 0.941 N/mm^2 and C3 is 1.01 N/mm^2.



C1 and C3 is 6 number of 12 mm diameters

Figure-7. Modulus of elasticity eccentricity 300 mm with 3.01% and 2.01%.

The modulus of the elasticity as shown in the Figure-8 the graph indicate the comparison between the stress and strain curve. For the biaxial columns of the C2 and C4 type tested the eccentricity 300mm with percentage of the steel is 3.01% and 2.01% for 4 number of 12 mm diameter. In the graph indicates the X-axis is strain and the y-indicate the stress respectivelyin the graph

modulus of elasticity shows the ultimate value is C2 is 1.21 N/mm^2 and C4 is 1.09 N/mm^2.

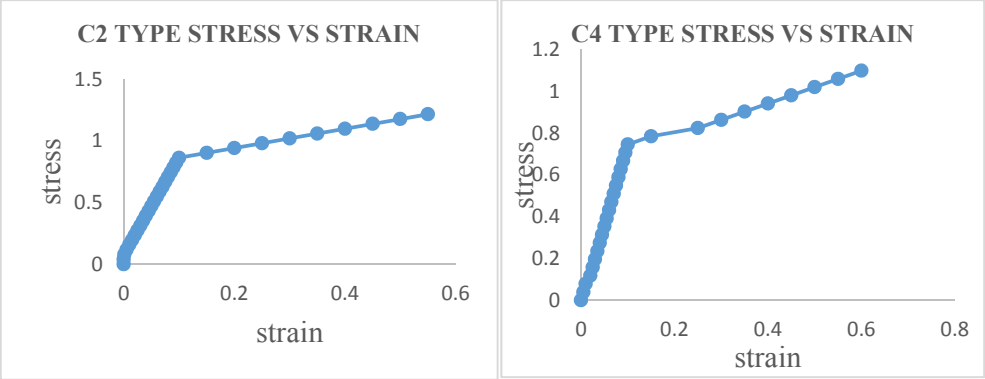


Figure-8. Modulus of elasticity eccentricity 150 mm with 3.01% and 2.01%.

In the Figure-9 shows the residual strength of the biaxial specimens of the all columns. Here we can measure the ultimate load of the axial load and the another columns for finding the percentage of the residual strength.

The residual strength of the column = maximum value - minimum value/ maximum value

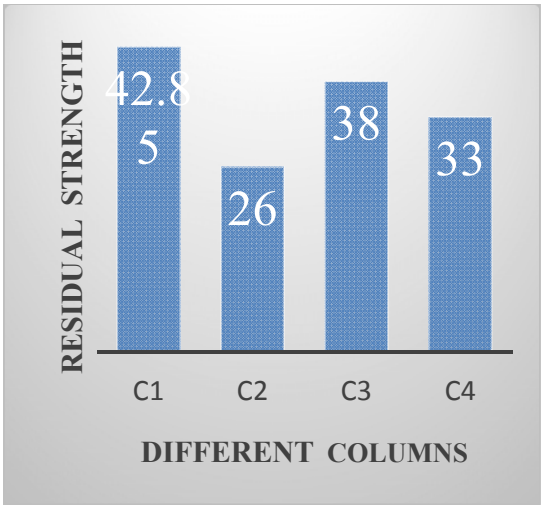


Figure-9. Residual strength of different columns.

7. CONCLUSIONS

Comparison on the results is done for eccentrically loaded slender column with different longitudinal percentage of steel is given eccentrically loaded column with different eccentricity like load deflection, stiffness, ultimate loads.

Based on the ultimate loads for reinforced concrete column for increasing the eccentricity like 300mm and 150mm the biaxial load capacity is reduced by 83.3% and76.9% for the percentage of steel is 3.01% The bi-axial load capacity is reduced for 300mm and 150mm is 71.4%and 64.51% for percentage of steel is 2.01%

The deflection is increasing for different eccentricity like 300mm and 150mm is subjected to variation of percentage of steel like 3.01%and 2.01%.

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