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CONCEPTUALISATION AND DEVELOPMENT OF A UNIQUE SELF STRAINING TESTING FRAME FOR BIAXIAL LOADING AND STUDY ON THE BEHAVIOUR OF UNIAXIALLY LOADED REINFORCED CONCRETE SLENDER COLUMN

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ABSTRACT

This paper aims at providing a brief experimental study on the behaviour of uniaxially loaded reinforced concrete slender column with different percentage of longitudinal reinforcement ratio with uniaxial loading. Totally six column specimens were cast with dimensions 2500mm X 200mm X 200mm for testing of uniaxial loaded column with different eccentricity like 200mm and 400mm.For the conduction of the test an unique self-straining loading frame with a range of capacity to apply axial to biaxial loads has been conceived, fabricated and erected indigenously. In this paper, the experimental results are presented, and the global behaviour of tested columns is discussed, particularly focusing on the deflection, stiffness and ultimate loads because of the increasing the eccentricity The results shows by increasing the axial load capacity is reduced, than stiffness is gradually decreasing 1/3 of axial load and ultimate load is decreased from central axial load for eccentricity 200mm and 400mm.

Keywords: uniaxially loaded, slender column, deflection, stiffness, eccentricity, self-straining frame.

INTRODUCTION

The significance study of behaviour of columns has gained a lot of thrust since their importance in saving lives during any disaster is well understood. Recent times have witnessed development of many new construction materials for structural adoption which need to be tested in columns for their elemental behaviour. The testing facilities that are normally available are to test for axial load behaviour and it is found that simple testing frames for uniaxial and biaxial loading are scarce. Hence an attempt has been made to develop a testing frame with simple principles of mechanics for usage in this work. Further uniaxial tests have been conducted as first step using this test setup.

Review of Literature

Many investigators have researched on axially loaded and uniaxially loaded slender column and founded the encouraging results. it has been observed that strength and ductility enhancements may still be expected but these improvements reduce with an increase in either the slenderness ratio or the load eccentricity by Dilip Kumar Singha Roy, *et al* (2012), it is concluded by H. Rodrigues, H. Varum, (2010 test results are presented and discussed comparing the uniaxial and the biaxial tests and the effect of the different biaxial load paths in the columns behaviour. In the previous journals by changing the different longitudinal reinforcement ratio and different spacing of stirrups were not used in the reinforced concrete slender column.

Objective

To experimental study and the behaviour of uniaxially loaded reinforced concrete slender column with different percentage of longitudinal reinforcement ratio.

Scope

The scope of the work is to study behaviour of uniaxially loaded reinforced concrete slender column. Parameter are investigated like

1. Load carrying capacity and stiffness at different percentage of longitudinal reinforcement with eccentric loading
2. Displacement at Centre of column

Material used

Materials used in the experimental work are tested for their properties and the details are furnished. Raw materials listed below were used for preparation of the specimens:Ordinary Portland Cement (OPC) 53 grade, Coarse Aggregate with 12.5 mm maximum size, Fine Aggregate as per indian standards and results shown in Table-1. And the mild steel 8mm and 10mm where tested in Universal testing machine as tensile test and tensile strength were carried 691 N/mm^2 and 751 N/mm^2, respectively.

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Table-1. Properties of cement.

S. No.	Property	Experimental results
1	Fineness of Cement	9%
2	Specific Gravity of Fine aggregate	2.62
3	Specific Gravity of coarse aggregate	2.72
4	Specific Gravity of Cement	3.1
3	Initial setting time	34 Minutes
4	Standard consistency	33%

Concrete mix proportion

M30 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 aggregate (kg)	Coarse aggregate (kg)	Water content
M30	425	543.28	1154.19	0.45

MAKING OF COLUMN TESTING FRAME

Hence in order to apply Uniaxial/Biaxial a self-straining loading frame of 25Tons capacity under biaxial load for column testing shown in Figure-5 has been conceptualized, fabricated and erected. The basic configuration of the loading frame consist of seven vertical Steel box 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 is shown in Figure-1. The maintenance department of SRM University has been carried out Fabrication and erection.

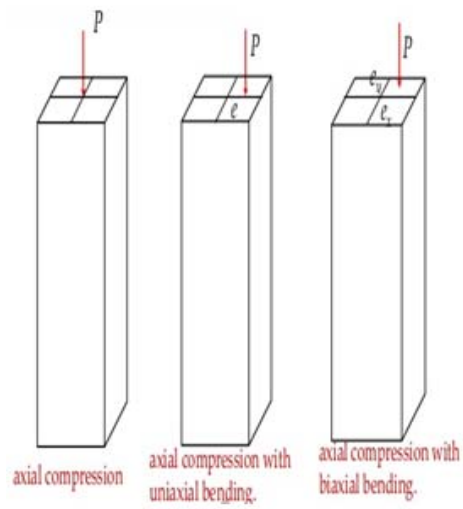

Figure-1. Load point under biaxial column.

Test setup for RC column under eccentrical loading

The test program consist of casting and testing of six columns, all having size of 200x200x2500 mm length and designed as slender column with two different reinforcement is 6nos of 10mm diameter and, 6nos of 10mm diameter rod as longitudinal reinforcement. The column was cast using M30 grade concrete and Fe 415 grade steel. Ordinary Portland cement, Fine aggregate and the coarse aggregate of maximum size 12.5 mm were used. High yield strength deformed (HYSD) bars of 10mm and 8 mm diameter with mean strength of 512 N/mm^2 were used as longitudinal reinforcement is shown in Figure-3. After 28 days curing specimens were tested in UTM to determine compressive strength, split tension strength. The column was tested under uniaxial bending with different eccentricity and details shown in Table-3 from centre of gravity of column. Test setup shown in Figure-2.

Table-3. Details of eccentrically loaded column.

Specimen details	Longitudinal reinforcement		Eccentricity in mm
	Steel details	Ratio	
Central Axial loading	6Nos of 10mm Dia	μ = 1.17%	0
C1			400mm
C2			200mm
C3	4Nos of 10mm Dia	μ = 0.785%	400mm
C4			200mm

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Figure-2. Test setup for column axial and Eccentrical loading.

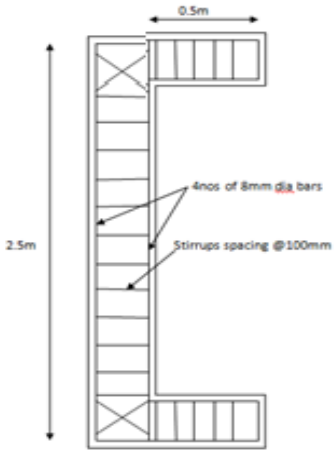

Figure-3. Reinforcement detail for column.

RESULT AND DISCUSSIONS

Compressive strength

The result of compressive strength obtained for M30 grade concrete by conducting compressive test on all specimens and the results are presented in Table-4 the comparison of compressive strength for 7 days and 28 days.

Table-4. Compressive strength for M30 grade after 7days and 28 days curing.

Cube in days	**Load** (KN)			**Area** (mm^2)	**Compressive strength** (MPa)
	Trail 1	**Trail 2**	**Trail 3**		
7days	430	442	436	150x150	19.27
28days	705	710	695	150x150	31.44

Split tensile strength

The result of split tensile test obtained for M30 grade concrete by conducting compressive test on all specimens and the results are presented in Table-5 the comparison of split tensile test for 7 days and 28 days.

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

Cube in days	**Load** (KN)			**Split tensile strength** (MPa)
	Trail 1	**Trail 2**	**Trail 3**	
7days	180	180	180	2.55
28days	240	260	250	3.55

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 2000 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 200×200 mm. The longitudinal steel reinforcement consisted of four normal mild steel bars either 4Ø10, 6Ø10 to account for the test variable of the ratio of the longitudinal steel bars "μ" which corresponded to steel reinforcement ratios of about 0.785%, 1.1% respectively. The load displacement, stiffness and moment of curvature were studied and the graph is plotted and details of the specimen are shown in Table-8.

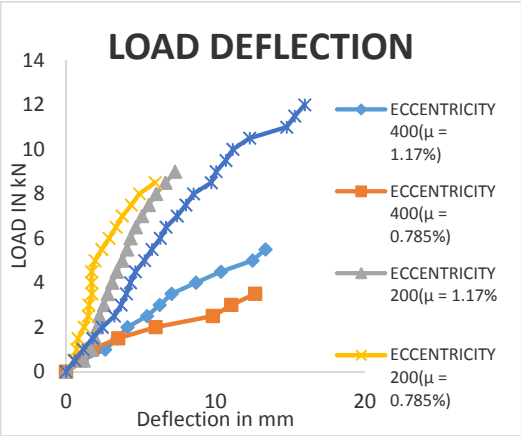

Figure-4. Load deflection curve for the specimen with different eccentric loading and longitudinal reinforcement.

In Figure-4 Load deflection curve for axially loaded column shows the maximum value as 15.98mm. In Figure-10 the plotted graph which represents the types C1, C3 for the eccentricity of 400mm as 6 nos and 4nos of 10mm dia bars shows higher values. The values for the maximum deflections are 12.35mm for the C1 type and 13.665mm for the type C2 following C2, C4 for the eccentricity of 200mm as 4 nos and 6nos of 10mm dia bars gives less deflection values while comparing to C1, C3.The values for the maximum deflections 7.295mm for C2 type and 5.965mm for C4 type.

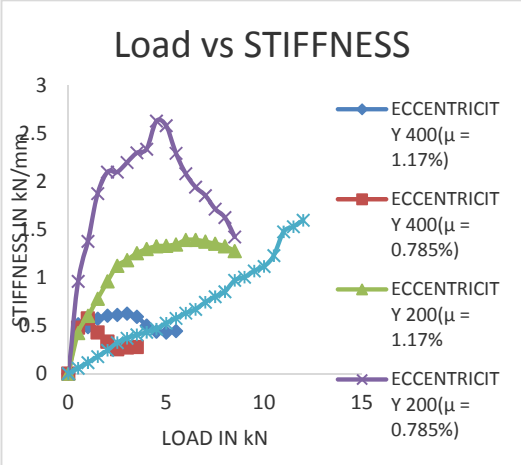

Figure-5. Load stiffness curve for the specimen with different eccentric loading and longitudinal reinforcement.

In Figure-5 Load vs stiffness curve for axially loaded column the peak value is 1.932 respectively. In Figure-12 the plotted graph which represents the types C2, C4 for the eccentricity of 200mm as 4nos and 6 nos of 10mm dia bars shows higher values. The values for the peak stiffness are namely 13.935 for the C2 type and 26.315 for the type C4 following C1, C3 for the eccentricity of 400mm as 4 nos and 6nos of 10mm dia bars gives less stiffness values while comparing to C2, C4.The values for the maximum stiffness are 6.265kN/mm for C1 type and 5.747kN/mm for C2 type.

MOMENT CURVATURE (M-Φ)

Moment curvature curve for unixially loaded column for eccentricity 400mm (C1 and C2) and 200mm (C3 and C4) graph is plotted and the values for eccentricity 400mm curvature gets higher value campare to Column C3 and C4.

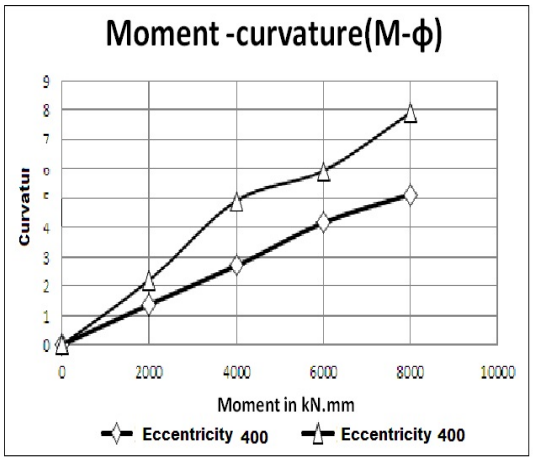

Figure-6. Moment curvature curve for the specimen C1,C2 and the eccentricity 400mm.

In Figure-6 the plotted graph which represents the types C1, C2 for the eccentricity of 400mm as 6 nos and 4 nos of 10mm dia bars shows higher values. The values for the maximum moments are 5.11mm for the C1 type and 7.89 for the type C2.

In Figure-7 the plotted graph represents typeC2, C4 for the eccentricity of 200mm as 6 nos and 4 nos of 10mm dia bars gives less moment values while comparing to C3, C4. The values for the maximum moment are 4.83 C3 type and 5.1for C4 type and the ultimate load is decreased in eccentricity 200mm compare to axial loading.

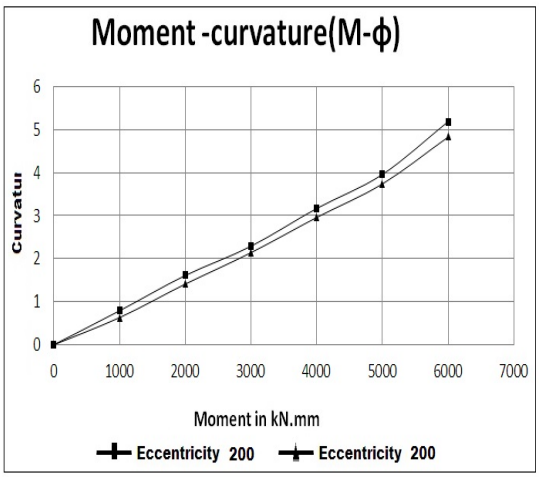

Figure-7. Moment curvature curve for the specimen C3,C4 and the eccentricity 200mm.

Ultimate loads for uniaxially loaded column for different eccentricities are found and compared by experimentally and theoretically by using Staad Pro V8i. Theoretical values are much higher experimentally calculated ultimate loads 15-20%, respectively.

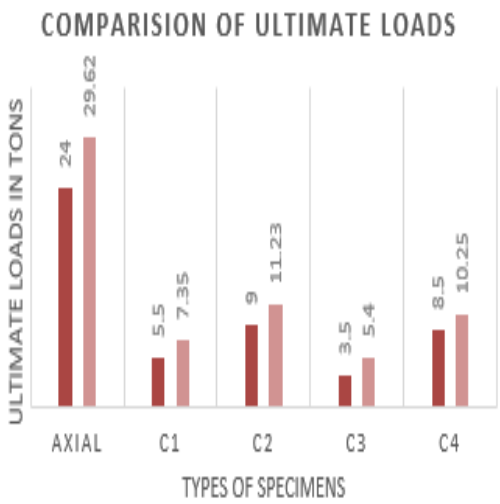

Figure-8. Comparison of ultimate loads for different specimens.

CONCLUSIONS

Comparison of the results is done for eccentrically loaded slender column with different longitudinal percentage of steel is given for eccentrically loaded column with different eccentricity like load deflection graph. Stiffness, moment curvature and comparison of ultimate loads are given below:

Based on the ultimate loads for reinforced concrete column for increasing the eccentricity like 400mm and 200mmthe axial load capacity has reduced by 77% and 62.5% for percentage of steel is 1.17%

The axial load capacity is reduced for 400mm and200mm is 85% and 65% for percentage of steel is 0.785%

By doubling the eccentricity the stiffness is decreasing in 1/3 of the axial load for eccentricity 400mm and 200mm is 85% and 68% for percentage of steels 1.17%

By increasing the stiffness is decreases for 1/3 of the axial load for eccentricity 400mm and 200mm is 90% and 67% for percentage of steel is 0.785%

The moment curvature relationship for all the Reinforced concrete column is linear for different eccentric loading

The deflection is increasing for different eccentricity like 200mm and 400mm is subjected to variation of percentage of steel like 1.17% and 0.785%.

The loading facility developed performed satisfactory during the testing.

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