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Effect on Deformation due to Presence of Extra Bars in Column Heads

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Abstract*: The purpose of the work is to investigate the effect of additional bars at column ends, when column is subjected to axial load. Due to this; reduction in the axial and lateral deformations of heads of the column are examined. The experimental study examined both ends' behaviour after providing extra bar at top head and bottom head of the column and experimental values indicate that presence of extra bars in column heads decreases axial and lateral deformation in the heads. The experimental values of axial and lateral deformations were validated with the help of ANSYS software. The variation in these values with respect to percentage of steel and grade of concrete is also studied.
Keywords: Column head, Axial deformation, Lateral deformation, M20, M25, RCC Column

I. INTRODUCTION

Column is vertical structural element, which mainly carries the axial load and if the effective length of the column is less than three times of least lateral dimension that is called as axially loaded column. Column is the useful element to transfers the load of superstructure to substructure. Moreover, it can also subject to bending moment because of rigid frame action and lateral load. The additional moment generated at the column head due to the action of vertical load. Stress concentration of the column is not equally same. It is higher at the top head of the column, less in middle and higher at bottom head. Development length is provided at beam column joint to facilitate easy and smooth stress transfer. To provide the development length we L- turned top and bottom reinforcement. This leads to the availability of additional bars. Therefore, behaviour changed at the top head of the column [1]. Due to this; the various changes occurred, such as axial load carrying capacity may enhance and there may be reduction in deformations. Many researchers worked on beam-column joints and its confinement [2]. Therefore, we provided the extra bars in square column. The present work deals with the study of deformation characteristics of square column carrying extra bars in column head zones.

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As we know that, in reinforced concrete column when axial load is applied deformations occurred at both heads of the column. We examined the axial capacity and deformations due to presence of available extra bar in column heads. Earlier work guided us that overall effect of scale on shear and flexure behaviour of RCC columns was quite similar with original columns [3]. We judge the variation in deformations and axial capacity due to additional available bars in the column due to L-turned bars of beams. There are many ways to increase the axial load capacity of concrete columns, such as adding new concrete Jacket with additional reinforcement, using external steel Angles and horizontal Strips [4]. Extra confining reinforcements were used for additional B.M. and load, which is produced in the column [5]. The objective of this research program is to determine the effect of the extra bars on the behavior of square R.C.C. column heads. A comparison is made between the experimental and analytical results obtained through the Static Structure program ANSYS 18.0 [6].

II. METHODOLOGY

A. Material Specification

Following material were used for making of the concrete-

Table No. 1 Material specifications

S. No.	Materials	Properties
1.	Reinforcement	HYSD bar of f_y = 500 N/mm^2
2.	Cement	Portland Pozzolana Cement
3.	Fine aggregate	Narmada River Sand, Passing from 4.75mm sieve
4.	Coarse Aggregate	Locally available, Passing from 20mm sieve
5.	Water	Tap water

HYSD steel bars are used for main reinforcement and lateral ties.

B. Nomenclature of specimen

Nomenclature system adopted for specimen was -

Table No. 2 Nomenclature

S. No.	Nomenclature	Specimen Details
1.	WE	With Extra bars
2.	WOE	With Out Extra bar
3.	S	Stands for specimen
4.	01, 02….etc.	Indicates serial No. of specimen

For example:
Sample WE-S01 indicates column specimen number 01 in category "with extra bars".
Similarly, WOE-S02 indicates column specimen number 02 in category "without extra bar".

C. Test Specimens

After 28 days curing, Total 36 Nos. of specimen were tested. The dimensional details and other properties of the columns are mention in Fig.1 and table 3 respectively.

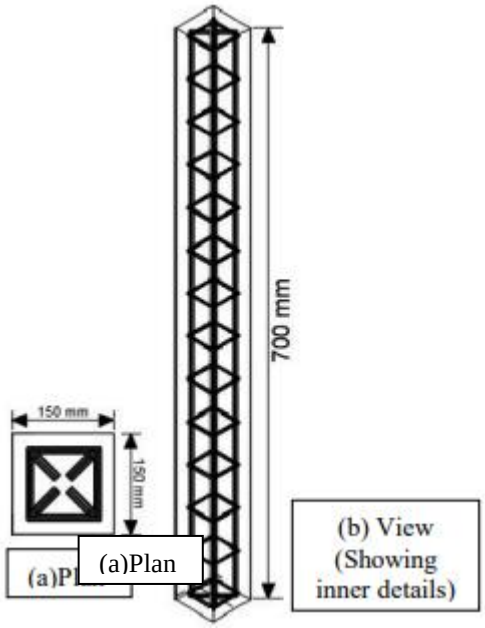
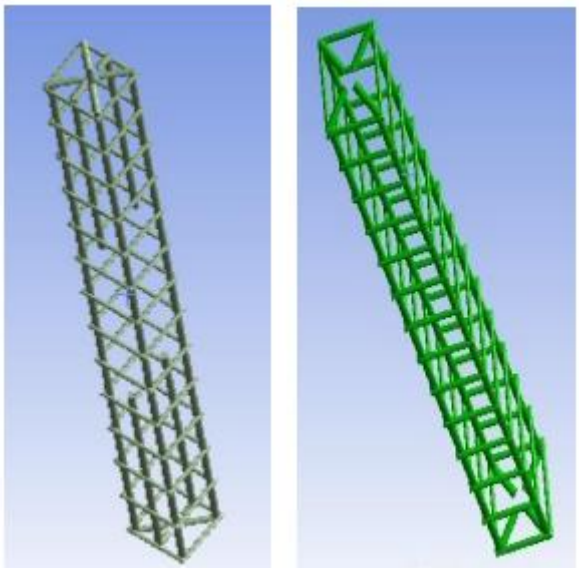


Fig. 1 Typical details of column and its cage

Table No. 3 Details of specimen

S. No.	Grade of Concrete	Main bar	Extra bar	No. of specimen	Total
1.	M 20	4-8Φ	-	03	03
2.	M 20	4-10 Φ	-	03	03
3.	M 20	4-12 Φ	-	03	03
4.	M 20	4-8Φ	2-8Φ	03	03
5.	M 20	4-10 Φ	2-10 Φ	03	03
6.	M 20	4-12 Φ	2-12 Φ	03	03
7.	M 25	4-8Φ	-	03	03
8.	M 25	4-10 Φ	-	03	03
9.	M 25	4-12 Φ	-	03	03
10.	M 25	4-8Φ	2-8Φ	03	03
11.	M 25	4-10 Φ	2-10 Φ	03	03
12.	M 25	4-12 Φ	2-12 Φ	03	03
Grand Total					36

The reinforcement details of specimen represent upper and lower head of column as shown in fig. 2. The reinforcement arrangement segments in frame subjected to axial loading.
36 Nos. of square columns of size 150 mm X 150 mm were cast. The total height of the specimens was kept 700 mm . 18 Nos. of column specimens were reinforced with the same longitudinal bars i.e. four bars; of diameter 8 mm, 10 mm, 12 mm. We used 8 mm HYSD steel square stirrups at spacing of 150 mm along the column height and first stirrup at a distance of 25 mm from both ends of the column as demonstrated in Fig. 1. In Another 18 Nos. of column specimen both the ends of the specimens were strengthened using 8mm, 10mm, 12mm extra bars provide at h/3 end of columns, as shown in fig. 2. Details of different percentages of steel are shown in Table No. 4.



(a) With extra bar (b) without extra bar

Fig. 2 sample with extra bar and without extra bar of the column

Table No. 4 variation of percentage of steel in different specimen categories

S. No.	Test Specimen	Column reinforcement		Percentage of steel
		Main bars	Extra bars	
1.	WE-S01	4-8Φ	2-8Φ	1.33%
2.	WOE-S02	4-8Φ		0.88%
3.	WE-S03	4-10Φ	2-10Φ	2.08%
4.	WOE-S04	4-10Φ		1.38%
5.	WE-S05	4-12Φ	2-12Φ	3.01%
6.	WOE-S06	4-12Φ		2.0%

D. Loading and instrumentation

(a) specimen before loading (b) specimen after loading

Fig. 3 testing of specimen without extra bar

The specimens were tested under axial compressive load in universal testing machine. After applying load, the axial deformations and lateral deformations have observed.
The tests were performed on "without extra bar" category specimen (as shown in fig.3 a and b) and on "with extra bars" category specimen (as shown in fig. 4 a and b)

(a) specimen before loading (b) specimen after loading

Fig. 4 testing of specimen with extra bars

III. RESULT

During the testing, we observed axial and lateral deformations (whose values have been averaged for three specimens) and further validated it through software analysis. The comparative results are tabulated as under-

Table No. 5 Axial deformation values for M 20

S. No.	Specimen	Software deformation	Experimental deformation	Percentage variation
1.	WE-S01	0.531	0.501	6.0%
2.	WOE-S02	0.591	0.557	6.2%
3.	WE-S03	0.674	0.622	8.4%
4.	WOE-S04	0.776	0.720	7.8%
5.	WE-S05	0.710	0.673	5.6%
6.	WOE-S06	0.811	0.756	7.3%

Table No. 6 Axial deformation values for M 25

S. No.	Specimen	Software deformation	Experimental deformation	Percentage variation
1.	WE-S01	0.459	0.433	6.1%
2.	WOE-S02	0.525	0.497	5.8%
3.	WE-S03	0.620	0.576	7.8%
4.	WOE-S04	0.710	0.665	6.9%
5.	WE-S05	0.670	0.621	8.0%
6.	WOE-S06	0.723	0.685	5.6%

Table No. 7 Lateral deformation values for M 20

S. No.	Specimen	Software deformation	Experimental deformation	Percentage variation
1.	WE-S01	0.0022	0.0021	5.4%
2.	WOE-S02	0.0029	0.0028	6.7%
3.	WE-S03	0.0040	0.0038	7.5%
4.	WOE-S04	0.0048	0.0045	8.3%
5.	WE-S05	0.0038	0.0036	5.7%
6.	WOE-S06	0.0043	0.0041	6.9%

Table No. 8 Lateral deformation values for M 25

S. No.	Specimen	Software deformation	Experimental deformation	Percentage variation
1.	WE-S01	0.0045	0.0043	5.8%
2.	WOE-S02	0.0054	0.005	6.1%
3.	WE-S03	0.0077	0.0072	7.3%
4.	WOE-S04	0.0083	0.0078	7.1%
5.	WE-S05	0.0086	0.008	8.5%
6.	WOE-S06	0.0088	0.0084	5.8%

The variation between the experimental values of deformations and the software value of the deformation is not very different (under 5 to 8%) and hence the experimental values are in good agreement to ANSYS software results.
Experimental values of axial deformations and lateral deformations of all categories of the columns specimen (with or without extra bar) are plotted in the graph as shown in fig.5,6 and fig.7,8 respectively.

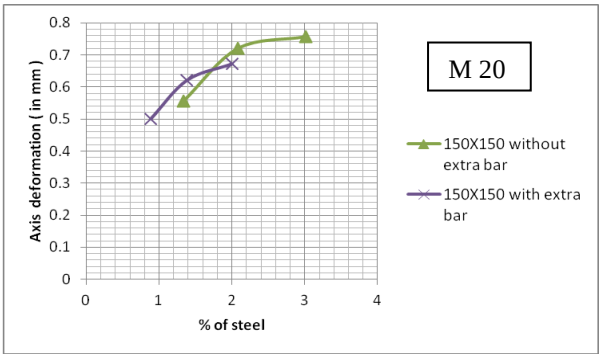


Fig.5 Axial deformation vs. % of steel for M-20

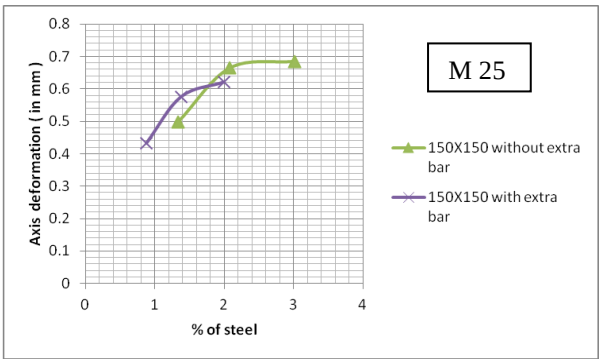


Fig.6 Axial deformation vs. % of steel for M-25

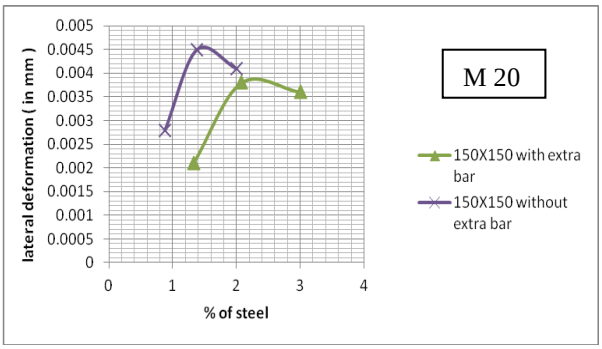


Fig.7 Lateral deformation vs. % of steel for M-20

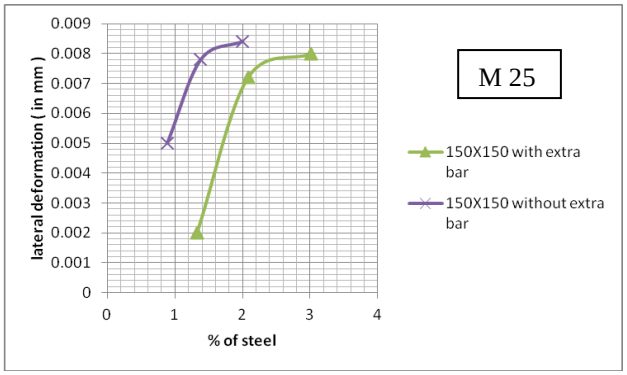


Fig.8 Lateral deformation vs. % of steel for M-25

IV. CONCLUSION

Based on different parameters of the columns, the behaviors of heads of R.C.C. columns like axial and lateral deformation were investigated through experimental work and validated in ANSYS software. After testing on sufficient number of specimen in the laboratory and validating its results with the help of ANSYS we arrived at the following conclusions.-

1. After providing extra bars in column head, axial and lateral deformation reduced in the column head.
2. We studied the column head behaviour in a range of 0.8% to 3% of steel and decrease in deformations was observed in a range of 10 to 16 %.
3. The maximum axial and lateral deformation is at the head of the columns, in all cases, i.e. without extra bar and with extra bar; both categories.
4. Axial Deformation and lateral Deformation values are associated with the ultimate load, as the ultimate load increases the axial and lateral deformation increases.

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