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Load-Moment Interaction behaviour of equally legged T column

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Abstract - *An abstract summarizes, in one paragraph (usually), the major aspects of the entire paper in the following prescribed sequence. The abstract of your paper must 250 words or less. This electronic document is a "live" template. The various components of your paper [title, text, heads, etc.] are already defined on the style sheet, as illustrated by the portions given in this document. Do not use special characters, symbols, or math in your title or abstract. The authors must follow the instructions given in the document for the papers to be published. This template, modified in MS Word 2007 and saved as a "Word 97-2003 Document (Size 10 & Italic , cambria font)* Interaction curves is already been developed for a Rectangular section which is available in SP-16 1980 which gives the appropriate reinforcement of the section . We can use T section Columns instead of rectangular and circular, and study their performance. The work describes the behaviour of the T section for the Load and moment interaction Curves for the section. The Curves are developed for the dimensions of 600 X 200mm in the flange area and 400X 200mm for the web portion and these are studied for Grades of M 20, 25, 30, 35, 40 and Fe 415 and 500 Steel. Some of the studies have made for different spacing of the reinforcement for different grades and steel. The method adopted for calculations are based on SP 16-1980 and IS 456-2000 assumptions and stress strain relationship of concrete and steel.

Key Words: T columns Moment interaction curve, Equally legged, equally spacing and unequal spacing

1. INTRODUCTION

Structural members subjected to axial load and bending are encountered in design practice from time to time, a typical example is Column. Column occupied an ornamental place in the olden architecture along with its structural need. In most of the cases the importance's given to columns were of aesthetic than structural. A good example to support this point could be that of Thousand Column "Basadi in Moodabidre", a place about 40 kms away from Mangaluru. Columns constitute the important part in a structure like a multi-storeyed building. Failures of slab or beam are often of local nature whereas that of a column endangers the whole structure. Hence designers will have to be more careful, accurate and conservative in their approach to column Columns are the primary vertical load carrying members of a typical multi storied building. The loads coming on the floors and beams are transmitted to the foundation through these columns. The same columns are also meant to resist lateral loads on a building due to wind and earthquake. In addition to direct vertical loads, bending moments and shears in one or two directions are often carried by these columns. If columns have axial loads and bending moments about either of x- x or y- y axis only, they are classified as uni-axially eccentrically loaded columns. The peripheral columns located on the sides of a building are of this category. On other hand, the corner columns of a building are loaded vertically and in addition they have moments about x- x and y- y axis. These columns are known as bi-axially eccentrically loaded columns. Further, the columns are classified with respect to its shape viz rectangular, square, circular, ele(L), tee(T), and cross(+) shaped columns. The T section of column is geometrically unsymmetrical about x- x and y- y axis. The T columns carry higher magnitude of moment and axial load in both directionsdesign.

Objectivies

- To develop interaction diagrams for various grades of concrete and steel for T- shaped columns.
- To develop interaction diagrams by varying the spacing of reinforcements for T- shaped columns.
- The develop interaction diagrams for above mentioned parameters for highly compressed edge situated parallel to flange direction and perpendicular to flange direction also.
- To develop interaction diagrams for various grades of concrete and steel for T- shaped columns.
- To develop interaction diagrams by varying the spacing of reinforcements for T- shaped columns.
- The develop interaction diagrams for above mentioned parameters for highly compressed edge situated parallel to flange direction and perpendicular to flange direction also.
- To Conclude the objective is, mainly to provide interaction diagrams that could facilitate the design of T- columns and to study the behaviour of same.

2. Methodology

2.1Methodology Methods of Design

The working stress method is based on the behaviour of column under the working load. It ensures satisfactory behaviour under service load and also assumed to possess adequate safety against collapse of the structure. In limit state method of design ensures adequate factor of safety against failure. The serviceability requirement for deflection and cracks in column are not checked since these are within the permissible limit at working stress. In this research "Limit State Method" design approach is adopted for the analysis.

Following are the basic assumptions made in the limit state design philosophy

i. The plane section normal to the axis of column before deformation remains plane after deformation, i.e. the strain at any point is proportional to its distance from the neutral axis.
ii. The tensile strength of concrete is neglected.

T-Shaped Concrete Column its Interaction Curve

On the other hand, it is also possible to prepare non-dimensional interaction diagram by selecting appropriate non-dimensional parameters. This would help to get several possible cross-sections with the respective longitudinal steel bars. This project explains the preparation of such non-dimensional interaction diagrams which are also known as "Design Charts". Similar design charts of circular and other types of cross-sections can be prepared following the same procedure as that of rectangular cross-section. However, the stress block parameters are to be established separately by summing up the forces and moment of several strips by dividing the cross-section of columns into the strips.

2.2 Design procedure

Design: Procedure and Interaction Curve of T Column

The design procedure basically involves two stages where the first stage involves design of interaction curve when neutral axis lies inside the section and the second stage when neutral axis is outside the section.

1. **N-A lies inside the section K= $X_u/D<1$**

- Step1:
- Assume data
- f_y= 415 N/mm^2
- f_{ck}= 20 N/mm^2
- Diameter of bar = 20 mm
- Step2: Axial load capacity of concrete [KN] = 0.361*f_{ck}*b*d
- Step3: Axial load capacity of steel
- e_{sc}= 0.0035 [D-d']/D>0.002
- f_{cc}= 0.446*f_{ck}
- e_c< 0.002
- f_{cc}= 0.446*e_c*f_{ck}*[1-250*e_c]
- Total Axial load, P_u= (0.361*f_{ck}*B*D)+∑Ast(stress in steel-stress in concrete)
- Ultimate moment, M_u= 0.361*f_{ck}*bd *[C.G-d']

2. **N-A lies outside the section K= X_U/D <1**

- (0.0035-0.75*e_{cb})/(D+0.1D)=e_{bb}/0.1D
- e_{cu}=0.0035-0.75e_{cb}
- Cc' =Cc/(f_{ck}* B*D) and Yc' =Yc/D
- Axial load carrying capacity of concrete=Cc'*f_{ck}*B*D

Stress calculation

- e_{cb}= e_{cu}(D-d')/D> 0.002
- f_{cc}= 0.446*f_{ck}
- e_{cb}< 0.002
- f_{cc} = 0.446*e_{cb}*f_{ck}*[1-250*e_{cx}]
- **Total Axial load, P_u** = (C_c' f_{ck}*B*D) +∑Ast (stress in steel-stress in concrete)
- **Moment, M_u**= (C_c' *f_{ck}*B*D)*[CG-Y_c'*d]

Table showing 1: Cc and YC
Coefficients C_c' and Y_c' when the axis lies outside the section

K= X_u/D	Coefficient C_c'= $C_c/f_{ck}BD$	Coefficient Y_c'= $Y_c/f_{ck}BD$
1	0.361	0.416
1.05	0.374	0.432
1.1	0.384	0.443
1.2	0.399	0.458
1.3	0.409	0.468
1.4	0.417	0.475
1.5	0.422	0.480
2.0	0.435	0.491
2.5	0.44	0.495
3.0	0.442	0.497
4.0	0.444	0.499

Table 2 :Salient points on the design stress-strain curve for cold-worked bars

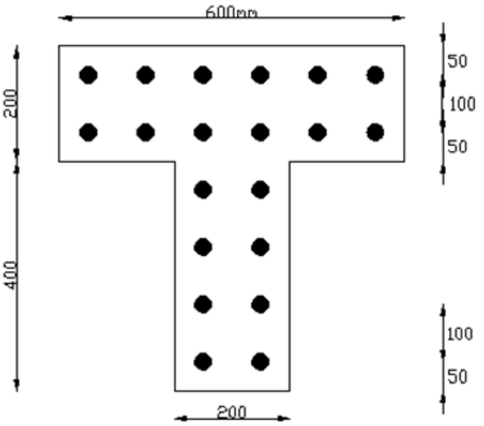
Stress level	f_y = 415 N/mm^2		f_y = 500 N/mm^2	
	Strain	Stress N/mm^2	Strain	Stress N/mm^2
0.80f_{yd}	0.00144	288.7	0.00174	347.8
0.85f_{yd}	0.00163	306.7	0.00195	369.6
0.90f_{yd}	0.00192	324.8	0.00226	391.3
0.95f_{yd}	0.00241	342.8	0.00277	413.0
0.975f_{yd}.	0.00276	351.8	0.00312	423.9
1.0f_{yd}	0.00380	360.9	0.00417	434.8

3. RESULTS ANDDISCUSSIONS

The below shows the Equal Spacing results of grade M20 and Fe 415 and Fe 500

Note: Xu=Neutral Axis from Highly Compressed Edge

Taking Dia of bars =20mm

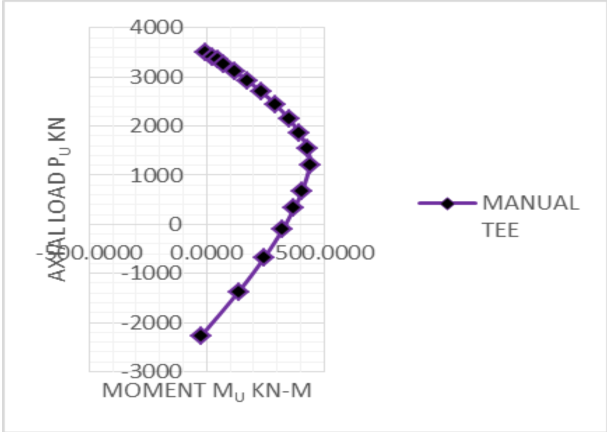


Dimensions are in mm

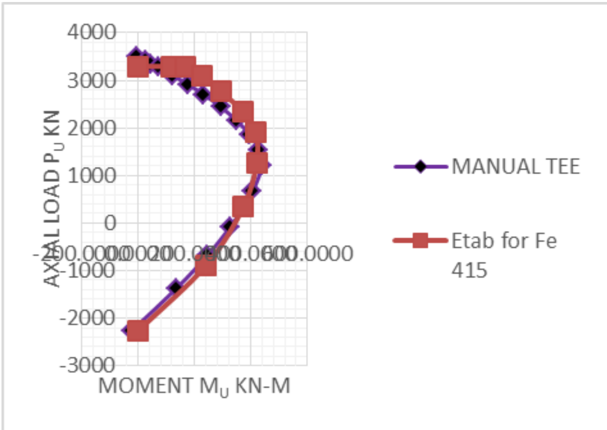
P_u and M_u for T column of equally spaced reinforcement for Fe 415 steel

Table 3: P_u and M_u for T column of equally spaced reinforcement for Fe 415 steel

'X$_U$' (mm)	P_u (kN)	M_U (kN- m)
∞ (PURE COMPRESSION)	3787.89587	0
2400	3792.44596	-112.4053
1800	3784.25583	-106.0822
1500	3774.68052	-100.0909
1200	3745.14261	-87.2661
900	3656.6274	-54.3589
840	3620.99498	-41.5736
780	3569.40663	-24.7815
720	3504.20679	-2.9761
660	3410.66571	26.7353
630	3349.3764	46.1971
600	3271.87884	71.1469
550	3106.05635	122.8363
500	2917.88816	176.3824
450	2702.08438	232.602
400	2436.18464	294.4653
350	2150.07165	349.9931
300	1848.42111	396.8505
250	1539.80967	428.367
200	1214.89558	439.736
150	665.764206	405.8865
125	326.750844	372.2982
100	-94.812863	324.7638
75	-676.21264	245.9961
50	-1371.178	136.0635
0 (PURE TENSION)	-2267.6011	-22.676



Graph 1: Interaction Curve for M20 grade and fe415 steel



Graph 2: Interaction for ETABS and manual calculation

4. DISCUSSIONS

The Interaction curves shown in the above are for different grades and steel, further for equally and unequal spacing of the reinforcement also Grades used are M 20, 25, 30, 35, 40 and Fe 415 and 500 Steel. These curves have mainly three regions; compression control region, balanced region and tension control regions as explained earlier .First the section is in pure compression, here the concrete crushes before steel reaches yielding point. In the balanced point the steel and concrete will fail simultaneously. After the balanced point, it reaches pure bending capacity of the section, and reaches to pure tension point. In this region the strain in the concrete reaches to its maximum and it crushes in compression region before reinforcement fails. For the design practice the area between minimum eccentricities to the balanced points are considered. The comparisons of the equal and unequal spaced reinforcements of T section for the grades of concretes. M 20, 25, 30, 35, 40 and grade of steel Fe 415 and 500 are shown in graphs. It mainly indicates the strength of the section increased as the grade of concrete and steels are increased. It also shows that providing the varied spacing of reinforcements rather than equal spacing for the column also Increases the moment carrying capacity of the section

5. CONCLUSIONS

1.For the case of equally Spaced reinforcement detailing increasing the grade of steel from Fe415 to Fe500 will result in a increase of both load and moment carrying capacity of columns.

2.For the case of reduced spacing in web region of T- column the study reflected a resulting decrease in moment carrying capacity of L- column, however the load carrying capacity remained unaffected by the varying reinforcement spacing.

3.For the case of equally spaced reinforcement detailing, with highly compressed edge at flange portion shows higher moment carrying capacity in comparison with that where highly compressed edge was considered perpendicular to flange of the L- column, however the load carrying capacity was found to be same in both the cases.

4.For the case of highly compressed edge considered perpendicular to flange the reduction in spacing between reinforcing bars of flange portion will result in increase of moment carrying capacity but the load carrying capacity remains unaffected.

5.Both load and moment carrying capacity were found to be increased with increase in grades of concrete for both equally spaced and unequally spaced reinforcement details.

The result were also compared with that obtained from ETABS, the deviations at some locations are because of the reason that the stress block parameters used by ETABS were of rectangle whereas the actual stress block parameters to be used as per IS-456 and SP-16 provisions were of parabolic- rectangular nature and the same were adopted in the present work for developing interaction diagrams.

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