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Research paper

Analysis of Pu-Mu Interaction Diagram of C-Shaped Equal Legged RC Column Developed using ETABS and Analytical Method

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Abstract

Interaction curve is a visual representation of bending moment (Mu) and axial force (Pu) and this curve explains the ultimate capacity of the compression member when it is subjected to axial load and moments. Interaction diagram for rectangular and circular columns are available in SP 16-1980 RC Handbook. Limit State Method of design approach is adopted for the analysis of the work. This work includes developing the interaction curve for C-shaped equal legged RC column with different grade of steel and concrete. Comparison of the interaction curve of the C-shaped equal legged RC column by using Analytical method with that of the ETABS is done, and their significance in civil fields.

Keywords: *Interaction diagrams, Load, Moment, Special C-shaped reinforced concrete column, ETABS Software, Grade of steel, Grade of concrete.*

1. Introduction

A column or pillar (A large post) in structural engineering is a structural system which mainly carries an axial compressive load is called as column; a structural element which is predominantly subjected to axial compression is called as compression members. When these compression members become vertical, it is called a column. Columns are structural elements that support the superstructure of the building, transfer vertical load from superstructure to foundation of buildings. In tall multistorey buildings and bridge pier, an arbitrary shaped RC column member are used; which is subjected to uniaxial moments. Along with axial compression are occasionally used [1]. Based on shapes Columns are classified as follows, a) Square Column, b) Rectangular Column, c) L-shaped Column, d) Circular Column, e) C-shaped Column, f) T-shape column, g) cross (+) section Column. Based on loadings Columns are classified as follows, a) Centrally loaded Column, b) Uni-axially eccentrically loaded Column, c) Bi-axially eccentrically loaded Column are shown in Fig1. The column is either short or tall according to its effective slenderness ratio (Klu/r). A column is treated to be short when the ratio of Klu (effective length) to its least lateral dimension doesn't exceed 12. If the ratios of the effective length to its least lateral dimensions exceed 12 the column is considered to be a long column. Where: K= effective length term, r= radius of gyration, lu= unsupported length of a member.

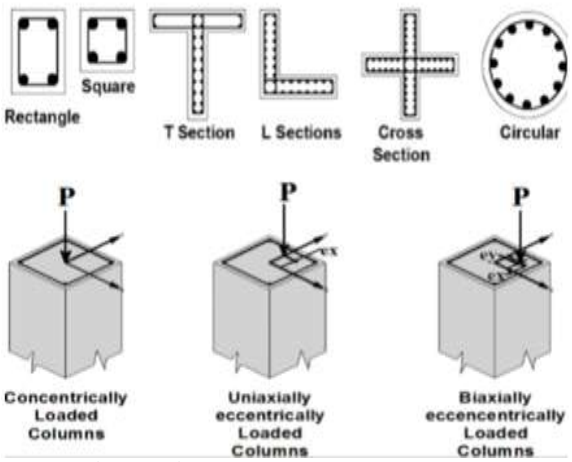

Fig.1: Classification of column based on shape and loading conditions

2. Interaction Diagram

The interaction curve is a graph, as shown in Fig.2. The X-axis of the graph is represented by moments and Y-axis of the graph is represented by load. The interaction curve consists of different points of locations with respects to load and moment; stress-strain parabolic block is used for calculation of each point on the graph. Interaction curves helps to analyzing the column during design aid, the point lies inside the curve that indicate the section is safe and if it is lies outside of the curve that indicates section is unsafe. The curve consists of various points and significance of points are listed below; Point1indicate that at zero eccentricity, moments is zero and pure axial load. Point2 indicate that at zero eccentricity,

maximum permissible axial compression. Point3 indicate that at maximum axial compression, moment strength is maximum. Point4 indicate that at strain is zero, compression load and moments capacity. Point5 indicate that at 50% of strain, compression load moment capacity.

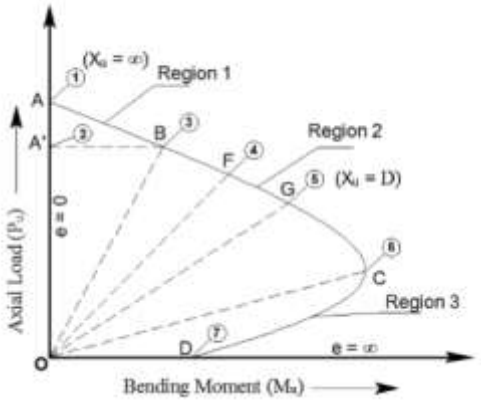

Fig.2: Typical Interaction diagram curve

Point6 indicate the axial compression load and moments are in balanced condition state. Point7 indicate that the point is lies on the x-axis of the graph, so force is zero and maximum bending moment.

3. Methodology

Limit State Method of analysis is used for the design and analysis of the column, assumption that are made by "Limit State Method" is, a) Section of the plane perpendicular to axis of the column remains plane after deformation. b) Tensile strength is not considered because concrete is weak in tension. c) stress-strain curve for concrete showed in Fig.3.The compressive strength of concrete is given by 0.67fck, and 1.5 safety factors is applied and taken it as 0.45fck. d) stress-strain

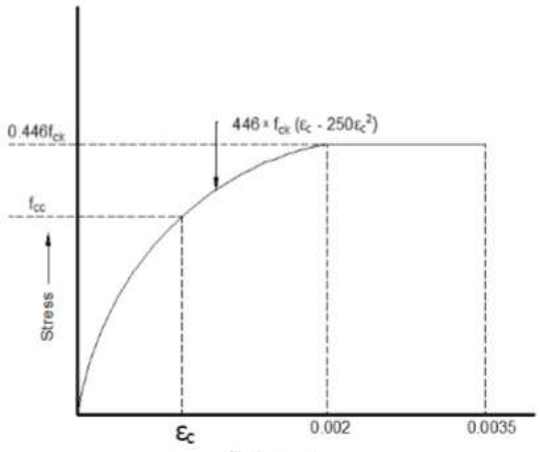

Fig.3: Stress-strain curve for concrete section

Curve for steel is shown in Fig.4, for the design aid purpose 1.15 factor of safety shall be applied. e) The compressive strain is 0.002 for concrete is considered as maximum strain in concrete and strain is uniform entire of the section, so stress in concrete taken as 0.45fck, shown in Fig.5. f) At highly compressed edge, when neutral axis is lies within the under section, 0.0035 bending strain for concrete, when neutral axis is lies outside of the section; bending strain is taken as 0.0035 minus 0.75times the strain at the least compressed edge of the section, shown in Fig.6.

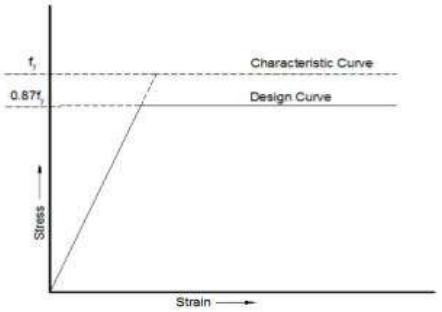

Fig.4: Stress-strain curve for steel

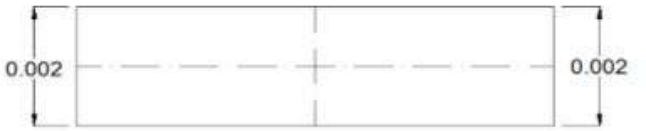

Fig.5: Strain curve for axial compression

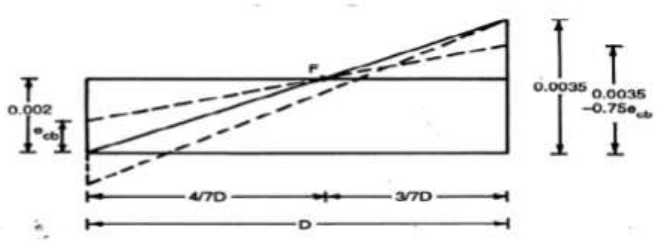

Fig.6: Strain diagram for N.A inside and outside the section

4. Interaction Curve for Equal Legged C-Shaped Rc Column by Using Analytical Method

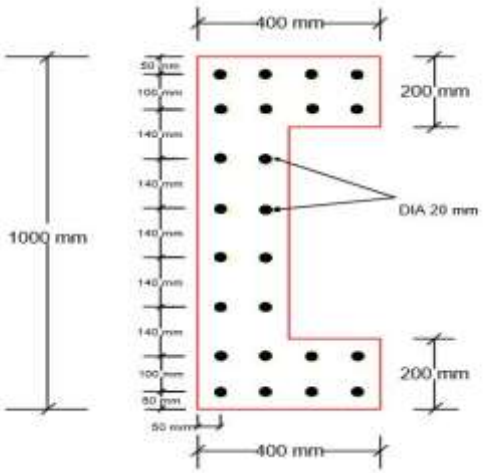

Fig.7: C-shaped equal legged RC column

There is no code book which provides interaction curve for equal legged C-shaped RC column. C-shaped equal legged RC column is shown in Fig.7. The dimensions of the channel shaped column are shown in TABLE 1.

Table I: Dimensions Of The Rc Channel Shaped Column

Parameter	Value	Unit
Width of top flange	400	mm
Width of bottom flange	400	mm
Depth of web portion	600	mm
Dia of bar	20	mm
Spacing of bar @leg portion	100	mm
Spacing of bar @web portion	140	mm

Overall depth	1000	mm
Thickness	200	mm
Concrete cover	50	mm

Intercation curve for C-shaped column is developed by varing the parameters such as grade of steel and grade of concrete. Interaction curve for M25 and Fe415, M30 and Fe415, M25 and Fe500, M30 and Fe500 are shown in Fig.8, Fig.9, Fig.10, Fig11 respectively.

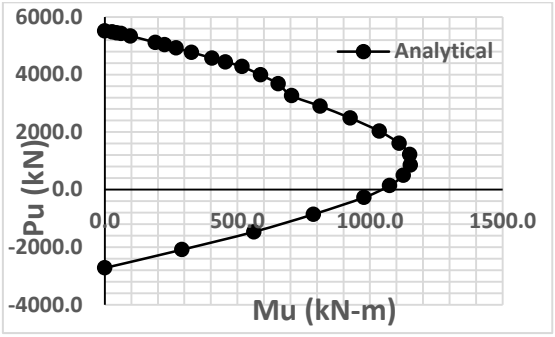

Fig.8: Interaction curve for M25 and Fe415

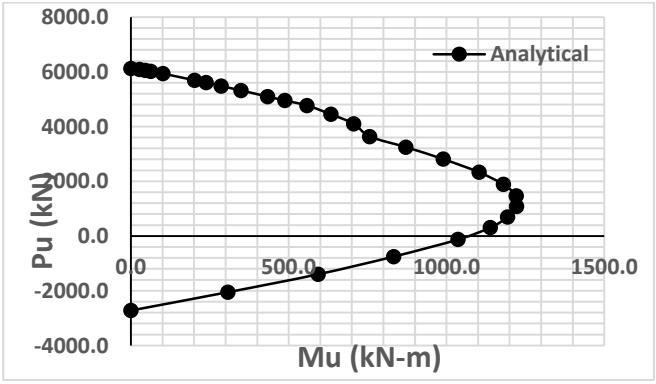

Fig.9: Interaction curve for M30 and Fe415

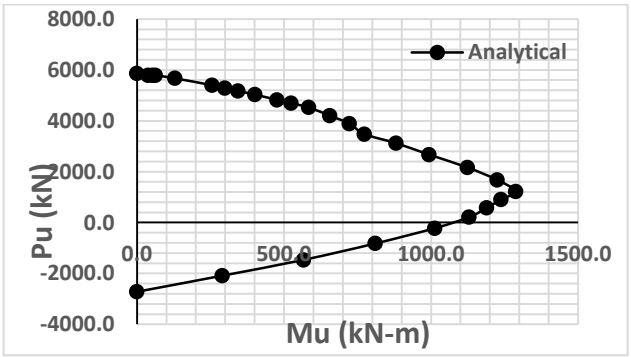

Fig.10: Interaction curve for M25 and Fe500

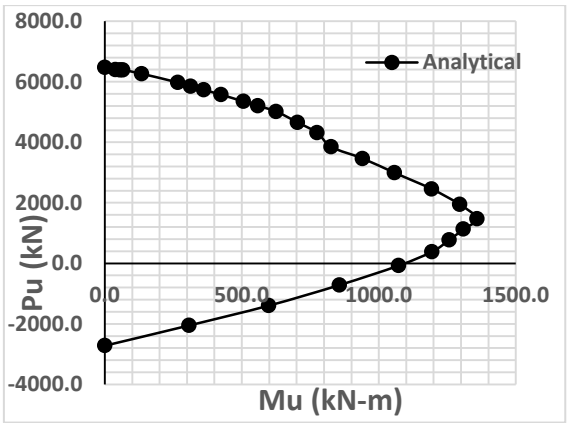

Fig.11: Interaction curve for M30 and Fe500

5. Interaction Curve for Equal Legged C-Shaped Rc Column by Using Etabs Software

The same size of C-shaped equal legged RC column is used to develop an interaction curve by using ETABS software. Fig.9 shows the typical equal legged C-shaped RC column by using ETABS keeping all the parameters same.

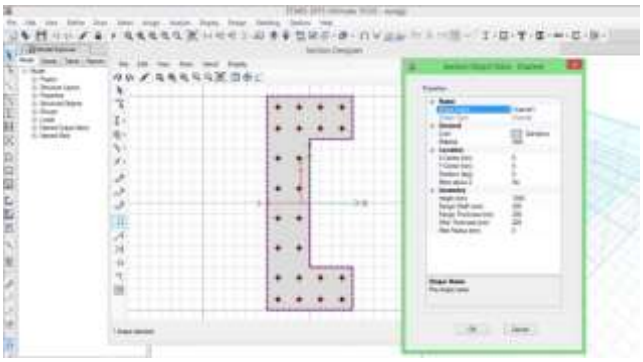

Fig.12: Typical equal legged C-shaped RC column by using ETABS software

Interaction curve for C-shaped column is developed by varing the parameters such as grade of steel and grade of concrete in ETABS. Interaction curve for M25 and Fe415, M30 and Fe415, M25 and Fe500, M30 and Fe500 are obtained from ETABS as shown in Fig.13, Fig.14, Fig15, Fig16 respectively.

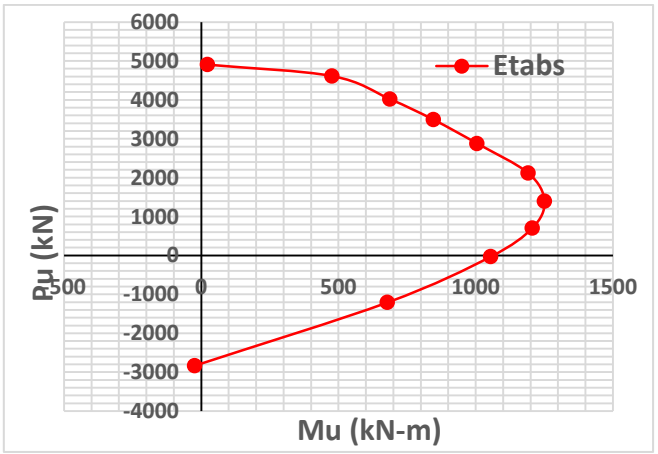

Fig.13: Interaction curve for M25 and Fe415 obtained from ETABS

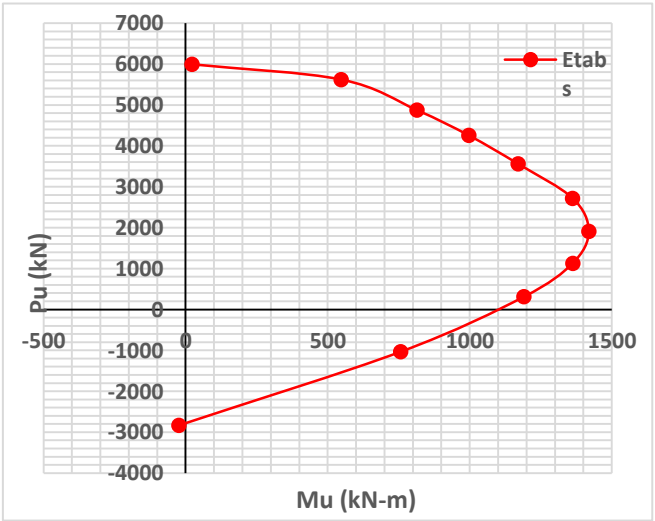

Fig.14: interaction curve for M30 and Fe415 obtained from ETABS

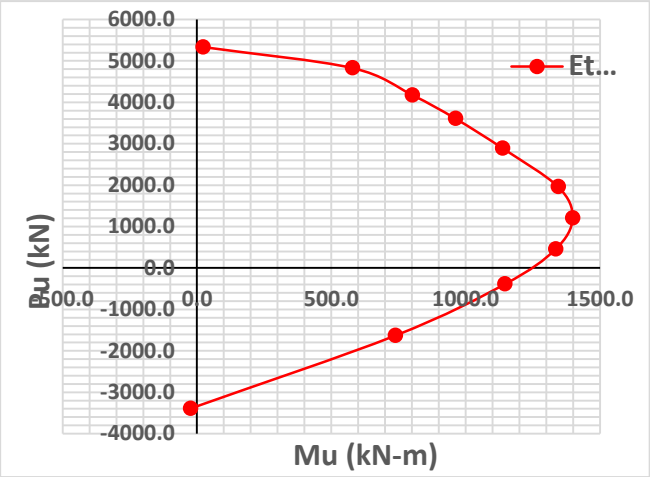

Fig.15: interaction curve for M25and Fe500 obtained from ETABS

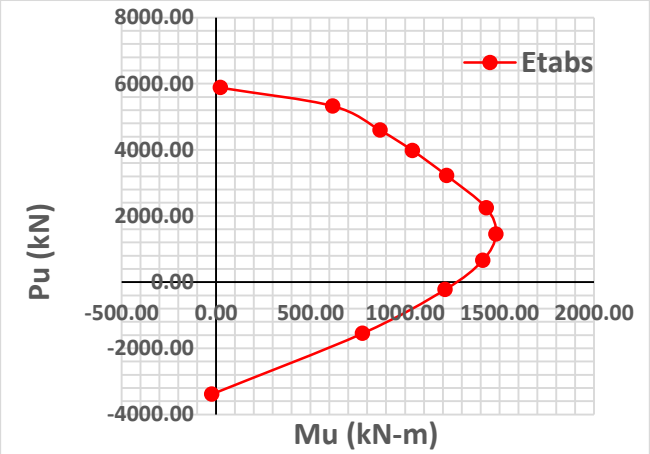

Fig.16: interaction curve for M30and Fe500 obtained from ETABS

6. Comparison of Interaction Curvebyusing Analytical Method and Etabs Software

Comparison of interaction curves between the analytical and ETABS method for M25 and Fe415, M30 and Fe415, M25and Fe500, M30and Fe500 are shown in Fig17,Fig18,Fig19,Fig20 respectively. The load and moment value obtained from ETABS are considerably higher compared to analytical method.

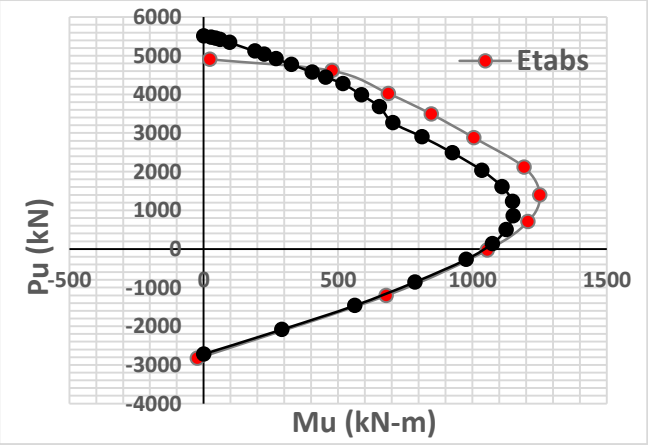

Fig.17: Comparison of interaction curve between analytical and ETABS method for M25 and Fe415

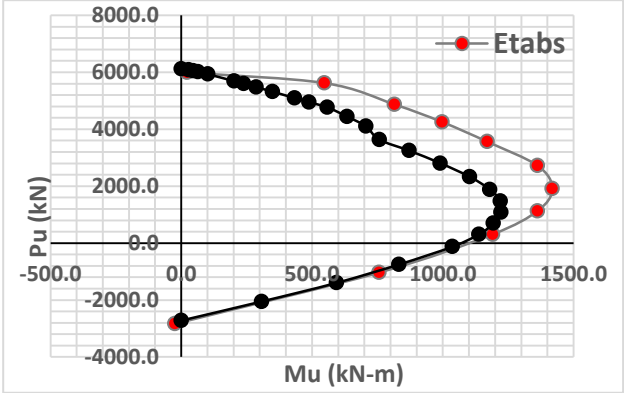

Fig.18: Comparison of interaction curve between analytical and ETABS method for M30 and Fe415

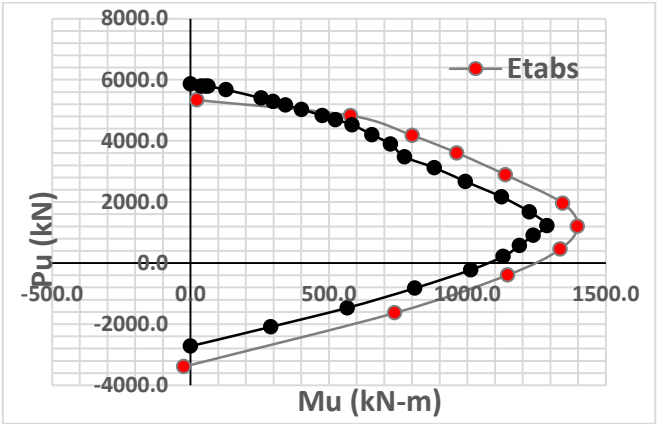

Fig.19: Comparison of interaction curve between analytical and ETABS method for M25 and Fe500

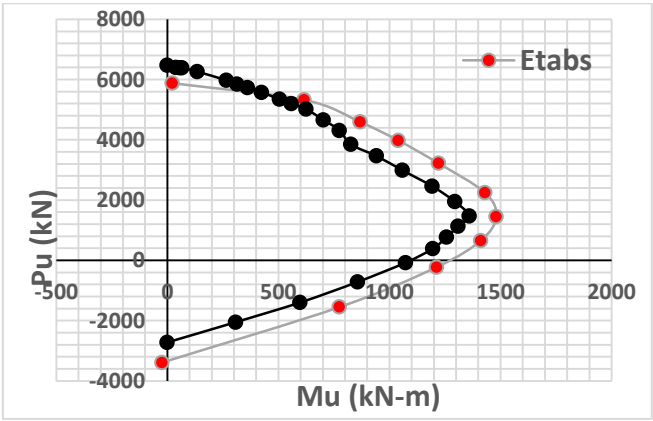

Fig.20: Comparison of interaction curve between analytical and ETABS method for M30 and Fe500

7. Conclusions

Maximum load and moment carrying capacity increases with increasing the grade of steel and grade of concrete in C-shaped RC concrete. Comparison of the graph results by manual and ETABS methods are made,considered deviation is are found due to following reasons,

- For the manual analytical calculation, parabolic stress block is considered but ETABS takes the Whitney's equivalent stress block for calculation, hence variations in results in load and moment.
- For the manual analytical calculation for stress in steel we used TABLE-A of SP 16 code book, but ETABS takes product of strain in steel and modulus of elasticity.

- For manual analytical calculation, the value of K ranges in between 1.05 to 4, but ETABS considered the value of K ranges in between the 1.05 to 1.2.

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