International Journal of Advance Research in Science and Engineering
Vol. No.5, Issue No. 04, April 2016
www.ijarse.com
IJARSE
ISSN 2319 - 8354

DEVELOPMENT OF P-M INTERACTION CHART FOR CONCRETE FILLED TUBE (CFT) COMPOSITE COLUMNS

Hardik. C. Patel[1] , Dr. Vijay. R. Panchal[2]

[1] *P. G. student,* [2] *Professor, Department of Civil Engineering,*

Chandubhai S. Patel Institute of Technology, Charotar University of Science and Technology (CHARUSAT), Changa, District: Anand, Gujarat(India)

ABSTRACT

The manual calculation for P-M interaction diagram for steel-concrete composite columns is laborious and time-consuming. Moreover, no attempts have been made in developing interaction chart of composite columns consisting of steel section, concrete and reinforcing steel. Therefore, an attempt has been made for developing P-M interaction chart for composite column with axial load and uniaxial bending. The paper presents a simplified method for development of P-M interaction chart for composite columns. The method can be used for plotting chart of composite column by solving equation for different points of chart. In order to study the effect of various parameters on the P-M interaction chart, parametric study has been also carried out. The parameters considered are percentage of steel, gross sectional area and shape of the column. P-M interaction charts for composite column has been developed for different reinforcement percentage (varying from 1% to 6%), for square column size (which is varied from 150 × 150 mm to 1200mm × 1200 mm) and circular column diameter (which is varied from 230 mm to 1200 mm).

Keywords: composite column, Concrete Filled Tube (CFT), interaction chart.

I. INTRODUCTION

A steel concrete composite column consisting of steel section, concrete and reinforcing steel is generally used as a load bearing member in a composite frame structure. The composite column is mainly of three types which are shown in Fig. 1 [1].

1. Fully concrete encased hot rolled steel section (ReferFig. 1(a))
2. Partially concrete encased hot rolled steel section(ReferFig. 1(b))
3. concrete filled tube section of hot rolled steel (ReferFig. 1(c and d))

International Journal of Advanced Technology in Engineering and Science
Vol. No.4, Issue No. 03, March 2016
www.ijates.com
ijates
ISSN 2348 - 7550

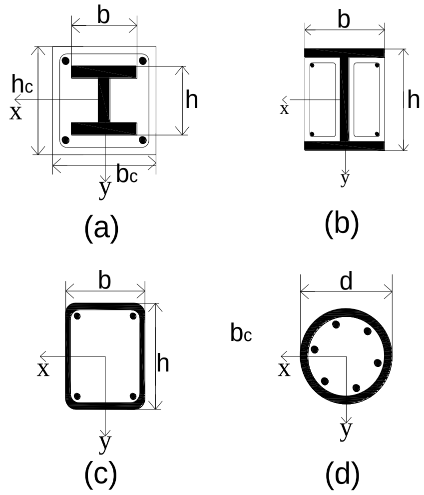


Fig.1 Different types of composite columns

Concrete filled steel tube columns are used in many earthquake resistant structures, columns in high rise buildings, bridge piers subject to high strain rate from traffic and railways decks.

There is few information available on development of P-M interaction chart for composite column. Therefore, in order to provide assistance to current research and engineering, it is necessary to develop the P-M integration chart for the composite column.

The objective of present study may be summarized as:

i. To develop simply method for development of P-M interaction chart

ii. To develop interaction chart for composite column with axial load and uni-axial bending

iii. To carry out parametric study in order to study the effect of various parameters

II. LITERATURE REVIEW

Gouwens [2] developed simplified design aids for rectangular columns. Rodriguez and Aristizabal-Ochoa [3] presented a general method that determines the biaxial interaction diagrams for any orientation of the neutral axis of a reinforced concrete (RC) short column of any cross section under axial load and bending about two axes. Panchal [4] developed a software for composite slab, beam, column with pre and post processing facilities in VB.NET. All design checks were incorporated in software. In the software full and partial connections and transverse reinforcement were also considered. Author also prepared a database of steel section with properties.Ketema and Taye [5] presented unified approach for the procedure of establishing design charts for concrete-filled steel tubes under uniaxial bending and prepared valuable charts for hexagonal and octagonal shape composite columns. Thakkar [6] presented a scheme for development of interaction curves for damaged and retrofitted columns enabling more accurate evaluation of the capacity of the column, before and after retrofitting. Gediya & Koradia [7] worked on design of concrete encased steel section. Authors developed a load versus moment interaction charts for different steel section in composite column by using a simple excel program. Kwon et al. [8] described development of the direct strength method (DSM) for concrete-filled tubular (CFT) sections.

Very few attempts have been made for the development of P-M interaction charts for Concrete filled tube composite columns. In order to provide assistance to current research, there is a real need to develop interaction diagrams for Concrete filled tube composite columns of various shapes.

III. METHODOLOGY

A typical load-moment interaction chart represents the relationship between axial load capacity and the ultimate bending moment capacity of a given column cross section. Using design interaction curve for a given column section, quick judgment as to whether or not the section is safe can be made.

The interaction diagrams of reinforced concrete (RC) rectangular columns have been investigated extensively by numerous researchers and included in the text books. But, there is no provision in Indian standard code covering composite columns. So, method to develop interaction charts for the composite columns based on Euro Code 4(2004) has been proposed. Two methods are available for calculations. The first one is general method which can be applied to columns of asymmetric cross-section as well as to columns whose section varies with height and second method is a simplified method which is based on simple European buckling curves for composite columns. Here, second method is considered as it is applicable to the majority of practical cases.

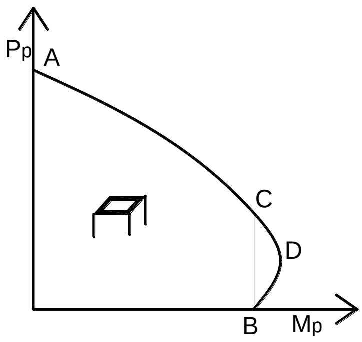


Fig.2 Interaction chart for composite column.

Fig. 2 shows an interaction curve drawn using simplified design method suggested in the EC 4. At point A, axial force resistance is maximum and moment resistance is zero. So, point A makes section for compression resistance only.

$$P_p = P_A = A_a p_y + \alpha_c A_c p_{ck} + A_s p_{sk} \tag{1}$$

where,

$$p_y = \frac{f_y}{\gamma_a}, p_{ck} = \frac{f_{ck}}{\gamma_c}, p_{sk} = \frac{f_{sk}}{\gamma_s}$$

The provisions contained in IS: 456 - 2000 are often invoked for design of composite structures. Extension of IS: 456 - 2000 to composite columns will result in the following equations.

$$p_y = 0.87 f_y,\ p_{ck} = 0.4 f_{ck},\ p_{sk} = 0.67 f_y$$

$$M_A = 0 \tag{2}$$

At point B, axial force resistance is zero and plastic moment resistance is as per equation.

$$P_B = 0 \tag{3}$$

$$M_B = M_p = p_y(Z_{pa} - Z_{pan}) + 0.5p_{ck}(Z_{pc} - Z_{pan}) + p_{sk}(Z_{ps} - Z_{psn}) \quad (4)$$

where,

$$Z_{pan} = t\,h_n^2$$

$$Z_{pcn} = b_c h_n^2 - Z_{psn} - Z_{pan}$$

At point C, axial force resistance and moment resistance of the sections are given as

$$p_c = A_c p_{ck} \quad (5)$$

$$M_C = M_p = p_y(Z_{pa} - Z_{pan}) + 0.5p_{ck}(Z_{pc} - Z_{pan}) + p_{sk}(Z_{ps} - Z_{psn}) \quad (6)$$

At point C, the tension area of concrete is same as the compression area of the concrete so the moment resistance of section is same as point B so value of M_B and M_C is same for section. So, compression region in the section creates some internal force which is same as plastic resistance to compression of the concrete only.

At point D Moment resistance of the section is maximum and axial force resistance is half of point C.

$$P_D = 0.5A_c p_{ck} \quad (7)$$

$$M_D = M_p = p_y(Z_{pa}) + 0.5p_{ck}(Z_{pc}) + p_{sk}(Z_{ps}) \quad (8)$$

where, Z_{pcn} and Z_{psn} are depend on value of h_n.

For Major axis bending

$$h_n = \frac{A_c P_{ck} - A_s'(2p_{sk} - p_{ck})}{2b_c p_{ck} + 4t(2p_y - p_{ck})} \quad (9)$$

For circular tubular section substitute $b_c = d$

For minor axis bending the same equations can be used by interchanging *h* and *b* as well as the subscripts *x* and *y*.

Condition must be satisfied for section for moment resistance of section.

$$M \le 0.9\mu M_P$$

where, μ is moment resistance ratio

For axial compression resistance of section

$$\chi . p_P > p$$

where, χ is reduction factor for column buckling

$$\chi = \frac{1}{\left(\phi + \{\phi^2 - \lambda^2\}^{\frac{1}{2}}\right)}$$

$$\phi = 0.5\left[1 + \alpha(\lambda - 0.2) + \lambda^2\right]$$

So these conditions must be satisfied for a safer section.

IV. NOTATIONS

A_a, A_s, A_c - Cross-sectional area of steel section, reinforcement and concrete

b - Breadth of section

b_c - Breadth of column

h_c - Depth of column

h - Depth of section

d - Diameter of section

E - Modulus of elasticity of section

f_{sk} - Characteristic strength of reinforcement

f_y - Yield strength of steel

f_{ck} - Characteristic strength of concrete

p_y,p_{sk},p_{ck} - Design strength of steel section, reinforcement and concrete

h_n - Depth of neutral axis from the middle line of the cross-section

M - Moment applied on section

P - Axial force applied on section

M_p - Plastic moment resistance of the section

P_p - Plastic resistance to compression of the cross section

P_c - Axial resistance of concrete

t -Thickness of element

Z_p - Plastic section modulus

Z_{psy},Z_{pay},Z_{pcy} -Plastic section modulus of steel section, reinforcement and concrete about their own axis

Z_{psn},Z_{pan},Z_{pcn}- Plastic section modulus of steel section, reinforcement and concrete about neutral axis

χ - Reduction factor buckling

α_c - Axial resistance ratio due to concrete

µ - Moment resistance ratio

γ - Safety factors for different materials

λ - Slenderness ratio

V. EXAMPLES OF INTERACTION CHARTS FOR CONCRETE FILLED TUBES

Developed charts for different cross-sections and different percentage of steel are shown in Figs. 4 to 6.

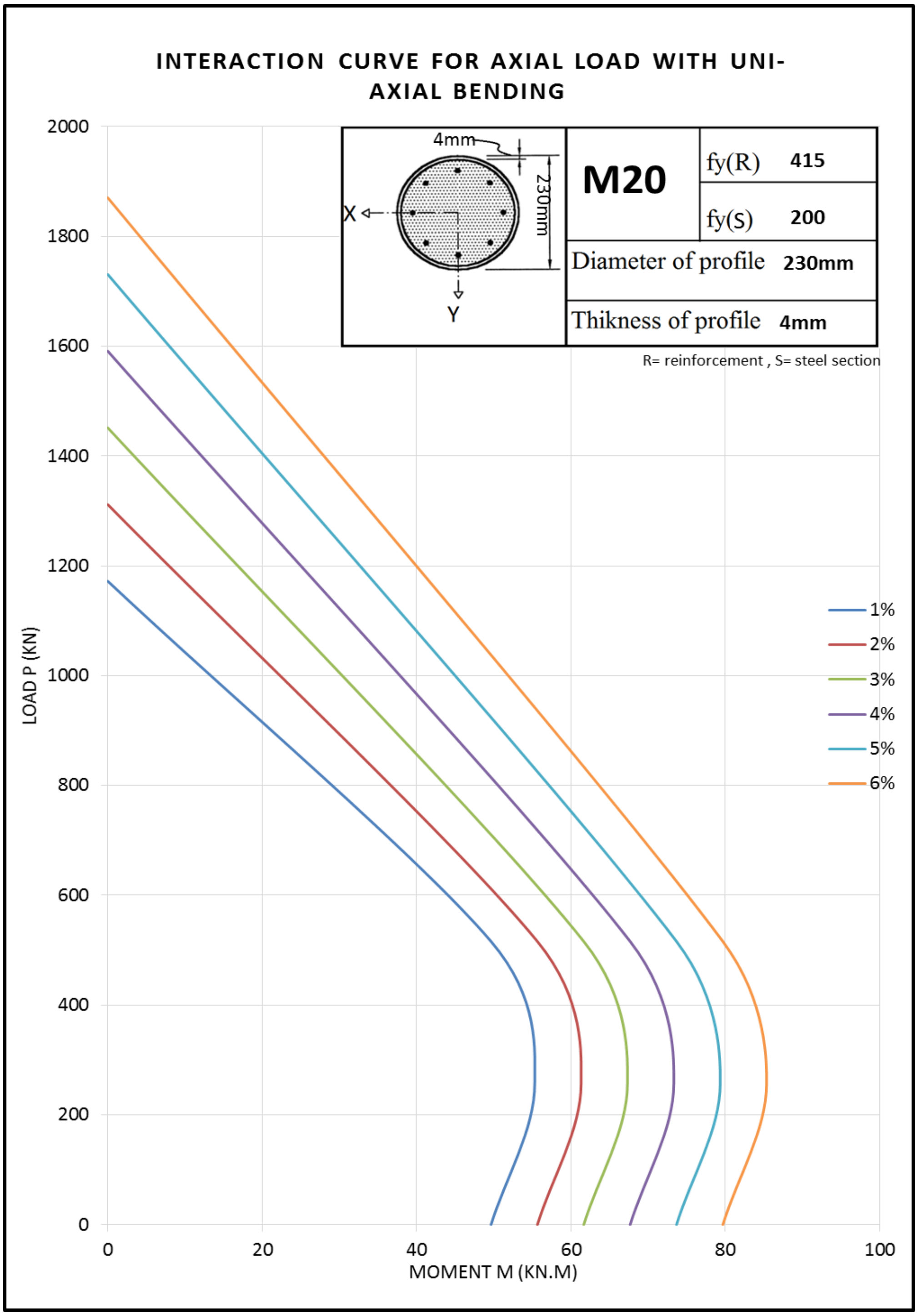


Fig.3 P-M interaction curve for circular section of 230mm diameter.

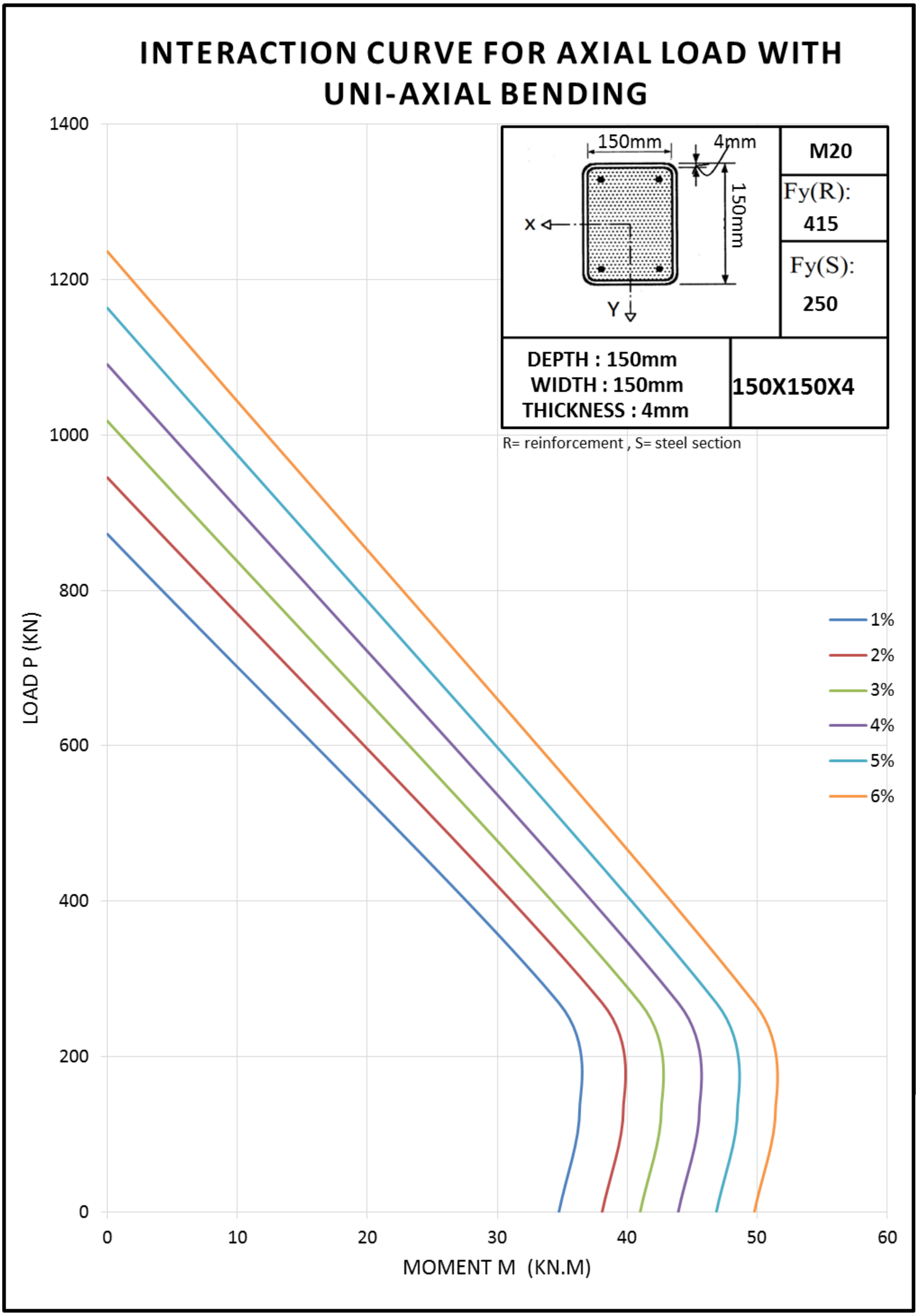
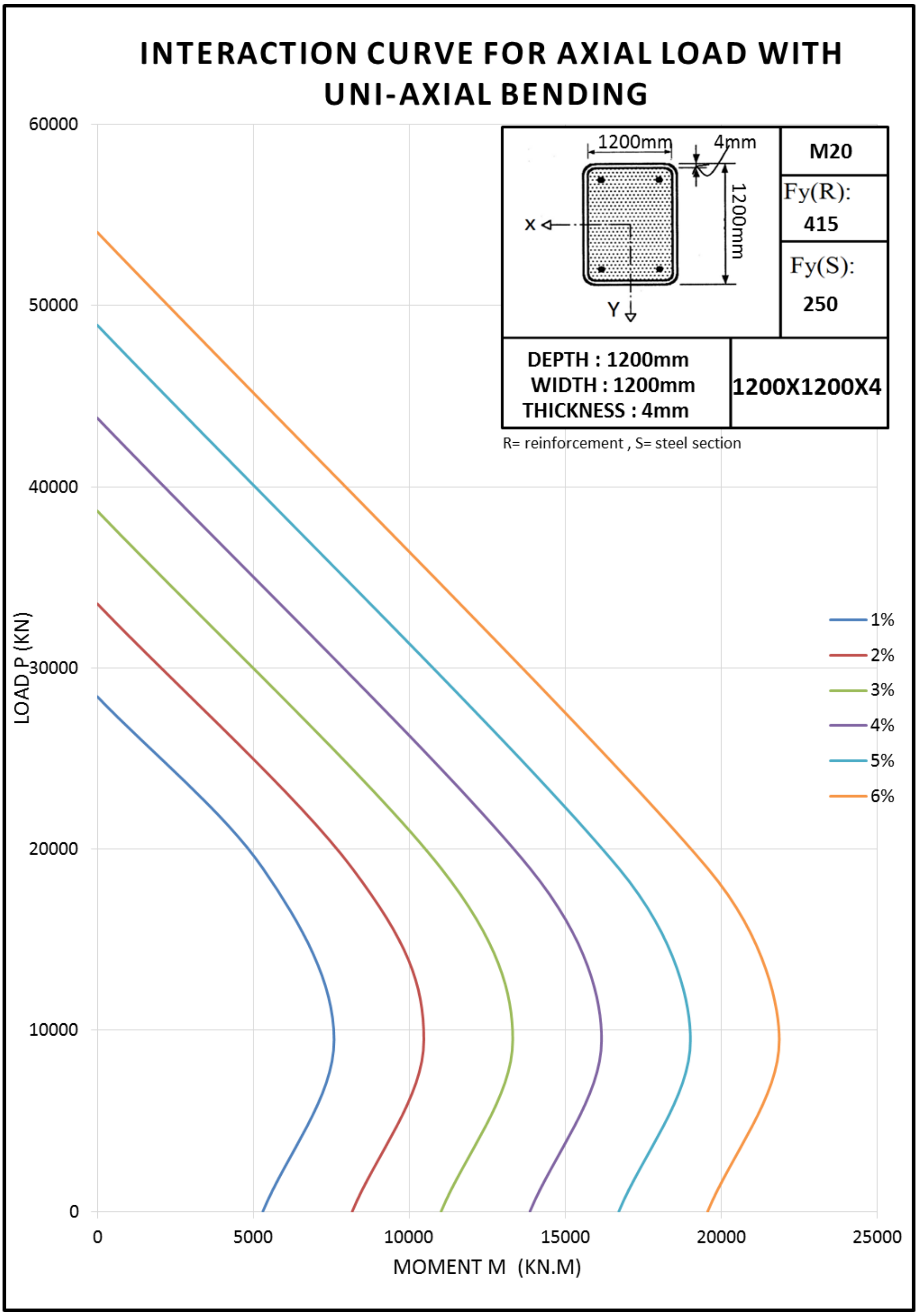


Fig. 5 P-M interaction curve for square section of 150 mm × 150 mm.



V. CONCLUSIONS

1 Interaction charts of composite column for Concrete filled circular steel tube and Concrete filled rectangular

Fig. 6 P-M interaction curve for square section of 1200 mm × 1200 mm.

steel tube type of sections using help of Eurocode 4 (2004), EN 1994-1-1:2004 has been enveloped.

2 Moment capacity and axial load carrying capacity of composite column can be directly found out from these charts for a desired percentage of reinforcing steel.

3 These charts eliminate manual calculations for finding out moment and axial load carrying capacity of composite columns mentioned above. It saves lots of time.

REFERENCES

[1]. Narayanan, R. and Kalyanaraman, V: ‘‘Teaching resource of structural steel design”, Vol. 2, Institute for Steel Development and Growth (INSDAG), Kolkata.

[2]. Gouwens, A. J: ‘‘Biaxial bending simplified.’’ Reinforced concrete columns. American Concrete Institute, special publication sp-50, pp.223-261,(1975).

[3]. J. A. Rodriguez and J. Dario Aristizabal-Ochoa: “Biaxial interaction diagrams for short RC columns of any cross section” Journal of structural engineering,125(6), pp.672-683 (1999).

[4]. D. R. Panchal: “Advanced Design of Composite Steel-Concrete Structural element” International Journal of Engineering Research and Applications, 4(7), pp.124-138, (2014).

[5]. Erimiyas Ketema and Shifferaw Taye: ‘‘Design chart procedures for polygonal concrete-filled steel columns under uniaxial bending” EthiopianJournal of Science,29(1), pp.1-16, (2006).

[6]. Bhairav K Thakkar: “Interaction Curves for Retrofitted Columns” International Journal of Engineering Research & Technology,1(8), pp.1-8, (2012).

[7]. Y.K.Gediya, K.C.Koradia: ‘‘Construction of interaction diagram for composite column” International Journal of Advance Engineering and Research Development,2(5), pp.482-486, (2015).

[8]. Young Bong Kwon, Sung Woong Park and In Kyu Jeong: “Resistance of rectangular concrete-filled tubular sections to the combined axial compression and bending” Conference on Advances in Civil, Structural and Construction Engineering CSCE (2015).

[9]. Eurocode 4 (2004), “General rules for buildings design of composite steel and concrete structure”, Committee Members of the European Union.

[10]. IS: 456 (2000), “Code of Practice for Plain and Reinforced Concrete”, Bureau of Indian Standards, New Delhi.

[11]. IS: 11384 (1985), “Code of practice for composite construction in structural steel and concrete”, Bureau of Indian Standards, New Delhi.

[12]. Shosuke Morino &Keigo Tsuda: “Design and Construction of Concrete-Filled Steel Tube Column System in Japan” Earthquake Engineering and Engineering Seismology, 4(1), pp.51-73,(2003).

[13]. Kamyar Bagherinejad, Emad Hosseinpour & Seyed Hamed Hosseini: ‘‘Evaluation Of Rectangular Concrete-Filled Steel-Hollow section Beam-Column”, Journal of Asian Scientific Research,5(1), pp.46-59, (2015).

[14]. Murugesh Dodakundi, Anand Layadgundi, Rekha G. Padaki. "RELIABILITY EVALUATION OF WIND FARMS." International Journal of Advanced Technology in Engineering and Science 3.Special Issue No. 01 (2015): 89-98.