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A BRIEF STUDY ON DIFFERENT STRESSES OF STEEL STRUCTURAL MEMBER AS PER INDIAN STANDARD PARALLEL SECTION

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Abstract- The motive of a structural engineer is to design a structure that can withstand its demand throughout the life span. A compressive member is primarily designed to carry axial loading but it always has a possibility to fail due to bending. Here, different stresses of compression members have been observed with different effective lengths, following the Indian code of limit state methods of steel structures IS 800-2007.As per the present Indian scenario, different sections of universal columns (as per BS-1:1993), which are available in the Indian market, has been taken for its high strength and variety.The designed tables and graphs are prepared for finding the capacity of cross section with various effective lengths which will be beneficial for the designer. In this paper, no attempt has been made to consider complete structure and the overall analysis of the building. Euro code and AISC code are compared with IS 800:2007 which are then preceded by a comprehensive set of explanatory notes.In this study, attempt has been made, to prepare a practical guide to the compression member as per IS 800-2007 focusing on buckling stress and other stresses.

Keywords – Compressive strength, Compressive members,yield stress, Buckling, Buckling stress, Design strength.

I. INTRODUCTION

Compressive members are one of the basic structural elements which are primarily designed to carry axial compression. In various types of compression members, the columns are ordinarily used in the buildings as vertical members to carry loads of beams,slabs etc. Columns are usually straight vertical members whose lengths are considerably greater than their cross-sectional dimensions. The safe axial load depends on the dimensions, length of the members and end conditions of the members. The various modes of failure of a column are crushing, buckling and a mixed mode of buckling and crushing.i

The buckling tendency of a column varies with the ratio of the length to least lateral dimension. The smallest force at which a buckled shape is possible is known as critical force. Steel plated structures are likely to be subjected to various types of loads and deformations arising from service requirements that may range from the routine to the extreme or accidental.

The mission of structural design is to design a stable structure that can withstand such demands throughout its expected life. In this paper attempt has been made to prepare a guide as per IS: 800-2007 by focusing on the problem of the designers.

II. DESIGN OF COMPRESSION MEMBER

A. Design of compression member –

A structural member which is subjected to compressive forces along its axis is called a compressive member;from the basic mechanics of materials for long columns, buckling occurs prior to developing the full material strength of member. So a sound knowledge of stability theory is necessary for designing compression member in structural steel. The strength of the column depends on the -Material of the column, Cross sectional configuration,Length of the column, Ends support condition,Residual stresses, Imperfections.

The effect of these parameters on the strength and stability of columns are briefly discussed in design as per Indian code of practice IS: 800:2007.

The design compression strength of a member$P_d = A_e * f_{cd}$

Section classification is depends on b/t_f and d/t_w

$$\text{If } t_f < 20\text{mm, then fy} = 250\text{n/mm}^2 \text{ then } \epsilon = \sqrt{250/fy}$$

$$\text{If } b/2/t_f < 15.7\,\epsilon \quad \text{then the flange us not slender} \qquad (1)$$

$$d/t_w = \frac{d-2\,tf-2\,r}{tw} < 42\,\epsilon \text{ then web is not slender}$$

The effective length depends on end condition;slenderness ratio is max 180 for axial loaded hot rolled sections. For imperfection factor buckling class is define on D/ B and t_f Thickness of flange.

Stress reduction factor

$$\chi = \frac{1}{[\phi+(\phi^2-\lambda^2)^{.5}]} \text{ if } \chi<1, \text{ then } \chi \text{ nor } 1$$

$$F_{cd} = \chi\,(fy/\lambda_{mo}) \qquad (2)$$

$$\text{Where } \phi = 0.5\,(1+\alpha\,(\lambda-0.2)+\lambda^2$$

Imperfection factor = α, which is depends on buckling class

Non dimensional effective slenderness ratio $\lambda = \sqrt{\frac{fy}{fcc}}$

B. According to the Euro code–

$$N_{ed} / N_{bRd} \le 1.0 \quad N_{ed} = \text{design value}, \; N_{bRd} = \text{design buckling resistance}$$

$$N_{bRd} = \chi\,(Afy/\gamma_{m1}), \chi = \frac{1}{[\phi+(\phi^2-\lambda^2)^{.5}]} \quad \text{but } \chi \le 1.0 \qquad (3)$$

$$\text{Where } \phi = 0.5\,(1+\alpha\,(\lambda-0.2)+\lambda^2$$

Imperfection factor = α,which is depends on buckling class

Non dimensional effective slenderness ratio $\lambda = \sqrt{\frac{A\,fy}{Ncr}}$

if $\lambda \le 0.2$ the buckling effects may be ignored and only cross sectional checks apply.

N_{cr}= elastic critical force for the relevant buckling mode based on the gross cross sectional properties.

B. According to AISC code -

The design strength of columns for the flexural buckling limit state is equal to φcPn

Where, $\varphi_c = 0.85$ (Resistance factor for compression members)

$$P_n = A_g F_{cr} \qquad (2.2.1)$$

$$\text{- For } \lambda_c \le 1.5 \qquad F_{cr} = (0.658^{\lambda 2c})F_y \qquad (2.2.2)$$

$$\text{- For } \lambda_c > 1.5 \qquad F_{cr} = (0.877/\lambda^2{}_c)\,F_y \qquad (2.2.3)$$

$$\text{Where, } \lambda_c = (K\,L/r\,\pi)\sqrt{\frac{Fy}{E}}$$

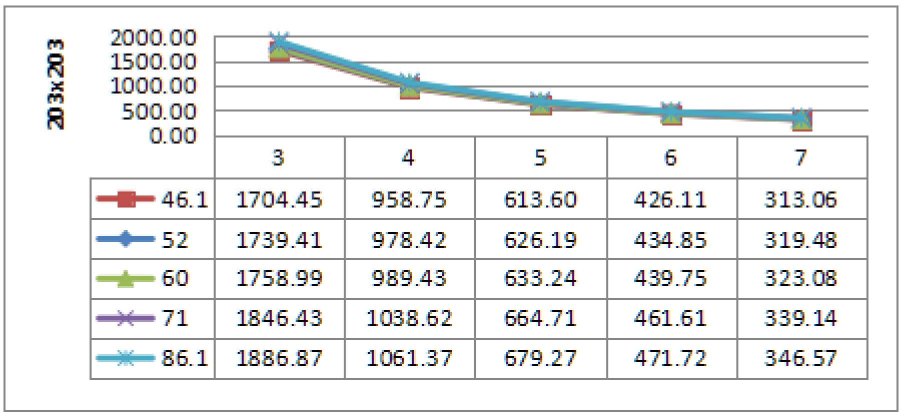
F_y = yield stress

Ag = gross member area;

K = effective length factor
L = unbraced length of the member;
r = governing radius of gyration

III. DESIGN ANALYSIS AND DISCUSSION

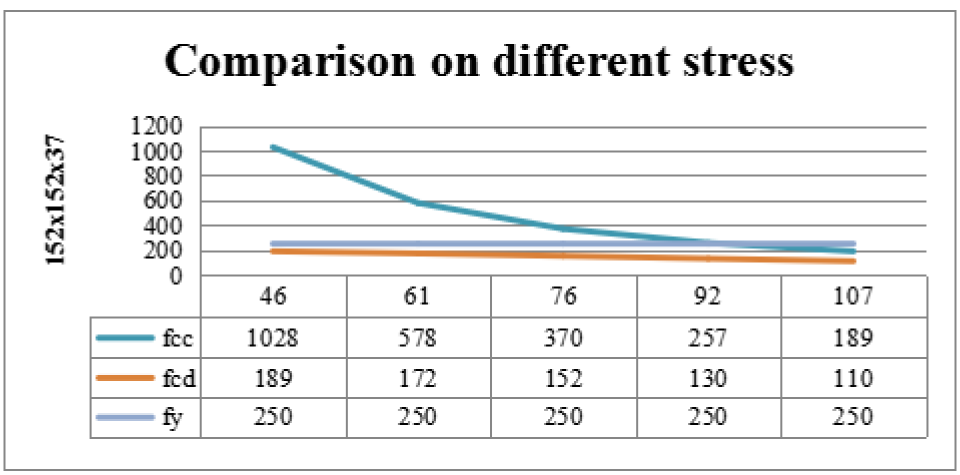
Stability has a vital role in designing a compression member. Normally, structural analysis is based on the condition of stable equilibrium between internal and external forces. In general, long columns fail by elastic buckling. In this study, different sections of universal columns (as per BS-1:1993), which are available in the Indian market, has been taken. According to IS:800-2007, it is clear that buckling stress will be increases with the sectional weight of constant effective length and will be decreases with the effective length. Here in this graph (graph-1) 203x203 UC sections are chosen for the examples and the unit of effective length in meter and stresses are considered in N/mm^2.



	3	4	5	6	7
46.1	1704.45	958.75	613.60	426.11	313.06
52	1739.41	978.42	626.19	434.85	319.48
60	1758.99	989.43	633.24	439.75	323.08
71	1846.43	1038.62	664.71	461.61	339.14
86.1	1886.87	1061.37	679.27	471.72	346.57

Graph 1: Buckling stress graph with the effective length of the section

Buckling stress crosses the proportional limit after the slenderness ratio 88.84,after that section cannot follow the hooks law.But the design compressive stress is still lower than buckling stress, so, the design is safe according to IS: 800-2007. i.e., the design can be applied on longer columns.



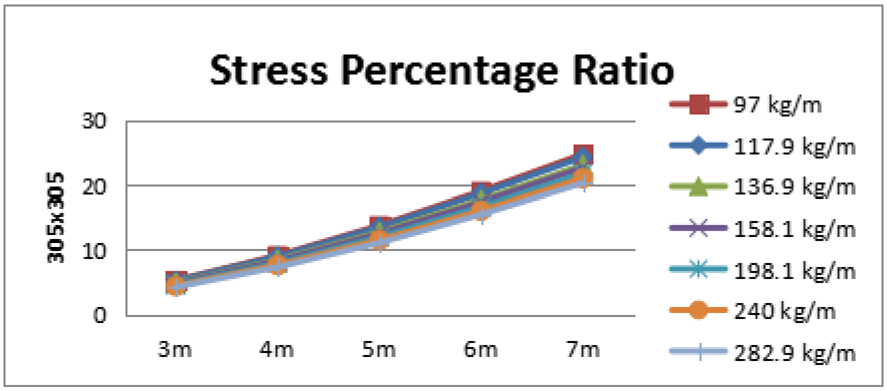
	46	61	76	92	107
fcc	1028	578	370	257	189
fcd	189	172	152	130	110
fy	250	250	250	250	250

Graph 2: Comparison between design stress, buckling stress and yield stress

Graph- 2 shows it clearly, that design compressive stress is less than yield stress on any section of any effective length, whereas the buckling stress is much higher than design stress.

Table 1: stress percentage ratio of 305x305 UC sections

305x305	3m	4m	5m	6m	7m
97 kg/m	5.31	9.15	13.79	19.07	24.79
117.9 kg/m	5.2	8.96	13.52	18.71	24.33
136.9 kg/m	4.9	8.45	12.77	17.7	23.09
158.1 kg/m	4.8	8.28	12.51	17.37	22.67
198.1 kg/m	4.59	7.92	11.99	16.66	21.78
240 kg/m	4.41	7.63	11.55	16.07	21.05
282.9 kg/m	4.24	7.34	11.12	15.49	20.32



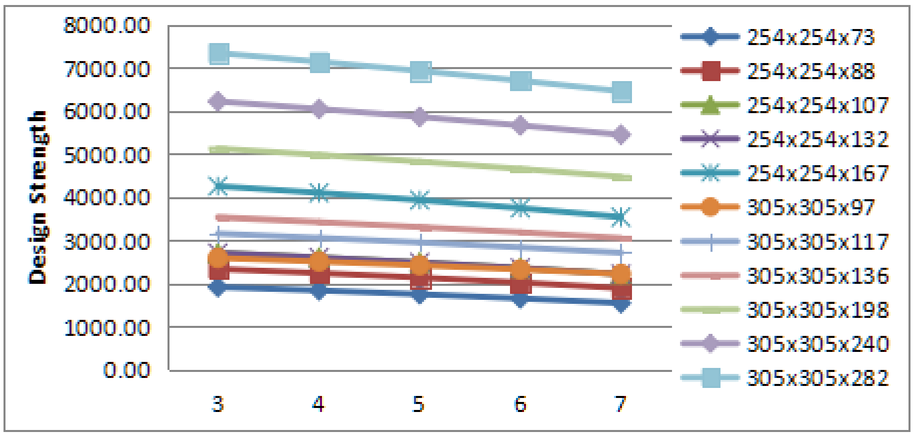
Graph 3: percentage of design stress on the basis of buckling stress.

From graph 3 and table 1, shows the percentage ratio of design stress and buckling stress.i.e.,[fcd/fcr)*100] the ratio of design compressive stress,on the basis of buckling stress, in percentage. Here, 305x305 section shows that, with the increases of weight, percentage ratio decreases and with the length, percentage increases. It is observed that design stress is considered 4-25 percent of buckling stress as per IS:800-2007. i.e., the chances of failure due to different stresses will be lower upto the design stress.

Table 2: design compressive strength of different sections of universal columns as per IS: 800-2007

		Design strength (KN)				
section	wt(kg /m^2)	3m	4m	5m	6m	7m
152x152x23	23	546.58	492.28	429.36	363.73	303.12
152x152x30	30	721.20	653.88	575.52	492.30	413.59
152x152x37	37	890.99	809.86	715.29	614.19	517.69
203x203x46	46.1	1169.20	1100.82	1022.35	933.36	836.90
203x203x52	52	1321.70	1245.66	1158.55	1059.73	952.33
203x203x60	60	1466.12	1385.23	1292.94	1188.26	1073.76
203x203x71	71	1744.77	1652.14	1546.88	1427.55	1296.42
203x203x86	86.1	2118.06	2007.50	1882.11	1740.02	1583.58
254x254x73	73.1	1913.36	1834.23	1746.93	1649.44	1541.09
254x254x88	88.9	2332.20	2237.58	2133.43	2017.33	1888.34
254x254x107	107.1	2704.72	2599.55	2484.37	2356.50	2214.61

254x254x132	132	2745.06	2641.50	2528.50	2403.43	2264.83
254x254x167	167.1	4243.15	4088.40	3920.24	3734.76	3529.57
305x305x97	97	2588.00	2505.60	2417.45	2321.65	2216.70
305x305x117	117.9	3153.30	3054.32	2948.63	2833.93	2708.44
305x305x136	136.9	3524.85	3418.57	3305.57	3183.48	3050.39
305x305x198	198.1	5116.54	4968.80	4812.45	4644.33	4461.80
305x305x240	240	6209.54	6034.71	5850.15	5652.26	5437.91
305x305x282	282.9	7330.52	7129.28	6917.40	6690.81	6446.00



Graph 5: design strength of different sections of universal columns as per IS: 800-2007

Now, according to IS:800-2007 compression member design is considered safe. So,here the design aid is prepared with the table and graph. Where it shows, the maximum safe design compressive strength (in N)of different section (available in Indian market) with their varying effective length. It will be very easy to find the safe design for new designer with the help of this table and graph .

IV.CONCLUSION

- Buckling stress crosses the yield stress at the value of slenderness ratio 88.84.
- As per IS: 800-2007 from the design point of view, for axial loading column slenderness ratio considered up to 180 which can withstand the design stress without failure.
- The design stress is 4-25 percent of buckling stress as per IS:800-2007.
- It is easy to find the safe design for new designer with the help of this table and graph.
- IS: 800-2007 code is nearly same as EURO code except the z-direction consideration of the section but the values of the designs are nearly same.
- In AISC code design strength formula depends on the value of λ_c .

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