ISSN 2347-4289

Analysis And Design Of Semi Rigid Steel Frame And Joints

Supriya Ghanekar

Department of Civil Engineering, A. I. S. S. M. S. C. O. E. Savitribai Phule Pune University, Pune, India.
Email: supriya.ghanekar@yahoo.com

ABSTRACT: This paper presents analysis and design method for semi rigid steel frame. The frame is having multi bay and multi storey. This frame is analyzed for number of rigidities varying from 0 % to 100 %. The design of members is done for each case. The case for which weight is coming minimum is selected. The semi rigid joint is designed for that case. The rigidity of the joint is achieved by adjusting the moment-rotation relationship.

Keywords: Semi rigid connections, Steel frame, Loads, Load factor, Load combination, Rotation, Minimum weight

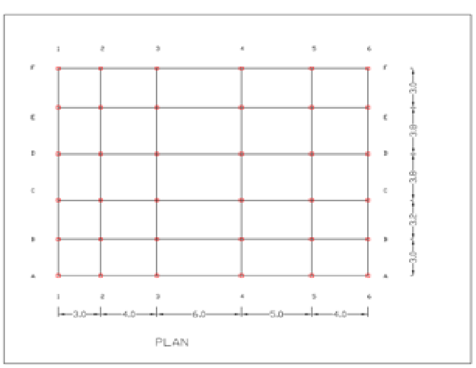
1. INTRODUCTION

Presently the joints in the steel frames are designed as fixed or pinned joint. Generally the welded joints and bolted joints are designed as fixed joints or pinned joints as per the requirement. While designing the joints it is assumed that the fixed joint is not having any kind of flexibility and pinned joint are not having any kind of stiffness. i.e. while designing it is considered as fixed joints are totally stiff and pinned joints are totally flexible. It is assumed that the pinned joint allows the rotation and fixed joint do not allow rotation as well as translation. Disadvantages of the conventional or present practice are that, it leads to incorrect analysis. As per new practice it is observed that fixed joints have some amount of flexibility and pinned joint have some amount of stiffness. i.e. fixed joint allow small amount of rotation also. But as per present analysis and design this effect is not considered in the analysis and hence it leads to incorrect analysis and design. Also this design leads to impractical analysis and design. Hence to overcome this drawback connections are considered as semi rigid i.e. partially fixed and partially pinned connection. It is the middle stage of fixed and pinned. It is in between the stiffened and flexible. These connections are neither totally fixed nor totally pinne

2. PROBLEM

A five bay five storey steel structure is selected for the analysis. The structure is analyzed for various load combinations. The structure is of dimension 22m in length and 15.8 m in width and 15.6 m height. The structure has 216 nodes, 180 columns and 300 beams.

Figure 1: *Plan*



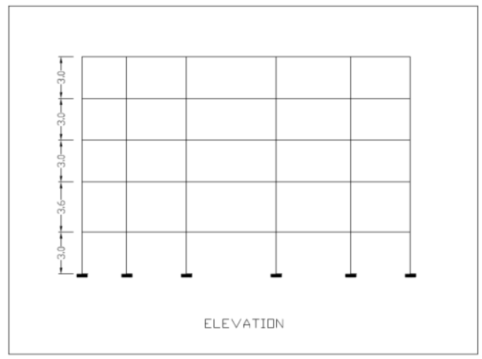


Figure 2: *Elevation*

3. ANALYSIS AND DESIGN

A model was generated in STAD-PRO and analysis was done for different rigidities. The Design was done for beams and columns for worst load combination were using standard programs . The Total weight required for the structure in each case of rigidity was calculated and tabulated.

Table 1: *% Release And Total Weight*

RELEASE	WEIGHT
	M.T.
0	72.97
10	71.71
20	70.07
25	69.45
30	68.82
40	67.38
50	65.23
60	62.88
70	61.33
75	61.78
80	62.76
90	66.19
100	75.32

ISSN 2347-4289

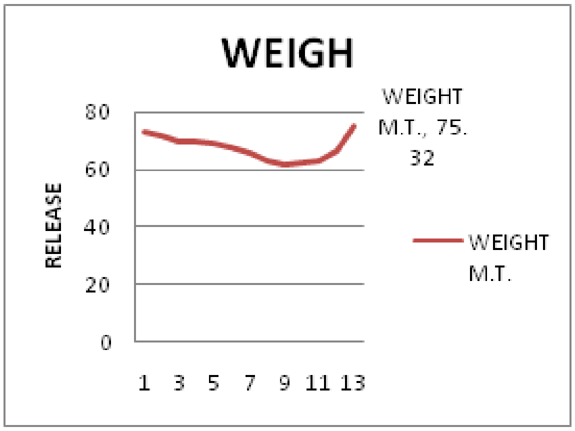


Figure 3: *% Release And Total Weight*

Similarly the sway is calculated in each case of rigidity and tabulated below.

3. LOADING

3.1 Loads considered are
Wall D. L. =14.4 KN/m on first floor
12 KN/m on upper floors
4 KN/m on roof
Slab dead load= 4.75 KN / $m2$
Slab live load= 4.0 KN / $m2$ on first floor
Slab live load= 2.0 KN / $m2$ on upper floor
Following are the load combinations for analysis
3.2 Load combination
1.5 D.L. + 1.5 L.L. PATTERN 1
1.5 D.L. + 1.5 L.L. PATTERN 2
1.5 D.L. + 1.5 L.L. PATTERN 3
0.9 D.L. + 1.5 EQ. L. X
0.9 D.L. + 1.5 EQ. L. Y
1.2 D.L.+ 1.2 L.L PATTERN 1 + 1.2 EQL X
1.2 D.L.+ 1.2 L.L PATTERN 1 + 1.2 EQL Y
1.2 D.L.+ 1.2 L.L PATTERN 2 + 1.2 EQL X
1.2 D.L.+ 1.2 L.L PATTERN 2 + 1.2 EQL Y
1.2 D.L.+ 1.2 L.L PATTERN 3 + 1.2 EQL X
1.2 D.L.+ 1.2 L.L PATTERN 3 + 1.2 EQL Y
Worst combination is considered for designing.
Where,
Pattern 1 is live load on all odd spans
Pattern 2 is live load on all even spans
Pattern 3 is live load on all spans

Table 2: *% Release And Horizontal Deflection*

RELEASE	SWAY
	mm
0	32.11
10	34.84
20	38.35
25	40.47
30	42.88
40	48.84
50	56.9
60	68.23
70	85.28
75	97.57
80	114.27
90	178.75
100	476.89

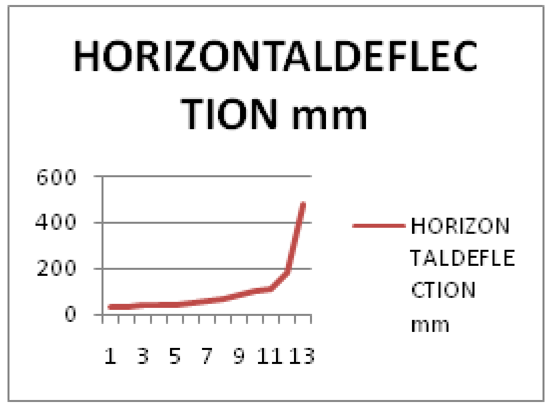


Figure 4: *% Release And Horizontal Deflection*

Permissible maximum sway is H/250 which is coming out to be 62.4 mm. Though the sway for 50 % release is well within the limit (56.9 mm) the maximum drift is not coming as per IS specification. Hence we have considered 40 % release for the joint designing. For this release sway as well as storey drift are coming well within permissible limits.

5. Joint designing

Maximum rotation of 0.003 radians is coming for node no.182. Design of typical joint for same node is shown below. Using Frye-Morris polynomial model for semi rigid connections $\theta r = C1(KM) + C2(KM)3 + C3(KM)5$
Where,
M=moment at the joint in KN m:
K=standardization parameter which depend on Connection type and geometry
$C1, C2, C3$= curve fitting constants
Type of joint considered is 'End plate without column stiffeners' because columns are square tube sections and there is no possibility of giving stiffeners. For this type of joint values of constants are
$C1$=1.78*10^4
$C2$=-9.55*10^16
$C3$=5.54*10^29

For this joint value of K is
K= $dg^{-2.4} tp^{-0.4} d_b^{-1.5}$
Where,

ISSN 2347-4289

dg=c/c of outermost bolt of the end plate connection in mm
tp=thickness of end plate
db=diameter of bolt

For node 182 connecting beam no 145 is designed as follows
Actual rotation is 0.003 radians
Section used is ISMB 200
Plate size used 200*200*10
Moment is 14.92 KN m
dg assumed is 230 mm
tp assumed is 10 mm
db assumed is 16 mm

With the above properties rotational capacity of the joint is coming as 0.00281 radians.
If dg is taken as 200 mm rotational capacity of the joint is coming as 0.00359 radians.
If dg is taken as 220 mm rotational capacity of the joint is coming as 0.00303 radians.
Thus by changing dg we can achieve required rotational capacity of the joint.

6. Conclusion

Weight reduction of about 5.59 ton or about 3,50,000 Rs. Can be achieved. Without affecting sway beyond permissible limits. Also joints can easily be designed.

REFERENCES.

[1] Phu-Cuong, Nguyen, Seung-EockKim, An advanced analysis method for three-dimensional steel frames with semi- rigid connections, Journal of Finite Elements in Analysis and Design, vol. 80 (2014) pp. 23-32.

[2] Dragan Zlatkov, Slavko Zdravković, Biljana Mladenović, Radoslav tojić Finite Elements in Analysis and Design, Journal of Architecture and Civil Engineering, vol. 9,(2011) pp. 89 - 104.

[3] Y. L. Wong, T. Yu, S. L. Chan A simplified analytical method for unbraced composite frames with semi-rigid connections Journal of Constructional Steel Research vol.63 (2007) pp 961–969.

[4] Jing-Feng Wanga,_, Guo-Qiang Lib,c A practical design method for semi-rigid composite frames under vertical load Journal of Constructional Steel Research vol.64 (2008) pp 176–189.

[5] Ioannis G. Raftoyiannis, The effect of semi-rigid joints and an elastic bracing system on the buckling load of simple rectangular steel frames Journal of Constructional Steel Research vol. 61 (2005) pp 1205–1225.

[6] K. Weynand1; J.-P. Jaspart 2 JCSR(1998) M. Steenhuis3 Economy Studies of Steel Building Frames with Semi-RigidJoints Journal of constructional steel research (1998) pp 125-132.

[7] M.S. Hayalioglu, S.O. Degertekin Minimum cost design of steel frames with semi-rigid connections and column bases via genetic optimization. Journal of Computers and Structures vol. 83 (2005) pp 1849–1863.

[8] M. Ashraf a, D.A. Nethercot a, B. Ahmedb, Sway of semi-rigid steel frames Journal of Engineering Structures, vol. 26, (2004), pp 1809–1819.

[9] T. Hagishita , M. Ohsaki Optimal placement of braces for steel frames with semi-rigid joints by scatter search, Journal of Computers and Structures, vol. 86, (2008) pp 1983–1993.

[10] A.N.T. Ihaddoudènea, M. Saidani b, M. Chemrouka Mechanical model for the analysis of steel frames with semi rigid joints Journal of Constructional Steel Research, vol. 65 (2009) pp 631-640. IS 800 2007