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High Rise Long Span Steel Structure with Semi-Rigid Connection using Bracing System

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Abstract: **Generally, in steel structure the connection between beam and column are designed as moment connection and pinned connection, but in actual condition the structure behaves between these two conditions, resulted into semi-rigid condition which is intermediate stage between rigid and pinned joints. Effect of semi-rigid connection on multi-story multi-bay frame is accomplished in this paper. The present study introduces the effect of static and dynamic loading on high rise steel structure of G+15 story with 4m, 6m and 8m three bay span length. Structure is analyzed under two different condition of partial release of semi-rigid connections which is derived by fixity factor of values 0.5 and 0.75 (as per AISC) in this study. The analysis is done commercially available software-STAAD.Pro. From the non-linear analysis, the story displacement and story drift are obtained. The overall performance of the structure from the analysis, semi-rigid joints display more story displacement and story drift compared to rigid joints. To overcome the results, bracing system is introduced at different location of periphery of structure. These brace frame structure consist of X- bracing and diagonal bracing. Again, comparative analysis is to be performed in STAAD.Pro on these three-bay span lengths. It is found that braced semi-rigid frame structure perform quite well as compared to unbraced frame structure.**

Keywords: Multi-story Multi-bay frame, Semi-rigid connections, Fixity factor, Brace frame.

1. INTRODUCTION

Steel structures are made up of different elements like beams, columns, bracings, flooring and roofing systems. In every structure Beam-to-column connections are important and inherent component of steel frame structure and their behavior influence the global performance of the structure under various loadings. Generally, connections are characterized in two types 1. Moment Connections and 2. Pinned connections. Besides that in actual practice steel connections are not providing ideal rigid or pinned but behavior of connections fall between these two-condition called as semi-rigid connections which basically based on their stiffness criteria. Basically, Connections are classified by their strength as well as their ductility, where ductility is a description of the rotation capacity i.e. rotational stiffness. As per AISC (American institute of Steel construction) fixity factor is derived to evaluate rotational stiffness of member of the structure which is conventional practice but it gives approximate value of partial releases in the structure as well as their behaviour is also influenced on the rotational stiffness of the member

2. LITERATURE REVIEW

Nandeesha and Kashinath (2017) Investigated the analysis of multi storey steel space frame by varying fixity factor and found the capacity of strength of joints and to perform linear static of semi-rigid connection steel frame using response spectrum method. Considering 0 fixity f actor for pinned or hinged joints and 1 for rigid joints and the variation of bending moment, shear Force with varying fixity factor was found out. Nihan dogramac aksoylar, Hussam mahmoud (2011) have studied the moment resisting frame with semi-rigid connections and prepared 26 sample model frames were evaluated with pushover and dynamic analysis under 25 strong ground motion records. Main outcome of investigation was overall top story displacement of structure with semi-rigid structure are smaller than rigid frame structure. Peng deng, yigjuan, Xiaotong shang (2015) had studied comparison of eccentric inclined braced steel frame with semi-rigid connection and simple steel frame with semi-rigid connections. Based on seismic performance the energy dissipation capacity was found out in terms of lateral stability and stiffness of the structure. Mohammad razavi, Ali abolmmali (2014), came up with new concept of hybrid steel frame system, as it contains the mixture of full rigid and semi-rigid steel connections used in 20-storey steel structure. They assigned the semi-rigid connections as replacement of rigid connections at different location of structure. By performing the parametric study of seismic analysis, they corelate the cyclic behaviour of HYBRID frame structure in terms of storey drift and life safety. Anuraj e, Hemalatha g (2018), their effort was made to find out actual behaviour of rigid and semi rigid connection by performing nonlinear static analysis on G+5 storey structure in SAP2000. From analysis, storey drift value and performance points were obtained

3. METHOLOGY FOR ANALYSIS

There are many methods to find out capacity of semi-rigid connections, but in this paper needs to estimate rotational stiffness of member of structure. Main aim to analyse the performance of high rise (G+15 storey) long span steel structure with semi-rigid connections using bracing system. It is proposed to carry out the analysis of multi-story multi-bay frame (contains 4m,6m & 8m bay length) considering the ideal rigid and semi-rigid conditions using STAAD.Pro and evaluate the effect of height, span, fixity factor, rotational stiffness. Apart from this analysis, in this research widely investigated the comparative analysis of semi-rigid connection with

or without bracing system. As per convenience, X- Bracing and Diagonal bracing are used at different location of periphery of structure.

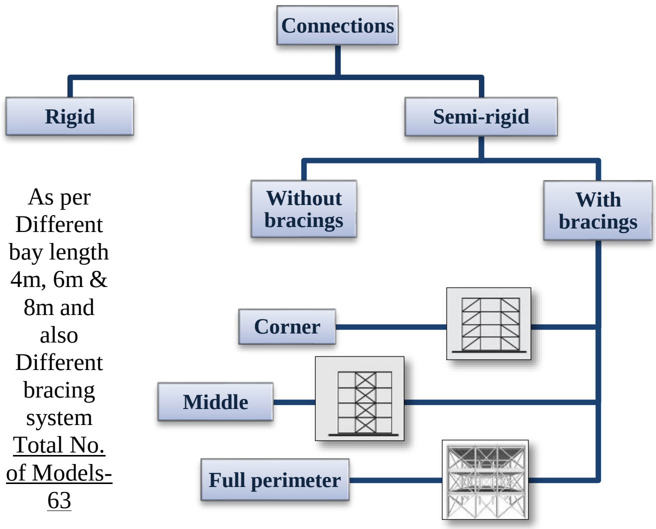
The primary aim of this study to compare the two types of partial release condition as per fixity factor equation.
Fixity factor considered '0'for ideally pinned conditions and '1' fixity for rigid conditions in the analysis of frame. As per past experiences and researches the most favourable results are obtained for the range of 0.5 to 0.7 fixity factor.

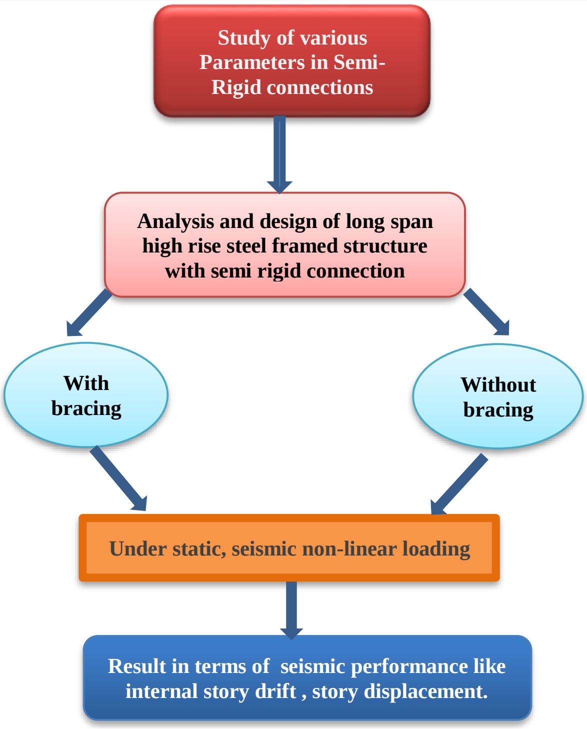
$$r_i = \frac{1}{1 + \frac{3EI}{R_i L}}$$

Present study incorporates the analysis of steel frame structure using fixity factors 0.5 and 0.75 (i.e. 50% partial release structure and 25% partial release in structure). In end fixity factor, r_i is written as

R_i: Rotational Spring Stiffness of connections
EI/L: Flexural Stiffness of elements

Using above equation, there are 63 models prepared as per different conditions of fixity factor (0.5 and 0.75), bay lengths and bracing system. The flow chart of methodology of analysis and classification of models are mentioned below.





Flow chart 1: Scope of study

4. ANALYSIS

All primary data are mentioned in table-1 & 2. Apart from this, section properties and loading conditions are given in table- 3 & 4.

Structural Data

Table 1: Primary structural data

Building type	Symmetrical High-rise G+15 storey
Numbers of bay	3 In both direction
Bay length	4m, 6m and 8m
Height of building	48m

Table 2; Rotational stiffness of members

Fixity Factor	**Rotational Stiffness (kN.m/rad)**			
	ISWB 250	ISWB300	ISMB300	ISMB400
0.5	9360.4	12375.22	13550.67	25777.6
0.75	26754.9	39188.18	42910.465	81629.02

Table 3 : Section properties of beams

Section	**Area (m^2)**	**Modulus of elasticity (E) (kN/m^2)**	**Moment of inertia (I) m^4**
ISWB 250 X 40.9	0.005205	210000000	0.000059431
ISWB 300 X 48.1	0.006133	210000000	0.000098216
ISMB 300 X 44.2	0.005626	210000000	0.000086036
ISMB 400 X 61.6	0.007846	210000000	0.000204584

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Table 4 : Loadings and primary data of columns and bracing

Dead load + Live load	4 kN/m^2	
Beam section (UDL) (For all structures)	ISWB250 ISWB300 ISMB300 ISMB400	0.409 kN/m 0.481 kN/m 0.442 kN/m 0.615 kN/m
Column Section	IW500400X012 IW500400X2040 I160016A50040	
Bracings (For all structures)	ISA 150X150X16	

In STAAD.Pro, the partial releases are providing at start and end of the beam members which is mentioned below fig-1.

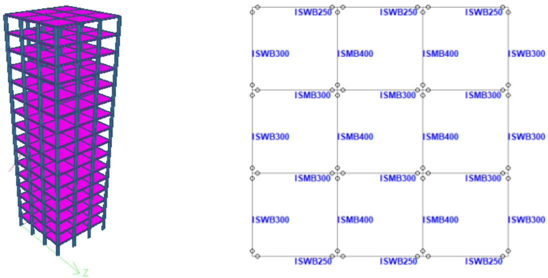

Figure 1: Using Partial Release in Beam Section for semi rigidity

Mainly two type of bracing system (X and diagonal) are provided on different location of periphery of structure. The detailed rendering view of structures are presented in fig-2 & 3.

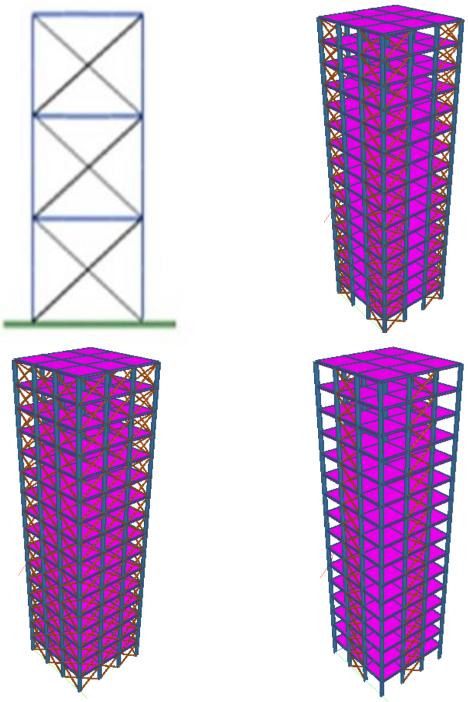

Figure 2: Different locations of provision of X - Bracings

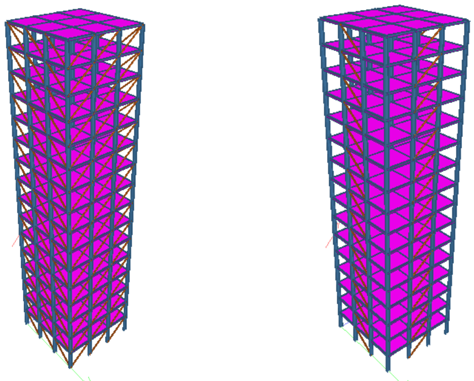

Figure 3: Different locations of provision of diagonal Bracings

5. PARAMETERS FOR EARTHQUAKE AND WIND ANALYSIS

Table 4: Seismic analysis data

AS PER IS 1893 2016 – PART I	
USING RESPONSE SPECRTRUM ANALYSIS	
City	Ahmedabad
Zone	III – 0.16
Response Reduction Factor(R)	5 (Steel Structure with SMRF frame)
Importance Factor(I)	1
Combination Method	CQC method
Soil Type	Medium Soil
Damping Ratio	0.05
(Sa/g)*(Z/R)	0.016 (X and Z direction)
Time	5.94 s
Acceleration	3.33426 m/s^2

Table 5: Wind analysis data

AS PER IS 875 PART- III 2015	
Design Wind speed	**$V_z = V_b*K_1*K_2*K_3$ Where V_b = 39 m/s**
Height (m)	**Wind pressure(kN/m_2) $p_z = 0.6*V_z^2$**
10	0.732
15	0.796
20	0.859
30	0.930
48	1.133

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After providing bracing (X and diagonal), reduction in lateral displacement as per bay lengths are shown in fig-6 to fig-11.

6. RESULTS

From the parametric analysis results (in mm) are in terms of lateral displacement and lateral drift (Both permissible <=L/300) as characterized in three different (4m, 6m & 8m) bay length and fixity factors are mentioned below.

(1) For 50% release i.e fixity factor is 0.5

(2) For 25% release i.e fixity factor is 0.75

Also, measure the effect of bracing system (X and Diagonal Bracing) on lateral stability of structure.

The results comparison of lateral displacement between rigid connection and semi-rigid connection for three bay lengths are shown in fig- 4 and 5.

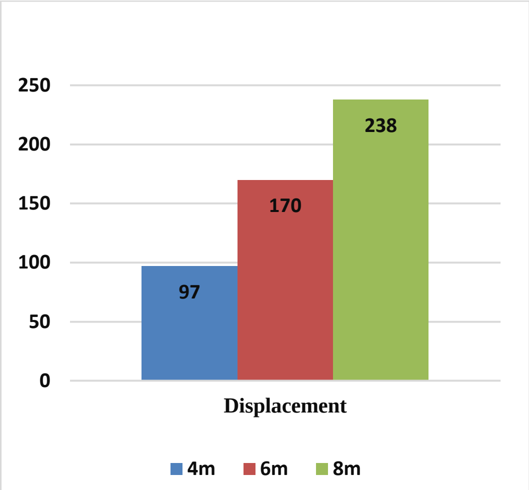

Figure 4: Rigid Connections

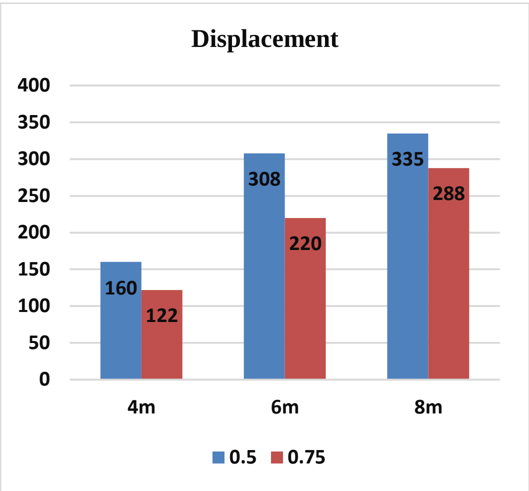

Figure 5: Semi-Rigid Connections

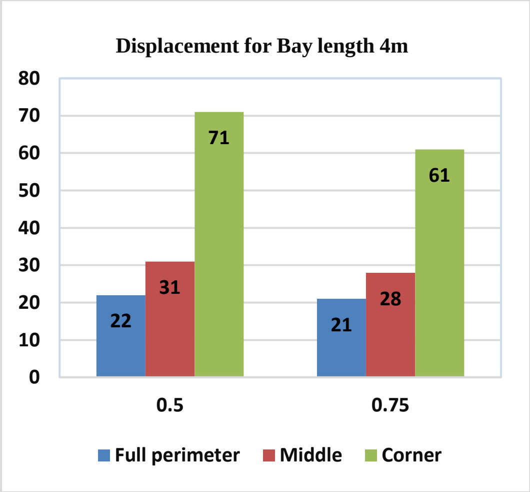

Figure 6: X-bracing

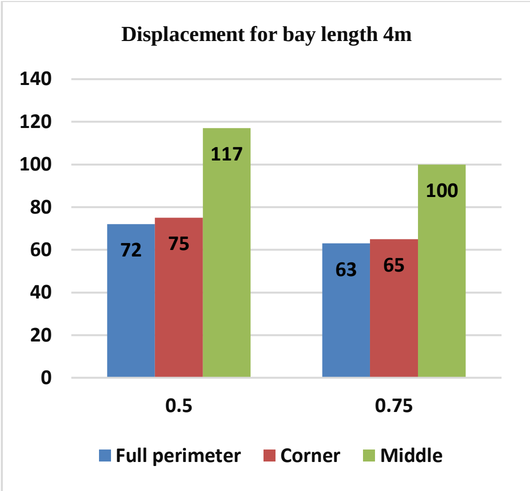

Figure 7: Diagonal bracing

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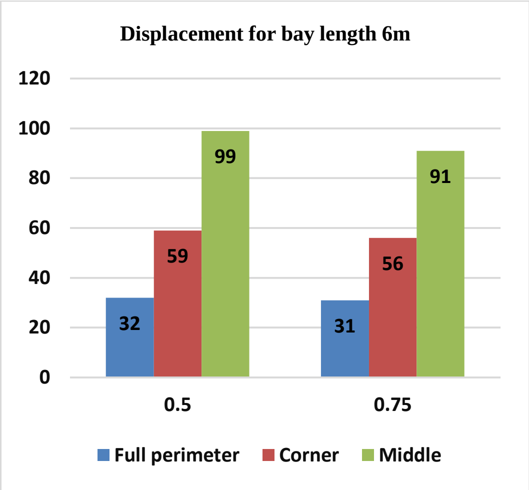

Figure 8: X-bracing

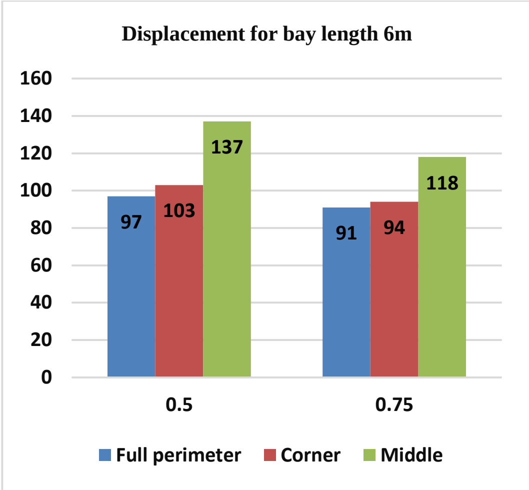

Figure 9: Diagonal bracing

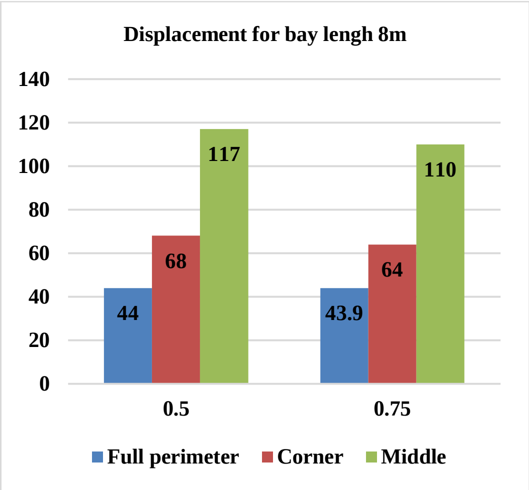

Figure 10: X-bracing

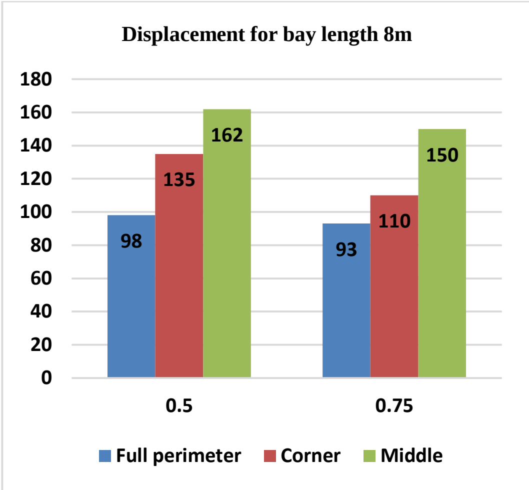

Figure 11: Diagonal bracing

Same as the comparison of results of lateral drift between rigid connection and semi-rigid connection for three bay lengths are shown in fig-12 and 13.

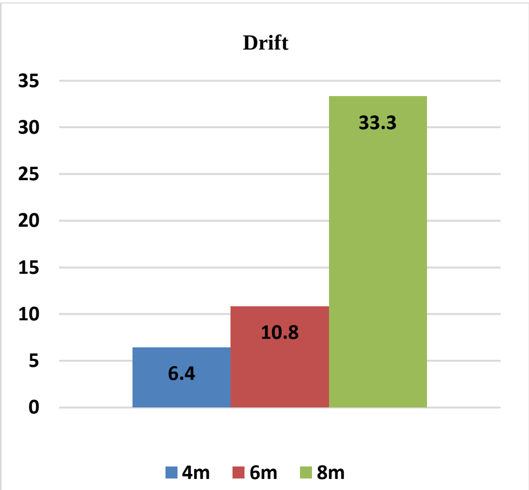

Figure 12: Rigid Connections

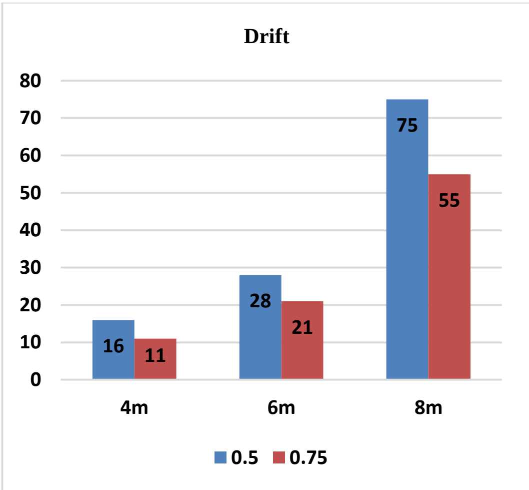

Figure 13: Semi-Rigid Connections

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As per different bay lengths and bracing system comparison of lateral drift are as shown in fig- 14 to 19.

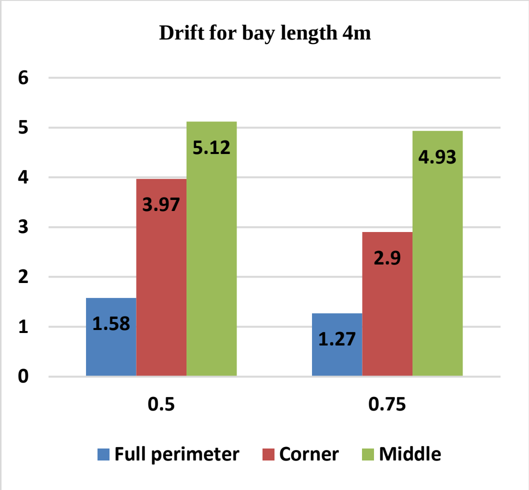

Figure 14: X-bracing

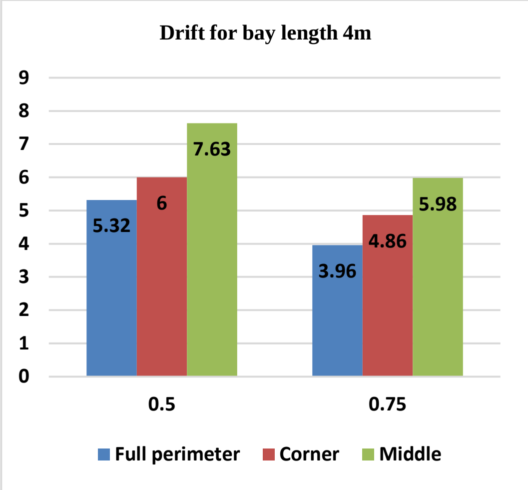

Figure 15: Diagonal bracing

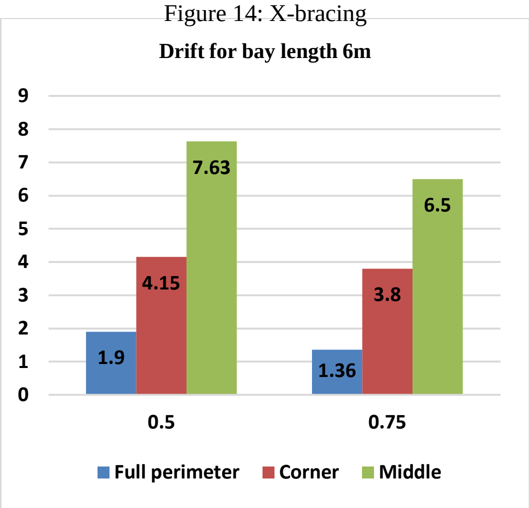

Figure 16: X-bracing

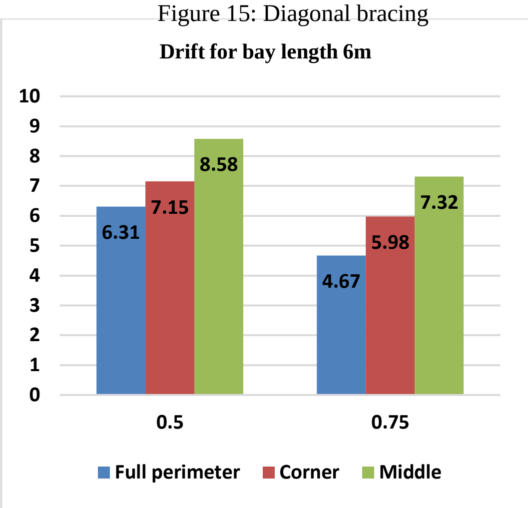

Figure 17: Diagonal bracing

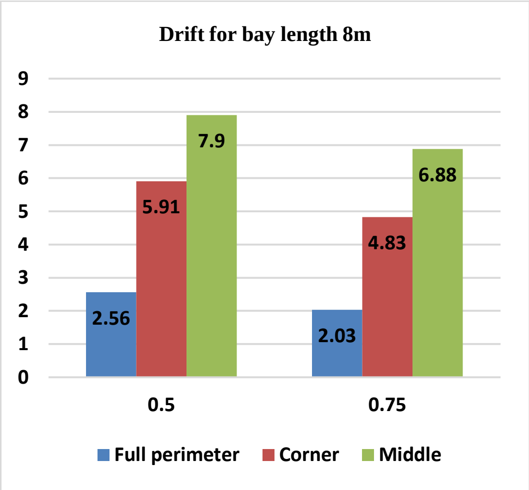

Figure 18: X-bracing

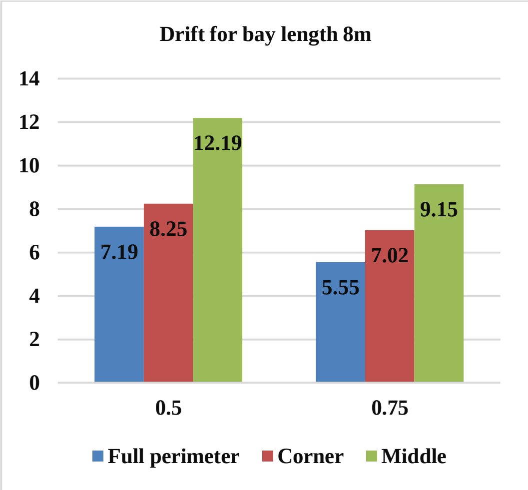

Figure 19: Diagonal bracing

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7. CONCLUSION

- From the overall analysis, it has been observed that lateral displacement in semi-rigid connection is more than rigid connections as well as increasing in bay length.
- Reduction in results with increasing the flexibility of connection about fixity factor '0.75' as compare to fixity factor '0.5'.
- As span increase the more lateral displacement observed. To overcome this effect the bracing system is used to improve the lateral stability of structure. The analysis results of X-braced frame have indicated more lateral stability than diagonal braced frame.
- In the overall seismic analysis of high-rise structure, corner and full perimeter braced frame enhance to give least lateral displacement and drift comparing with middle braced frame from above figures.

8. REFERENCES

1. Nandee-sha G. , Kashinath B. Rugi, Nov-2017, "Influence of semi-rigid connection on behavior of steel frame under static loads", International Research journal of engineering and technology (IRJET), vol. 4, pp. 1441-1445.
2. Arunraj e and hemalatha G, Nctober 2018, "Performance analysis of semi rigid connection over rigid and hinged connections", International journal of civil engineering and technology (IJCIET) vol-9, pp.1749-1755.
3. Mohammad Razavi, Ali Abolmaali, 22 February 2014, "Earthquake resistance frames with combination of rigid and semi-rigid connections", Journal of Constructional Steel Research, vol-98, pp. 1-11.
4. Nihan Dogramac Aksoylar , Amr S. Elnashai , Hussam Mahmoud , 9 July 2010, "The design and seismic performance of low-rise long-span frames with semi-rigid connections", Journal of Constructional Steel Research, vol-67, pp. 114-126.
5. Peng Deng, Yingjuan Ma ,Xiaotong Shang, "Research on Seismic Behavior of Semi-rigid Steel Frame Structures With Eccentric Brace", 5th International Conference on Advanced Engineering Materials and Technology (AEMT 2015).
6. Sanjaykumar N. Sonune, Dr. Nagesh L. Shelke, 2017, "Response of structural steel frame by using semi-rigid connections", International journal of advance research and innovative ideas in education, vol-3, pp. 1675-1686.