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INFLUENCE OF SEMI-RIGID CONNECTION ON BEHAVIOUR OF STEEL SPACE FRAME UNDER STATIC LOADS

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Abstract- In this analysis and design of steel space frame are taken out based on idealization that the connections joining the beam-column are both fixed and flexible. There is a complication in assigning the connection behaviour, along research on the semi-rigid behaviour and design has been continued for years. Study on the earthquake effects of multi storey semi-rigid space frame are selected for present study. Of 10 storey of 4m x 5m x 3.5m, semi-rigid connected steel space frame based on rotation spring stiffness.

Key word: **symmetric space frame, connections- rigid, pinned, semi-rigid.**

1. INTRODUCTION

The semi-rigid support conditions usually lay in between the rigid and simple supports.

Building connections classified based on the moments-rotation characteristics, according to the AISC conditions.

Type A: Rigid frame (Fully restrained fixed ended) assumed to the beam-column connection has sufficient to prevent any rotation moments between the intersect members.

Type B: Simple Frame (Unstrained Free- Ended), assumed to the beams-column connection, allows only shear forces, so the member to rotate freely under gravity load.

Type C: Semi-rigid frame (Partially Restrained), assumed to the beam-column connection based on known moments and lies in intermediate between the rigidity of type A and B.

2. OBJECTIVES

The main objective of the work is

1. To perform linear static of Semi-rigid connection steel space frame structures using Response Spectrum method.

2. The multi storey steel space frame is analysis by varying the joints fixity factors and found the capacity of strength of joins.

3. METHOD OF ANALYSIS

To calculate the semi-rigid connection influence on the structural responses, static analysis was conducted. The section properties of the constituent's elements were arrived, for vertical gravity loads, in addition to equivalent earthquake forces.

In this research, the semi rigid connections effect on the behaviour of structure is widely investigated. The analysis by conventional stiffness matrix method is ultimately to cover a more frame vibrations general cases with connection of semi-rigid and as per the action of earthquake forces. In frames was analyzed for fixity factors varying from 1.0 for rigid to 0.0 for hinged conditions and the findings are presented and discussed in the sections to follows;

3.1 Numerical Problem:

Plane dimensions: 4m in X axes and 5m in Y axes direction.
Storey height: 3.5m in Z axes direction.

3.2 Structural model:

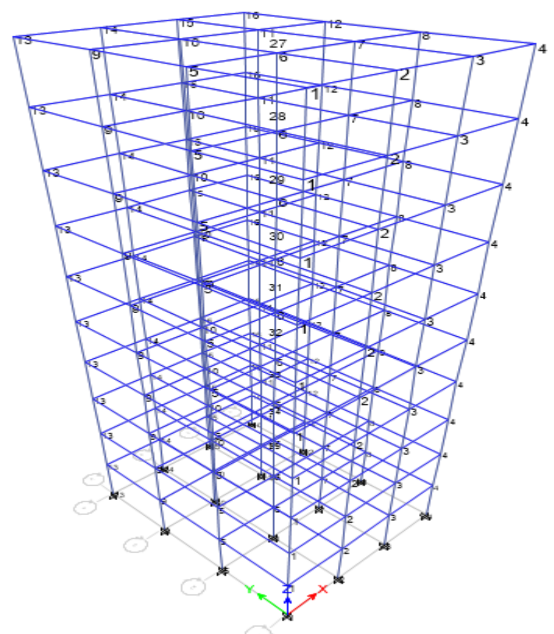

Fig 1: Steel space frame with node numbers

Fig 2: Plan view showing beam and column

Table 1: Section properties of the steel space frame

Section	Area (m^2)	I_{XX} (m^4)	I_{YY} (m^4)
ISWB 250 X 40.9	0.005205	0.00005943	0.000008575
ISWB 300 X 48.1	0.006133	0.00009821	0.000009901
ISMB 300 X 44.2	0.005626	0.00008603	0.000004539
ISMB 400 X 61.6	0.007846	0.00020458	0.000006221
ISWB 600 X 145.1	0.0185	0.00115626	0.000052983

Methods of beam analysis which the end restraints fall in between the assumed pin and rigid end is end fixity concept. In end fixity factor, r_i is written as,

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

Where, r_i is spring stiffness connection and EI/l is flexural stiffness of the fixed elements. The fixity factor defines as the rotation stiffness of the fixed elements.

Table 2: Sectional properties of beam section

Section	Modulus of elasticity (E) k N/m^2	Moment of inertia (I) m^4	Length (L) m
ISWB 250 X 40.9	210000000	0.000059431	4
ISMB 300 X 44.2	210000000	0.000086036	4
ISWB 300 X 48.1	210000000	0.000098216	5
ISMB 400 X 61.6	210000000	0.000204584	5

Table 3: Rotational spring stiffness of beam sections for different fixity factor

Fixity Factor	Rotational spring stiffness (R) kN-m / rad			
	ISWB 250	ISMB 300	ISWB 300	ISMB 400
0.1	1040.04	1505.63	1375.02	2864.18
0.2	2340.1	3387.67	3093.8	6444.4
0.3	4011.6	5807.43	5303.66	11047.54
0.4	6240.26	9033.78	8250.14	17185.06
0.5	9360.4	13550.67	12375.22	25777.6
0.6	14040.6	20326.1	18562.82	38666.4
0.62	15272.2	22108.99	20191.14	42058.16
0.65	17383.6	25165.53	22982.54	47872.66
0.67	19004.41	27511.96	25125.44	52336.31
0.7	21840.9	31618.23	28875.5	60147.7
0.8	37441.53	54202.7	49500.86	103110.34
0.9	84243.44	121956.03	111376.95	231998.26

3.3 Static analysis

Computation of equivalent static lateral force (as per IS 1893 (part-1):2002;

Plan dimensions of the structure (D_s) = 12m x 15m

Height of the building (H) = 35m

Fundamental natural period of vibration (T)

T = 0.085 $H^{0.75}$ for steel framed structure (clause 7.6.1)

Hence, T= 1.223sec

Average Response Acceleration co-effective (Sa/g) = 1.112

(For medium soil site type-2 and as, 0.55≦T≦4; Sa/g = 1.36/T)- Clause 6.4.2

Importance factor (I) = 1.5

(Community building: clause 6.4.2, Table-2)

Design horizontal seismic co-efficient (A_h) = 0.06

$$\left(A_h = \frac{Z}{2}\frac{I}{R}\frac{S_a}{g}\right)$$ (Clause 6.4.2)

Total design lateral loads or seismic base shear along X-axes (V_D) = 310.44 kN ($V_D = A_h$ W: Clause 6.4.2) .

Total design lateral force and storey weight computed as per IS1893 (Part-1): 2002 are presented in table 4 for steel space frame.

Table 4: Design lateral force and storey weight of space frame

Storey No.	Storey weight (kN)	Design Lateral Force (kN)	
		Along X-dir	Along Y-dir
1	1086.27	0.814	1.19
2	1086.27	3.25	4.77
3	1086.27	7.32	10.12
4	1086.27	13.02	19.06
5	1086.27	20.34	29.78
6	1086.27	29.29	42.89
7	1086.27	39.87	58.37
8	1086.27	52.07	76.24
9	1086.27	65.90	96.50
10	1048.82	78.56	115.02
Total	(W) = 10825.25 kN	V_D = 310.44 kN	V_D = 454.54 kN

3.4 Moments v/s Fixity factor

Considering the beam element B-12 with semi-rigid connection, the end moments and mid span moments with varying fixity factors are tabulated in table 5.

Table 5: End moments and mid span moment's v/s end fixity factors.

Beam Element B12		
Fixity Factor	Moment at end (kN-m)	Moment at span (kN-m)
0.0	0	57.33
0.1	14.22	52.46
0.2	20.67	47.98
0.3	25.20	43.83
0.4	30.94	39.95
0.5	35.88	36.31
0.6	40.16	32.87
0.7	43.85	29.62
0.8	47.00	26.52
0.9	49.67	23.55
1.0	50.65	23.33

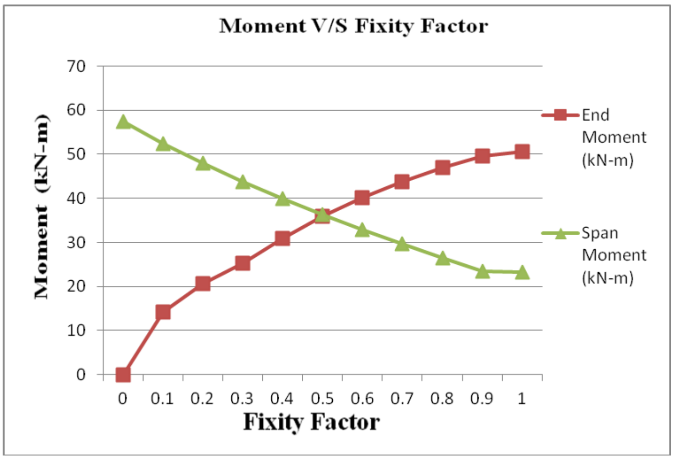

Chart-1: End moments and mid span moment's v/s end fixity factors.

To reach the maximum design moment condition, the moment at support and mid-span is equal. This condition seems to be satisfied for fixity factor between 0.5 and 0.6 as observation in chart-1. Hence the design of semi-rigid beams with fixity factor betweens 0.5 to 0.6 results in optional or uniform, section for the entire length of the beam. The span moments for a simply supported or flexible connection (FF = 0.0) is 57.33 kN-m. However, for the same beam element with connections of semi-rigid, the moments of end and mid span moments are equal and observed to be minimum of 36.31 kN-m.

3.5 Variation of bending moments

The bending moment's variation for typical beam elements in ground floor (B-12) with semi-rigid connections is shown in Chart-2.

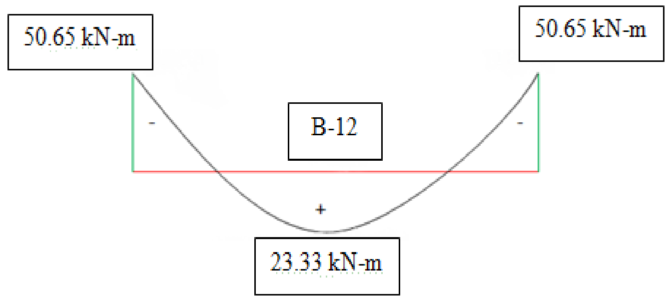

Chart-2(a): Variation of bending moments for FF 1.0

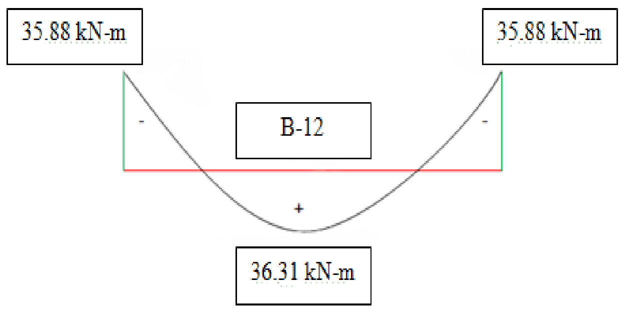

Chart-2(b): Variation bending moment for FF 0.6

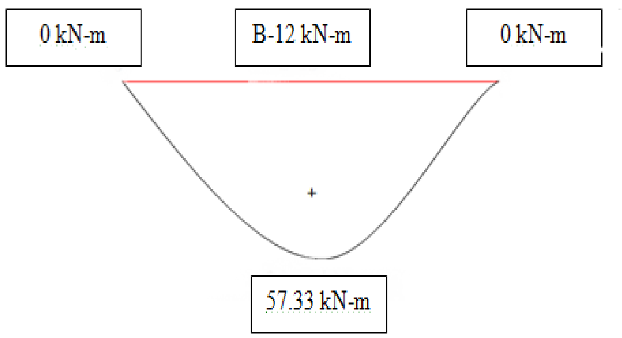

Chart-2(c): Variation bending moments for FF 0.0

Chart-2: Bending moment's diagrams for beam with flexible connections.

By comparing the bending moments diagrams, as shown in chart-2 it was observed that beams having rigid joints has an end moments of 15.65 kN-m, compared to the maximum moments of 57.33 kN-m for the flexibly connected beam. Therefore to the rigidly jointed beam has a requirements is small for the section flexural strength, so this design is not economical because the difference between the maximums of -ve and +ve moments is approximately 40.68 kN-m.

4. CONCLUSIONS:

- To reach maximum moments of design for beams the moments at the supports and at mid-span must be equal. This condition is observed to be satisfied for fixity factors ranging betweens 0.60 to 0.70 (i.e., 30% to 40%) of joint flexibility.
- The presence of the semi-rigid connections do not affects the stiffness co-efficient related to the axial effects, shear force and torsion effects is not affects by joint boundary conditions.
- The moments of bending generated at the ends of the beams clearly seen that the variation between semi-rigid and rigid connections is major. Due to reduce stiffness in semi-rigid and rigidly connected frame resulted in increase in the bending deformation and increase values of primary bending moments.

These results indicates that semi-rigid connections in frame will have major effects on the structural requirements find and that along a proper selection of the stiffness and strength connection properties these responses may be changed to produce advantageous on the structure effects.

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