RESEARCH ARTICLE

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Analysis of Initial Rotational Stiffness for Different Section of Semi-Rigid Connection

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Abstract

Structural frames are designed for gravity loads. For rigid connections, the entire 100% intensity of the beam section is not used, this is because the end support moment of the beam at the end is always greater than the midspan moment. The end moment value of the beam is reduced by using a semi-rigid connection. In this paper we have analyzed semi rigid connections for different sections. The results of the study indicatethat the formula in the paper appropriately stated the initial rotational stiffness of the top and seat angle connections. The type of semi-rigid connection is usually chosen based on stiffness of connection. In this paper initial connection stiffness (Rki) of an unstiffened top and set angle with double web angle semi-rigid connection of G+3 steel structure is estimated and result obtained are validated using theLiu Wei and Shu Ganping.

Keywords: Semi rigid connection, top and seat angle with double web angle, initial rotational stiffness.

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Introduction

Steel structural frameworks are built to withstand vertical loads and provide connection stability. Because support moments are always greater than span moments, the entire power of the beam section is never completely used, and so section selection is based on support moments. Support moments can be lowered and span moments can be raised when connection flexibility is provided, resulting in smaller sections and cost savings. Semi-rigid connections can be used to accomplish this. The semi-rigid connection's initial stiffness must be determined first, and then a Moment-Rotation relationship curve for the semi-rigid connection must be produced. Moment required to motive unit rotation is known as "Rotational Stiffness." As we know, in pinned connection, at supports, moment is continually zero in order that stiffness of a pinned connection is always zero. Similarly, in inflexible connection, at supports, angle of rotation is continually zero in order that stiffness of an inflexible connection is infinity [1]. But in semi-inflexible connection, at supports, moment and angle of rotation will now no longer be identical to zero. This method moment and angle of rotation each may be exist collectively with having a specific value[2]. Consider the steel frame structure to indicate connection flexibility in steel frames. Connections between the beam BC and the supporting columns can be made in different ways.

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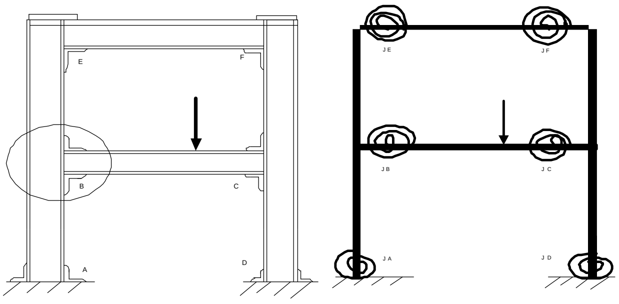
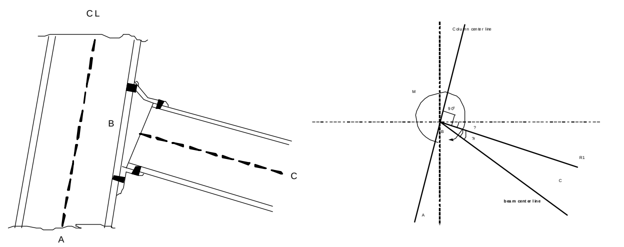


a) Actual Frame b) Idealized Frame

Figure 1: Steel frame connections



a) Twisted shape of joint B b) Centre line diagram of joint B

Figure 2: Beam-column joint Connection flexibility

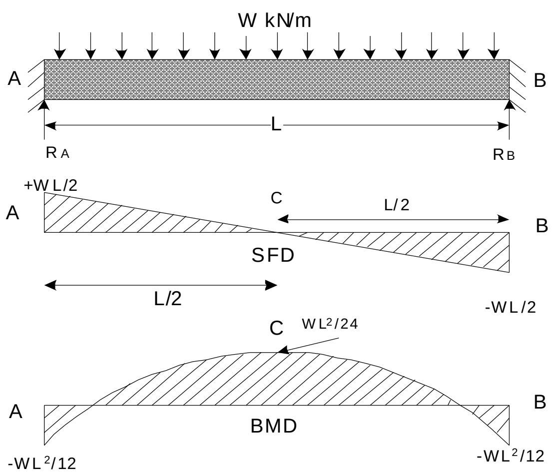


Figure 3: Fixed Beam with Uniformly Distributed Load Over Entire Span [1]

1. In this study, the support moment is always greater than the mid-span moment.
2. So, we always select the section to resist the support moments. Hence, full strength of the beam section is never fully utilized.
3. By providing connection flexibility means semi-rigid connection, support moment can be reduced and span moment can be increased. This means we can transfer the support moment towards the mid-span of the beam.
4. Here, full strength of the beam can be utilized and this leads to economy.

Literature Review

Steel frame joints are presently designedas either fixed or pinned joints.Depending on the application, welded and bolted joints are usually designed as fixed or pinned joints. When designing the joints, it is assumed that the fixed joint will have no flexibility and that the pinned joint will have no stiffness. i.e., while designing, fixed joints are assumed to be completely rigid, whereas pinned joints are assumed to be completely flexible[3]. The pinned joint is assumed to allow rotation while the fixed joint does not allow rotation or translation. The traditional or gift exercise has the disadvantage of causing incorrect evaluation. Constant joints contain a few amounts of flexibility, while pinned joints have a few quantities of stiffness, according to recent research. Constant joints, on the other hand, allow for a tiny amount of rotation[4]. However, in the case of gift evaluation and design, this impact is no longer taken into account inside the evaluation, resulting in incorrect evaluation and design. In addition, this layout makes evaluation and layout impractical [5,8]. As a result, to overcome this disadvantage, connections are considered semi-inflexible, i.e., a connection that is part constant and part pinned. It's the steady and pinned canter degree. It is in the stiffened and flexible category. These connections are neitherdefinitely constant nor definitely pinned[6]. The initial stiffness of semi rigid connections was investigated based on mechanical parameters and deformation characteristics. The initial stiffness calculated using the component technique. [2]

Materials

Steel constructions frequently use a top seat anglewith a double web angle connectionBecause of its strong flexural resistance, the term "semi rigid" refers to this form of connection.

Table-1: Properties of angle used[1]

Sr. No.	ISA	L1	L2	tt/ts	Unit
1	Top Angle ISA (Lt x Lt x tt)	0.05	0.08	0.01	m
2	Seat Angle ISA (Ls x Ls x ts)	0.05	0.08	0.01	m
3	Web Angle ISA (Ls x Ls x ta)	0.065	0.065	0.01	m

METHODOLOGY

Steel structure frames with semi-rigid connections were designed and analyzed with limit state design parameters. The nonlinear performance of beam to column connections is taken into consideration throughout the analysis. Members were designed and analyzed with preferably stiff and pinned end conditions in mind. for a framed three-story building Secant stiffness (Rotational stiffness) is used to analyze semi-rigid structures, as specified by IS 800:2007.

The technique contains the following steps:

1) Select a G+3 framed structure to examine.
2) Consider Initial Connection Stiffness Parameters.
3) Calculation of Initial Rotation Stiffness (Rki).
4) Comparing the results for rigid & semi-rigid connections with Previous Papers.

ANALYTICAL CALCULATIONS

The building under consideration is three bay three storey steel structure. Various load combinations are investigated for the structure.

1. Geometrical Specifications of the Structure:

1. Type of Building Industrial
2. Number of bays in X Direction 3 with 3m (each)
3. Number of bays in Y Direction 4 with 3m (each)
4. Total Height of Structure 12m
5. 1st Tier Height is 3 m
6. 2nd & 3rd Tier Height is 3 m (each)
7. Yield Strength of Steel 250 Mpa
8. Ultimate strength of Steel 420 MPa
9. SBC for Soil = 300 kN/m^2
10. Wind Speed = 39 m/s
11. Seismic Zone = III

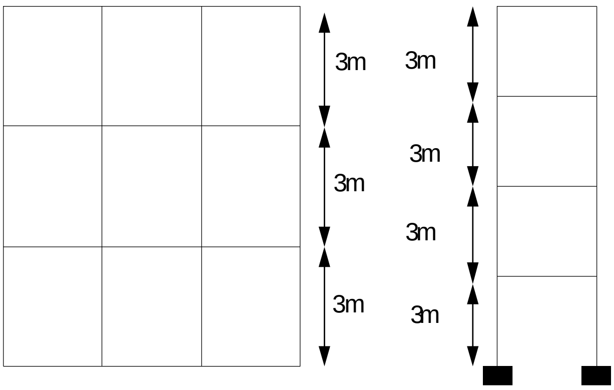


Figure 4: Planand Elevation of G+3 steel structure

Initial Rotation Stiffness (Rki) of Top-Seat angle with Double web angle

To decide the preliminary elastic connection stiffness with the use of angle segment and From Table 3.1 input Parameters, the initial connection stiffness Rki has Calculated by following equation[1].

$$Rk_i = \left[\frac{3EI_t}{1+\frac{0.789(t_t)^2}{(g_{ct})^2}} \frac{d1^2}{(g_{ct})^3} + \frac{6EI_a}{1+\frac{0.78(t_a)^2}{(g_{ct})^2}} \frac{d3^2}{(g_{cc})^3} \right] kN.m/rad$$

.........(1)

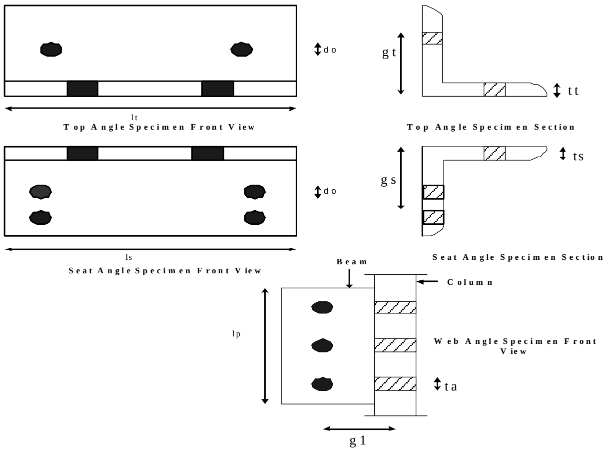


Figure 6: Top angle front, Seat angle and Web angle Specimen

Now,

Bending stiffness for Top and Seat angles,

$$EI_t = \frac{E \times (It \times tt^3)}{12} \ldots\ldots (1) \quad EI_a = \frac{E \times (Ip \times ta^3)}{12} \ldots\ldots (2)$$

$$g_{ct} = g_t - \frac{t_t}{2} - \frac{w}{2} \qquad \ldots\ldots(3)$$

$$g_{cc} = g_1 - \frac{t_a}{2} - \frac{w}{2} \qquad \ldots\ldots(4)$$

$$d_1 = d + \frac{t_t}{2} - \frac{t_s}{2} \qquad \ldots\ldots(5)$$

$$d_3 = \frac{d}{2} + \frac{t_s}{2} \qquad \ldots\ldots(6)$$

The equation corresponding values and unit are shown below in Table-2

To determine the initial connection stiffness by use of angle section and beam section the Rki connection is modelled as follows :

Table-2: Initial Connection Stiffness Parameters

Equation	Values	Unit
EI_t	2.33	kN/*m²*
EI_a	3.33	kN/ *m²*
gc_t	0.03	m
g_{cc}	0.02	m
d1	0.36	m
d3	0.18	m
Rk_i	1722.36163	*kN.m/rad*

$$Rk_i = \left[\frac{3(2.33)}{1+\frac{0.789(t_t)^2}{(0.03)^2}} \frac{(0.36)^2}{(0.03)^3} + \frac{6(3.33)}{1+\frac{0.78(t_a)^2}{(0.02)^2}} \frac{(0.18)^2}{(0.02)^3} \right] \text{kN.m/rad}$$

$$Rk_i = 1722.36163 \text{kN.m/rad}$$

Results and Discussion

The results comparison of Rotational stiffness is calculated for end connection by stiffness equation. The rotational stiffness value is provided to end connection. The Results obtained from manual calculations are more convenient as compared to previous results [1,2] So we can provide this type of sections for the structure.

The initial stiffness in Table-3 is calculated with Eq. (1) again and the results are analysed comparatively with initial stiffness.

Table-3: Comparison of Initial Rotational Stiffness

Sr. No	Column Section	Beam Section	Angle Section	Parameter	Kishi and Chen's model	Liu Wei and Shu Ganping	Manual Calculation
1.	HW200X200X8X12	HW150X150X7X10	2L100X80X8	Rk_i	1273	891	2082
2.	HW250X250X9X14	HW200X200X8X12	2L100X80X10		1253	877	5897
3.	HW300X300X10X15	HW250X250X9X14	2L140X90X12		1305	913	11369

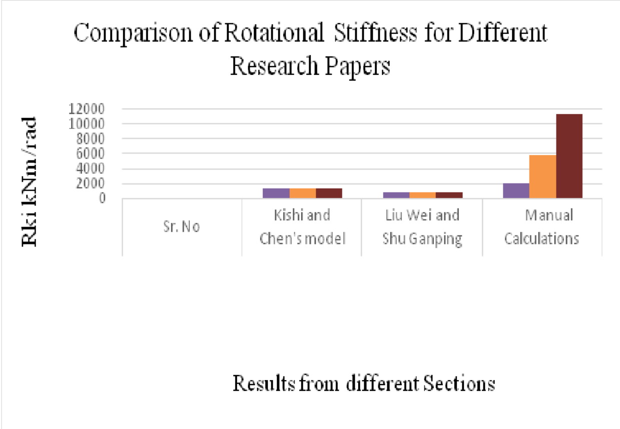


Figure 7: Comparison of Initial stiffness of connection

Conclusion

On the basis of the literature overview in steel structure of semi-rigid connection, it was concluded that, In this paper, according to top and seat angle semirigid connections, the initial stiffness was determined manually for Providing partial flexibility. Results were validated with Previous results;test data was used to validate the results and ensure that the calculations were correct. The increase in the Rotational stiffness is observed 60%- 63% as compared to previous papers. So,these values of the stiffness can be used for further investigation. The findings of this study give a good theoretical foundation for the actual design technique. From this conclusion current study will be more feasible.

List of Abbreviation

SymbolSpecification

(EIt) Stiffness of top angle leg close to the column flange

(EIa) Web angles leg stiffness near column flange

(gct)Distance between centre of upper angle leg to the centre of bolt diameter

(gcc) Distance between centre of web angle leg to the centre of bolt diameter

(d1)Distance between the centres of legs of the top & seat angles

(d3)Distance between the centre of depth of beam to the centre of seat angle

(d)Depth of beam

(t_t)Top angle Thickness

(t_a) Seat angle Thickness

(w) Width of fastener nut

(gt) Gauge distance

(lt) Angle length of top

(lp) Angle length of web

(E)Modulus of elasticityis taken as 200 x 10^6 kN/m^2

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