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# Effects of Semi rigid Joint on Analysis of Frame Structure

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**ABSTRACT:** This paper is represent the comparatively analysis of different Joint .In that fixed , pinned and semirigid joints are used for design and behaviour of steel structural frame. Frye and Morris polynomial model is used for semi-rigid connections as suggested in IS 800:2007(Annexure-F) <sup>[7]</sup>. Secant stiffness is calculated for connections using Frey and Morris polynomial equation. Values of secant stiffness for the semirigid joint like single web angle, double web angle, top seat plate without angle, header plate. are incorporated in analysis for all alternatives using STAAD Pro. (5<sup>TH</sup> SERIES) in place of assumption of ideal rigid and pinned end conditions, analysis result show in graphical form of shear force, bending moment of beam, axial force in column.

**KEYWORDS:** Steel frames, Semi-rigid connections, Frye and Morris polynomial Equation, Secant stiffness.

## I. INTRODUCTION

Steel structures are made up of different elements like beams, columns, bracings, flooring and roofing systems. These elements are properly connected to form a composite unit. Performance of building or structure is depends upon the connection and joints between them. Beam-to column connections are a major part of a steel frame and their behaviour affects the overall performance of the structure under different loadings. In common engineering practice, it is usually assumed that steel connections are rigid or pinned but in actual practice, steel connections are not providing ideal rigid or pinned end conditions. Due to action of different loading, Connections provide flexibility for ideal rigid connections and provide rigidity in case of ideal pinned end conditions so that it is necessary to know the moment-rotation behaviour of actual beam to column connections and to formulate appropriate  $m-\theta_r$  model for use in analysis and design of semi rigid frames. More popular approach to describe  $m-\theta_r$  curve is to curve-fit experimental data with simple expressions. A connection rotates through angle  $\theta_r$  caused by applied moment  $M$ . <sup>[10]</sup> Several moment-rotation relationships have been derived from experimental studies for modelling semi-rigid connections of steel frames. Secant stiffness is nothing but the concept use to show moment rotation behaviour between beam and column due to action of moment.

## OBJECTIVE AND SCOPE OF WORK:

The objective is to study of effects of semirigid joint on design of steel structural frame and scope of work is

- To study the modelling of semirigid joints.
- To study in details the basis behaviour of connection like rigid, semirigid, pinned connection.
- To study the effects of semirigid joint in analysis.

## II. LITERATURE SURVERY

1. **J.M.Cabrero, E.Bayo , (2005)** The proposed method allows to optimize not only the size of the structural profiles, but also the joint design to make it fit to the optimal theoretical values. Pre-design methods for semi-rigid extended end-plate joints were also provided to easily check the feasibility and suitability of a connection design. Two design examples were proposed to demonstrate the application of the proposed semi-rigid design methods, and their results compared to pinned and rigid alternatives. The semi-rigid approach results in more economical solutions. It must be pointed out that, in spite of optimizing the structural profiles, if the joints were not optimized, the resulting structure cannot be considered optimal and even adequate, as its main differential characteristic, the semi-rigid joint, has not been yet fully exploited. A design method suitable for semi-rigid joints

was proposed. Apart from minimizing the need for iteration, the main advantage is its similarity to the design method used at present for the traditional types of joints (pinned and rigid).

2. **Alfonsas Daninas , (2010)** “Influence of the semirigid bolted steel joints on the frame behaviour” Conducted study on the research work describes the analysis of steel semi rigid joints that are subjected to bending and tension or compression. The main attention is focussed on the beam-to-beam and plate bolted joints. Usually influence of axial force is neglected. In fact, the level of tension or compression of axial force can be significant and has some impact on joint behaviour and on its stiffness and strength characteristics. Nowadays the most powerful method for the estimation of joints characteristics is the component method. The adaptation of the component method for the determination of joints characteristics under bending and axial forces is shown in the paper.
3. **Bayan A, (2011)** “Cold formed steel joints and structures” Conducted study on this document contains three works. First, an introduction to cold-formed steel constructions is reviewed. Second, it provides an overview of the main design concerns for cold-formed steel structures. It concludes with a summary of joint and structural studies for cold-formed steel. In recent years, stronger materials and a broader variety of structural applications have led to a significant advancement in cold-formed steel in comparison to the more prevalent, heavier hot-rolled steel structural elements. Understanding the performance of cold-formed steel becomes a significant area of research.
4. **Lanhui Guo, (2015)** “Structural Performance of semi-rigid composite frame under column loss” Conducted study on the behaviour of the semi-rigid connection under single column removal scenario, a pseudo-static test of a composite frame with flush-endplate connections under the loss of middle column was carried out. Also, a FE model using both 3-D elements and 2-D elements was developed and analyzed. The accuracy of FE analysis results are validated by comparing with the experimental results.
5. **M. Gholipour Feiz, (2015)** “Effect of semi-rigid connections in improvement of seismic performance of steel moment-resisting frames” Conducted study on this study showed that in all frames, it could be found a state of semi-rigidity and connections configuration which behaved better than rigid frame, with consideration of the base shear and story drifts criterion. Finally, some criteria were suggested to locate the best place of the semi-rigid connections for improvement of the seismic performance of steel moment resisting frames.
6. **V. D. Kapatte, Dr. K. N. Kadam (2015)** This paper presents analysis of a pinned, rigid, semi rigid jointed portal frame using a versatile program developed in FORTRAN language using stiffness matrix formulation, where analysis has been done without changing source program and only with a minimal change in data file. This paper describe in detail computer implementation of formulation of the program organization in the form of a flow chart. Numerical is presented to show the effect of joint flexibility on overall response of structures. Single story portal frame with semi rigid beam to column is analyzed by changing rotational spring stiffness. Results are presented to show variation of bending moment, shear force and axial force.

### III. METHODOLOGY

For this study G+2 frame model is prepared as shown in the plan & 3D frame structure (Fig a,b,c). Analysis is done by using STAAD Pro software, is followed by designing these members in STAAD Pro by using IS 800:2007. Bolted connections are considered for the frame. Support conditions for column considered as fixed. Analysis takes into account the nonlinear behaviour of beam-to-column connections. The analysis and design of members has been done considering ideally rigid and ideally pinned end conditions. As suggested by IS 800:2007 (Annexure-F) secant stiffness (rotational stiffness) based on Frye-Morris polynomial model is used for analysis of semi-rigid structure. The values of secant stiffness are used in analysis for all alternatives by releasing beam in both end. Secant stiffness is rotational stiffness based on Frye - Morris polynomial equation.<sup>[7]</sup>

$$\theta_r = C1 (KM) + C2 (KM) + C3 (KM)$$

where K is a standardization parameter and is dependent upon connection type and geometry. C1, C2, C3 are curve fitting constants.

The methodology for study:

#### STEPS

- Modelling of frame structure for study
- Working out loading details that is dead load, live load.
- Analysis and design of considered frame with different joint.
- Comparing analysis result

**MODEL DETAILS**

Geometrical details  
 X direction: 3m  
 Z direction: 4m  
 Floor to floor height: 3m

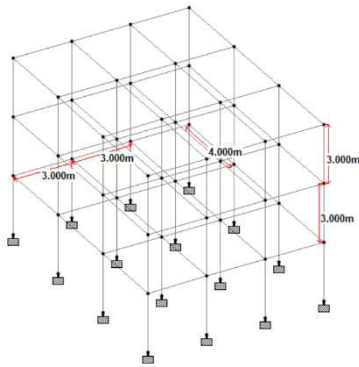


Fig (a)

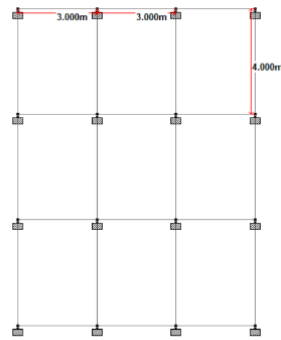


Fig (b)



Fig (c)

**SEMRIGID JOINT DETAILS**

Single web angle	$C1=1.91 \times 10^4$ $C3=2.7 \times 10^{17}$	$C2=1.3 \times 10^{11}$	$K= d_a^{-2.4} t_c^{-1.81} g^{0.15}$
Header plate	$C1=3.87$ $C3=6.06 \times 10^{11}$	$C2=2.71 \times 10^5$	$K= dp^{-2.3} tp^{-1.6} g^{1.63} tw^{-0.5}$
Double web angle	$C1=1.64 \times 10^3$ $C3=8.18 \times 10^{25}$	$C2=1.03 \times 10^{14}$	$K= d_a^{-2.4} t_c^{-0.5} I_a^{-0.7} d_b^{-1.1}$
Top and seat angle	$C1=1.63 \times 10^3$ $C3=3.31 \times 10^{23}$	$C2=7.25 \times 10^{14}$	$K= d_g^{-2.4} t_a^{-0.5} I_a^{-0.7} d_b^{-1.1}$

Table 1

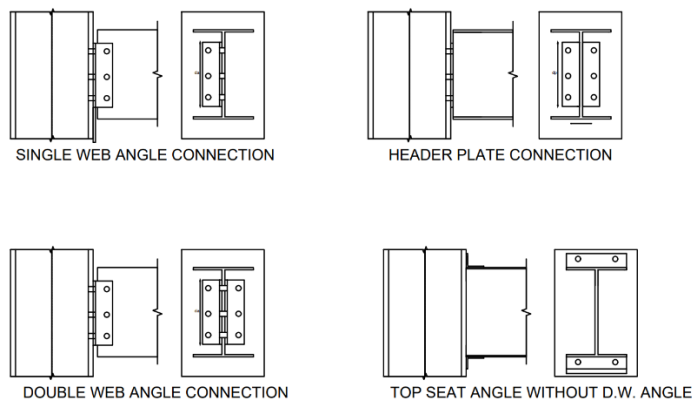


Fig (d) semirigid connection

**COMPARISON OF ANALYSIS RESULTS FOR RIGID, PINNED & SEMI-RIGID CONNECTIONS:**

Analysis is done for considered frame structure by using staad pro software. result for presentation is taken for frame 1 (Fig e) which 9 beams and 5 column. the result show of beam which is in X direction.

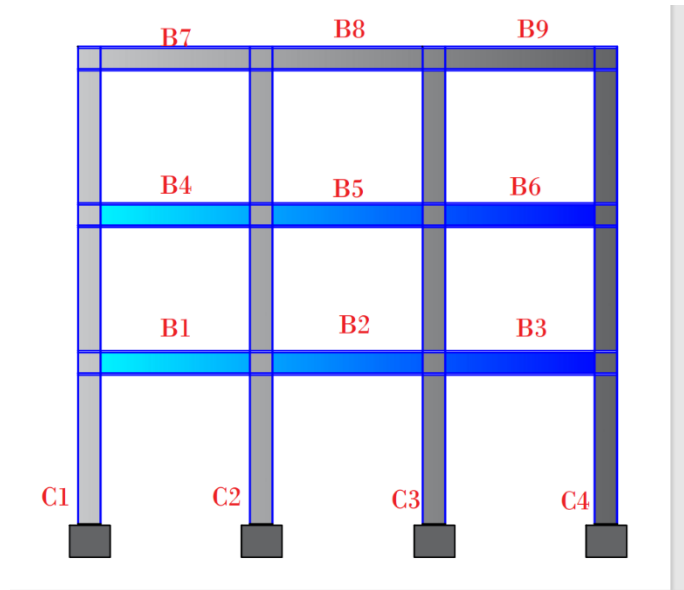


Fig (e) Elevation of Frame

SWAC	SINGLE WEB ANGLE CONNECTION
DWAC	DOUBLE WEB ANGLE CONNECTION
HPC	HEADER PLATE CONNECTION
TSWA	TOP AND SEAT WITHOUT WWB ANGLE CONNECTION

**IV. RESULTS**

Table 2 : Column Axial Forces (1.5DL+LL)

COLUMN AXIAL FORCES (KN)						
	PINNED	SW	DW	HP	TSWA	FIXED
C1	255.84	261.87	261.93	261.936	261.921	262.693
C2	440.73	470.44	479.817	479.952	480.051	480.951
C3	440.73	479.249	479.817	47.952	480.051	480.951
C4	255.84	262.044	257.431	261.936	261.921	262.093



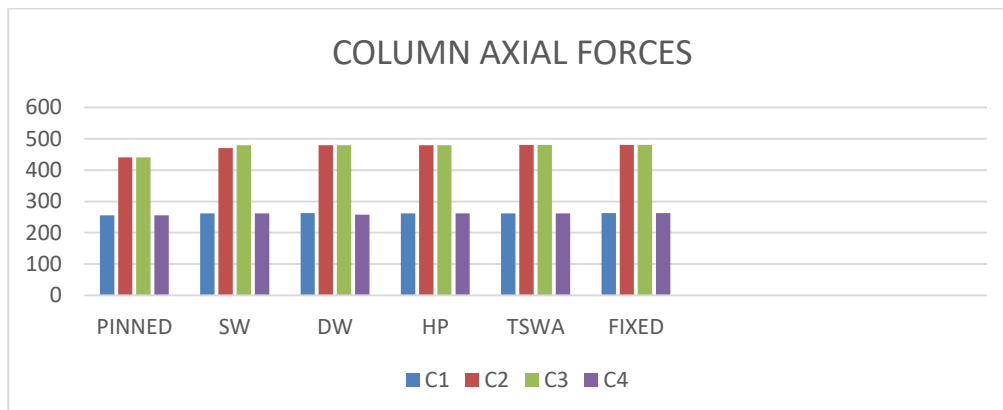
Table 3 : Beam Shear Forces (1.5DL+LL)

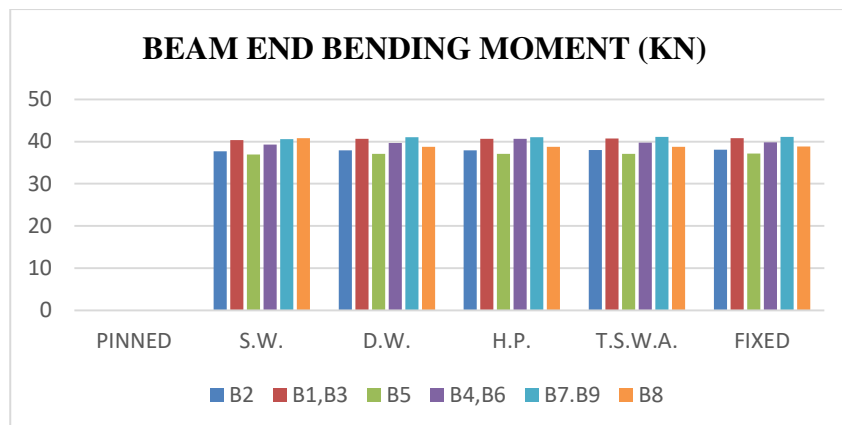
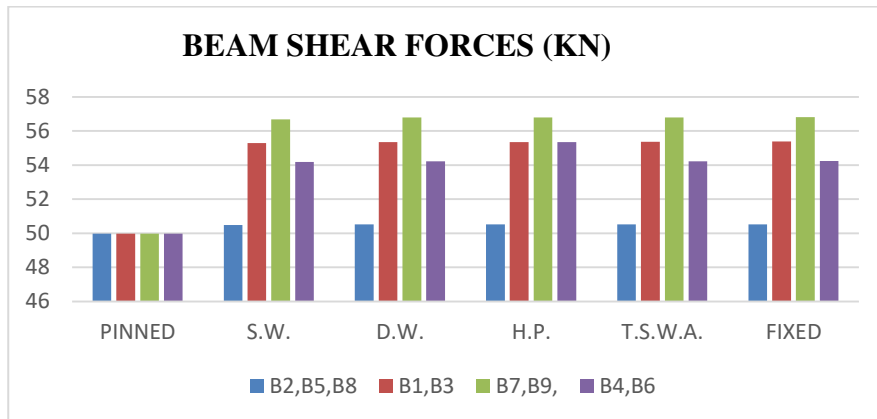
SHEAR FORCES ON BEAM (KN)						
	PINNED	SW	DW	HP	TSWA	FIXED
B1	49.98	55.293	55.352	55.343	55.361	55.378
B2	49.98	50.49	50.522	50.522	50.522	50.522
B3	49.98	55.262	55.352	55.346	55.361	55.373
B4	49.98	54.189	54.216	55.346	54.225	54.239
B5	49.98	50.5	20.522	50.522	50.522	50.522
B6	49.98	54.13	54.216	54.21	54.5224	54.239
B7	49.98	56.753	56.785	56.779	56.795	56.813
B8	49.98	50.5	50.522	50.522	50.522	50.522
B9	49.98	56.673	56.785	56.779	56.795	56.813

Table 4 : Beam END Bending Moment (1.5DL+LL)

BENDING MOMENT ON BEAM						
	PINNED	SW	DW	HP	TSWA	FIXED
B1	49.98	40.344	40.664	40.637	40.704	40.779
B2	49.98	37.699	37.953	37.931	37.986	38.048
B3	49.98	40.268	40.664	40.637	40.704	40.779
B4	49.98	39.414	39.667	40.637	39.706	39.778
B5	49.98	36.9	37.072	37.051	37.103	37.162
B6	49.98	39.266	39.667	39.641	39.706	39.778
B7	49.98	40.807	41.026	40.999	41.065	41.139
B8	49.98	38.583	38.745	38.722	37.78	38.845
B9	49.98	40.579	41.026	40.99	41.065	41.139

Above result are shown in graphical format or chart format below:





### V. CONCLUSION

- Variation has been observed in analysis result. they are gradually changed with joints and connection
  - Axial force in column is increased with rigidity increases.
  - Shear forces on beam are also increase with increase rigidity.
  - Beam end Bending Moment is gradually changed with change in connection. this change is directly proportional to each other.
  - At the different type of connection, change in stiffness not affected on weight of frame.
  - By observing overall result, reduction in joint moment is increase in span moment After that we can say that, semirigid joint are more suitable and economical design solution.
- All these connection are analysed and many researcher also presented that actual stiffness should be used for analysis instead of fixed or fully rigid and pinned which depend upon there connection.

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