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RESPONSES OF FRAME STRUCTURE BY USING SEMIRIGID JOINT

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Abstract : This paper is represent the comparatively seismic 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) **[7].** 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. (5TH 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.

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

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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-θ_r model for use in analysis and design of semi rigid frames. More popular approach to describe m-θ_r curve is to curve-fit experimental data with simple expressions. A connection rotates through angle θ_r caused by applied moment M. [10] 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.
- To study responses of beam under seismic analysis.

II. RELATED WORK

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 ant 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. Kapgate, 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). Seismic 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 Fyre - Morris polynomial equation.[7]

$\theta r = C1 (KM) + C2 (KM) + C3 (KM)$

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

LOADING DETAILS

Dead Load
- Selfweight (From staad model)
- Dead load of floor slab : 4.75 kn/sqm
- Dead load of brick wall – 10kn /m

Live Load
- Floor live load = 2kn /m (as considered residential building)

Seismic load (EQ)
Following value are used for seismic analysis by using IS 1893:2002 (Part I)
- Zone = III
- Zone factor (Z)= 0.16
- Important Factor = 1
- Response reduction Factor = 5
- Type of soil= Hard

Load Combination

1	1.5 DL+LL	**8**	1.2 DL +LL+ EQ Z
2	1.5 DL+ EQ X	**9**	1.2 DL +LL- EQ Z
3	1.5 DL- EQ X	**10**	0.9 DL+1.5 EQ X
4	1.5 DL+ EQ Z	**11**	0.9DL- 1.5 EQ X
5	1.5 DL- EQ Z	**12**	0.9 DL+1.5 EQ Z
6	1.2 DL +LL+ EQ X	**13**	0.9 DL- 1.5 EQ Z
7	1.2 DL +LL- EQ X		

TABLE1

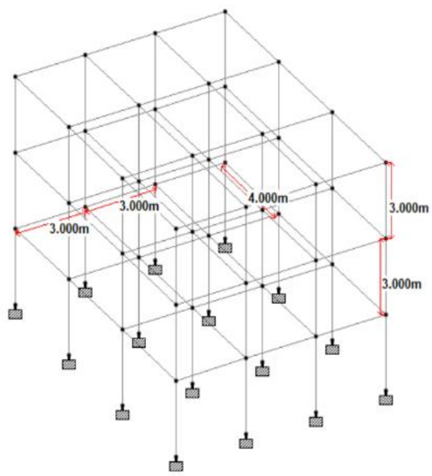
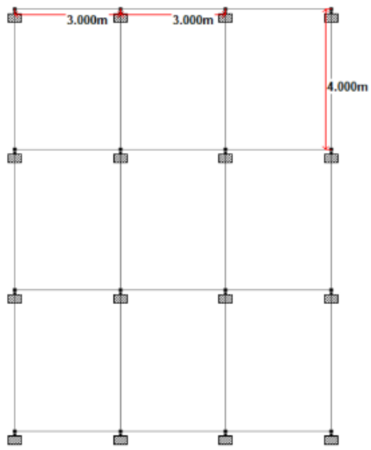


Fig (a)



Fig(b)

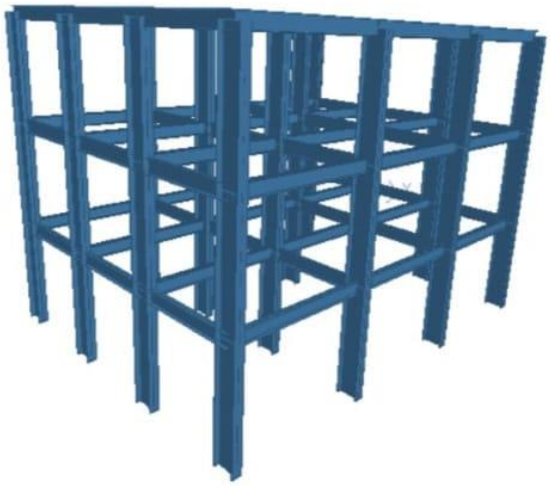


Fig (c) 3D RENDERED VIEW

SEMIRIGID JOINT DETAILS

Single web angle	$C1=1.91 \times 10^{4}$ $C2=1.3 \times 10^{11}$ $C3=2.7 \times 10^{17}$	$K= d_a^{-24} t_c^{-1.81} g^{0.15}$
Header plate	$C1=3.87$ $C2=2.71 \times 10^{5}$ $C3=6.06 \times 10^{11}$	$K=dp^{-2.3} tp^{-1.6} g^{1.63} tw^{-0.5}$
Double web angle	$C1=1.64 \times 10^{3}$ $C2=1.03 \times 10^{14}$ $C3=8.18 \times 10^{25}$	$K=d_a^{-2.4} t_c^{-0.5} l_a^{-0.7} d_b^{-1.1}$
Top and seat angle	$C1=1.63 \times 10^{3}$ $C2=7.25 \times 10^{14}$ $C3=3.31 \times 10^{23}$	$K= d_g^{-2.4} t_a^{-0.5} l_a^{-0.7} d_b^{-1.1}$

TABLE 2

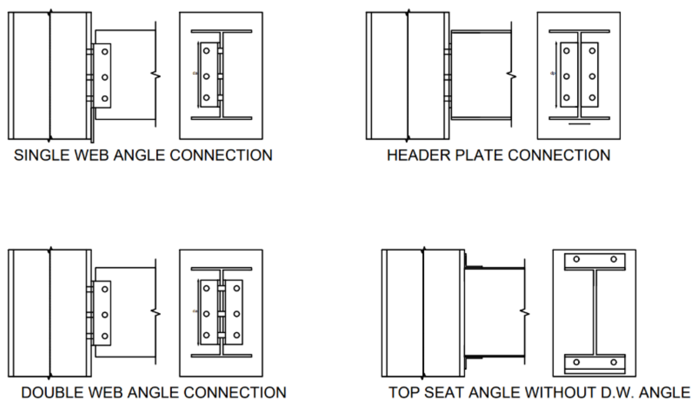


Fig (d) semirigid connection

COMPARISION 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.

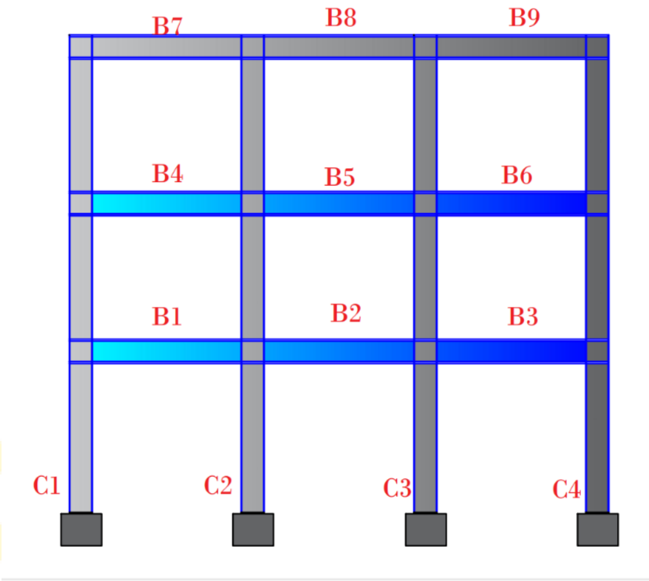


Fig (e) Elevation of Frame

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

IV. RESULT AND DISCUSSION :

TABLE 3

BEAM SHEAR FORCES (KN)						
	PINNED	SW	DW	HP	TSWA	FIXED
B1	45.168	50.131	50.221	51.32	50.234	50.257
B2	45.168	45.174	45.168	45.168	45.168	45.168
B3	45.168	50.089	50.221	50.213	50.234	50.257
B4	45.168	49.195	49.27	49.262	49.282	49.304
B5	45.168	45.177	45.168	45.168	45.168	45.168
B6	45.168	49.145	49.27	49.262	49.282	49.304
B7	45.168	51.201	51.32	51.312	51.333	51.358
B8	45.168	45.149	45.168	45.168	45.168	45.168
B9	45.168	51.199	51.32	51.312	51.333	51.358

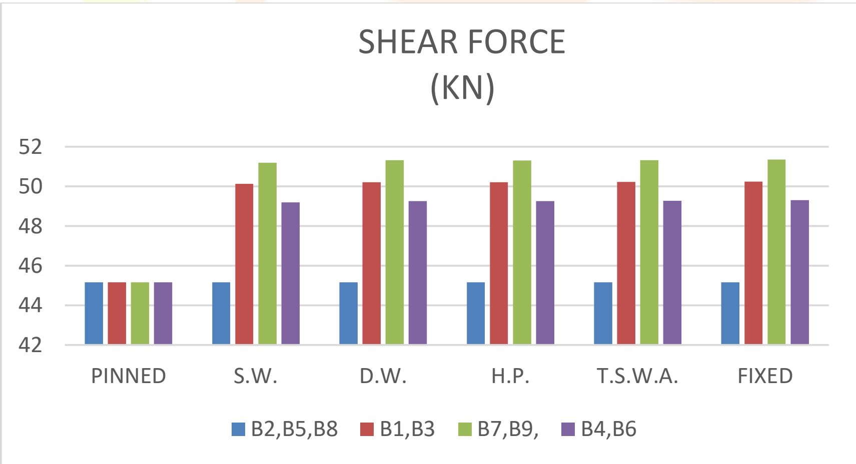
TABLE 4

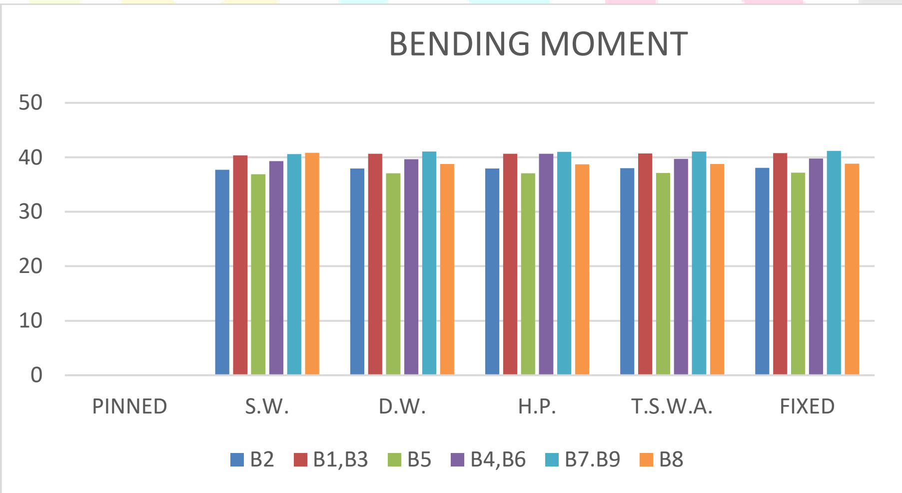
BEAM BENDING MOMENT (KN/M)						
	PINNED	SW	DW	HP	TSWA	FIXED
B1	0	35.572	36.011	35.976	36.064	36.162
B2	0	33.35	33.76	33.73	33.805	33.889
B3	0	35.486	36.011	35.976	36.064	36.162
B4	0	34.74	35.148	35.114	35.2	35.296
B5	0	32.539	32.919	32.89	32.962	33.042
B6	0	34.629	35.148	35.114	35.2	36.164
B7	0	35.518	36.016	35.981	36.068	36.164
B8	0	33.871	34.352	34.321	34.399	34.486
B9	0	35.542	36.016	35.981	36.068	36.164

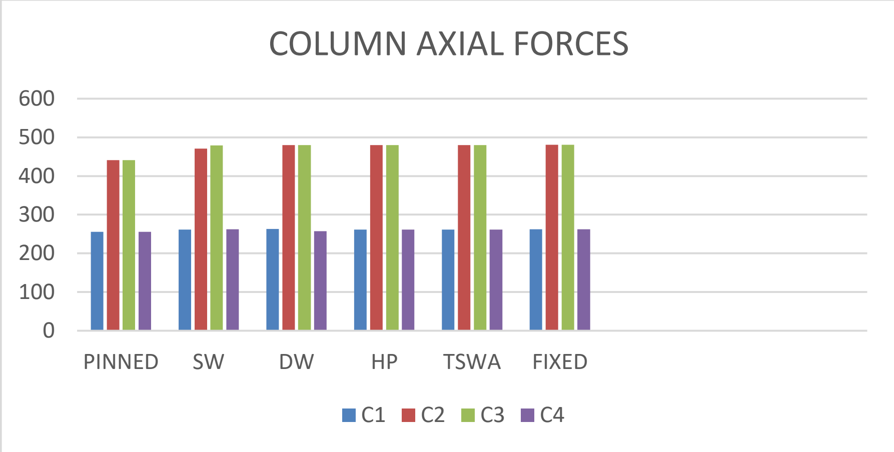
TABLE 5

COLUMN AXIAL FORCE (KN)						
	PINNED	SW	DW	HP	TSWA	FIXED
C1	248.753	192.923	194.16	194.155	194.155	194.18
C2	408.305	357.61	363.435	363.372	363.372	363.707
C3	408.305	361.259	363.435	363.72	363.372	363.707
C4	248.753	194.233	194.16	194.155	196.64	194.18

GRAPHICAL FORM OF RESULT







V. CONCLUSION :

- Variation has been observed in analysis result by the combination of DL+EQ . result are changed gradually with joints and connection.
- 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.
- Axial force in column is decreased with rigidity increases.
- 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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