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Comparative Analysis of Steel Structure with Rigid and Semi Rigid Joints Using Analysis Tool ETABS A Review

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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.

In this paper literature survey is presented related to analysis of steel structure.

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

I. INTRODUCTION

The 2001 Bhuj earthquake of India was an eye opener. It made thousands of people lose their lives and rendered millions to lose their houses. The effect was so wide spread that it not only affected the people in the vicinity of the epicenter but also those living in a metro city Ahemdabad, about 250 km away from the epicenter were badly affected. Alfredo Reyes-Salazar et al (2014) research paper investigated nonlinear seismic responses of 3D steel buildings with perimeter moment resisting frames (PMRF) and interior gravity frames (IGF), explicitly considering the contribution of the IGF. The effect on the structural response of the stiffness of the beam-to-column connections of the IGF, which is usually neglected, was further studied. It is commonly believed that the flexibility of shear connections is negligible and that 2D models can be used to properly represent 3D real structures. Results stated that the moments developed on columns of IGF can be considerable and that modelling buildings as plane frames may result in very conservative designs. The contribution of IGF to the lateral structural resistance may be significant. The contribution increases when their connections are assumed to be partially restrained (PR). The incremented participation of IGF when the stiffness of their connections is considered helps to counteract the no conservative effect that results in practice when lateral seismic loads are not considered in IGF while designing steel buildings with PMRF. Thus, if the structural system under consideration is used, the three-dimensional model should be used in seismic analysis and the IGF and the stiffness of their

connections should be considered as part of the lateral resistance system.

II. LITERATURE REVIEW

M. Ghassemieh and A.R. Bahadori (2015) research paper aimed at investigating the seismic performance of a steel moment frame considering influence of flexibility of its connections , hence, dealt with a spring-stiffness model called "the component method" to predict the real behaviour of steel moment connections (especially their moment-rotation curves). The behavior of the frame with cover plate moment connections in both cases of including as well as excluding the flexibility of the connections is compared using nonlinear static pushover, and incremental dynamic analyses. In all models, P-Delta effects along with material and geometrical nonlinearities were included in the analyses.

The results from the pushover analysis revealed that the initial stiffness and the ultimate strength of the cover plate frames with fully rigid connections are more than their counterpart frame with considering the flexibility of connections. In addition, considering the flexibility of the connection in the behavior of the structural frame made the period of the structure increases. Moreover, the maximum inter-story drifts in frame with considering the flexibility of the connections experience greater values than frames with fully rigid connections. And finally, conducting the incremental dynamic analysis revealed significant difference between the two seven story frames in terms of performance levels and indicated that overlooking the flexibility of beam to column moment connections may lead to inaccurate conclusions.

Dr B. A. Shah (2016) research paper considered a set of G+3 to G+7 RC space frames having an overall plan dimension of 6m x 6m with four panels of 3m x 3m and having a column at each panel point. The mathematical models developed were considered to have four variations in the beam column joint rigidity varying from pinned to fixed and two variations in column cross section i.e. rectangular and equivalent square cross section. A combination of rigid and semi rigid joints was used to define a frame called hybrid frame for analysis under seismic loads. The storey drift values noted for all the mathematical models at performance point under push over analysis, carried out by using commercially available ETABS software, was used as a basis of seismic performance.

Results stated that for low rise frames having G+3 to G+7 storey, the seismic performance of a frame with square columns is found better than that having rectangular columns from the storey drift criterion. Also, the storey drift was found maximum at the first storey level regardless of the size, column shape or the joint rigidity for G+3 to G+7 storey frames. The hybrid frames show less drift as compared to semi rigid frames keeping all other parameters the same. Also, there is a negligible difference in storey drift when hybrid frames with a joint rigidity of 100000 kNm/rad is considered for G+5 storey frame having either square or rectangular shaped columns. Hence conclusion stated that the square shaped columns exhibit less drift as compared to the rectangular shaped columns. It is also found that the hybrid frames with internal beam column joint having an intermediate rigidity perform almost like a frame having all joints as fully rigid.

Iman Faridmehr et al (2017) research paper incorporated nonlinear stiffness matrix method
The nonlinear stiffness matrix method was incorporated to investigate the structural performance of steel portal frames with semirigid connections. A portal frame with unstiffened extended end-plate connection was designed to demonstrate the adequacy of the proposed method. Besides, the

seismic performance of steel portal frames with semirigid connections was investigated through time history analysis where kinematic hysteresis model was assigned to semirigid connections to account for energy dissipation and unloading stiffness.

Based on the results of the study, it was found that generally semirigid connections influenced the force distribution which resulted in the decrease in base shear and lighter frame compared to the rigid one. The results also indicated that there was no direct relationship between maximum displacement at the top and connection stiffness in high-rise frames. The maximum displacement at the top in high-rise frame is mainly controlled by frame properties and ground motion level.

A. Moghadam et al (2018) The geometry of torsional plate, especially its thickness, is the most inuential parameter for determination of the proposed PR connection's behavior. Therefore, the response of structures can be easily adjusted in the design procedure by proper selection of the torsional plate thickness. Other inuential parameters are connection height, the thickness of the column connection plate, and the width of the torsional plate. By performing nonlinear, time-history analysis, it is shown that the frame with the proposed PR connection has the most acceptable seismic performance without requiring an increase in the size of columns and beam sections. If the special moment-resisting frame is considered as a seismic resistant system, the structure with PR connection can be designed to prevent formation of plastic hinges in columns and, thus, there is no need to design it due to strong column-weak beam restriction.

Hardik M Paghadal et al (2018) research paper presented seismic behavior and inelastic response of steel moment resisting frames in order to evaluate ductility on the basis of the Indian code of practice and inelastic behavior of the three dimensional frames under response spectrum analysis was investigated. A typical 5-bay frame with five stories have adopted with rigid and semi-rigid connections and by performing dynamic and non-linear static analysis, story and global ductility was evaluated. The modelling and analysis was done using analytical application ETABS.

In steel frame with semi-rigid connections, lateral displacement of structure increases and storey (local) and global ductility of structure also increases. The proper use of semi-rigid connections along with rigid connections provides a good ductile behavior of structure than the use of only either of them. The combination in which the outer frame is having full rigid connections and middle and inner frames having semi-rigid connections provide higher storey ductility. With the use of semi-rigid connections ductility of lower stories are increasing very significantly. With the use of semi-rigid connections in steel structure the design steel weight will reduce than using rigid connections. In steel structures steel column orientation plays an important role for evaluation of ductility to find out particular lateral direction for the more adequate values for storey and global ductility.

Neema B.R. et al (2018) research paper presented the effect of connection rigidity on seismic performance of G+9 storeyed steel frame using ETABS software (Version 2016). Fixity factors are varied from 0 to 1 at an interval of 0.1. Fixity factor is taken as ‘1’ and ‘0’ respectively for rigid and flexible connections. Whereas for semi-rigid connections, fixity factor is varied from 0.1 to 0.9. The developed models are subjected to Response Spectrum Analysis as per IS 1893 (Part 1, 2002) codal guidelines. Using ETABS software (Version 2016), the developed steel frame models are subjected to Response Spectrum Analysis (RSA) as per IS 1893 (Part 1, 2002) codal guidelines. Seismic parameters viz. storey displacement, storey

drift ratio and storey shear values was obtained for all the developed steel frame models.

Results stated that RSA predict similar variation of storey displacement and storey drift ratio in both X and Y directions for all the fixity factors. Maximum storey shear is observed at the base of the developed steel frame. In both X and Y directions, maximum storey displacement (i.e. at top storey) increases with decrease in the values of fixity factors i.e. shifting from rigid to semi-rigid to flexible condition. From fixity factor 0.3 (semi-rigid connection) in X-direction and fixity factor 0.2 (semi-rigid connection) in Y-direction to zero fixity factor (flexible) in both the directions, maximum storey drift ratio exceeds the allowable limit (i.e. 0.004) as specified by Cl. 7.11.1 of IS 1893 (Part 1, 2002). As the developed steel frame model shows variation in seismic parameters due to variation in fixity factors (which represent rigid, semi-rigid and flexible beam-to-column connections), connection rigidity should be considered in seismic analysis of steel structures.

Harsh Rana et al (2020) research paper introduced 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 was done commercially available software-STAAD.Pro. From the non-linear analysis, the story displacement and story drift was 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 was introduced at different location of periphery of structure. These brace frame structure consist of X- bracing and diagonal bracing. Comparative analysis was 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.

Results stated 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.

Cinitha A et al (2014) research paper conducted pushover analysis of a 3- and 9-storey steel building frames and a thermal power plant structure are carried out by incorporating user defined inelastic material behavior and assigning inelastic effects to plastic hinges at member ends for seismic perfromance evaluation. The analytical procedure proposed to estimate the inelastic deformations of beams, columns and connections are validated by incorporating the same in analysis. The capacity curves with acceptable performance levels for 3- and 9-storey building was discussed. Pushover analysis is found to be helpful in assessing the structural behavior in preliminary predictions of seismic demands.

Results stated that The lateral resistance of the structure varies profoundly in the nonlinear range with rigid and semi-rigid connections. The distinct performance levels such as IO, LS and CP are observed for frames with rigid and semi-rigid connections. The idealized realistic frame behavior (capacity curve) may be that observed with semi–

rigid frame connections. The moment-rotation characteristics of flexural hinges vary with rigid and semi-rigid connections (the rotation capacity of semi-rigid connections are much more than rigid connections even though its load carrying capacity is less than rigid connections) this may not be accounted for default provisions in the software as it may be taking the average characteristic features. The thermal power plant structure follows an elastic behavior under site specific MCE, due to high factor of safety imparted to the structure by considering the importance factor as 1.75 and it satisfies the requirement of life safety under DBE and collapse prevention under MCE.

Yang Rongqian and Zhou Xuejun (2020) in the research paper, Two semi-rigid concentrically braced steel frames were designed and tested to failure under reversed low-cyclic loading. The hysteretic curves, bearing capacity, energy dissipation capacity, ductility and stiffness degradation performance were studied in detail. Then the performance was compared to analyze the advantages and disadvantages of the two frames. The tests showed that the plastic deformation and damage were primarily concentrated at the braces, and the columns and semi-rigid connections exhibited hardly any plastic deformation. The specimens went through the elastic stage, elastic-plastic stage and failure stage during the tests. The results indicated the specimen with chevron braces has better seismic performance. The structure presents the characteristic of ductile failure on the whole. The steel frame and braces of the specimens cooperatively perform together so that the structure has two seismic fortification lines. The structure with chevron braces possesses an excellent bearing capacity, a high lateral stiffness, a reliable lateral-resistance performance and a strong energy dissipation capacity. In contrast, because of the premature fracture of the cross joints, the structure with X-shaped braces has a lower material utilization efficiency, which leads to a dramatic decrease in the bearing capacity.

Iman Faridmehr et al (2017) research paper incorporated nonlinear stiffness matrix method to investigate the structural performance of steel portal frames with semirigid connections. A portal frame with unstiffened extended end-plate connection was designed to demonstrate the adequacy of the proposed method. Besides, the seismic performance of steel portal frames with semirigid connections was investigated through time history analysis where kinematic hysteresis model was assigned to semirigid connections to account for energy dissipation and unloading stiffness.
Based on the results of the study, it was found that generally, semirigid connections influenced the force distribution which resulted in the decrease in base shear and lighter frame compared to the rigid one. The results also indicated that there was no direct relationship between maximum displacement at the top and connection stiffness in high-rise frames.

Bishal Koirala and Dr Rajan Suwal (2020) research paper aimed to determine the effects of the semirigid behaviour of the beam-column connection in the response of the frame structure. The moment-rotation relationship serves as the measure of semi-rigidity of the connections. Zero-length link elements in SAP2000 was used to model the moment-rotation relationship of different connections in steel structures. Based on this moment rotation relationship, the moment-resisting frame was modelled considering rigid connections as well as semi-rigid connections. Response parameters like lateral displacements and bending moments are compared for both the rigid as well as different types of semi-rigid connections. The effects on seismic performance of the frame due to the presence of semi-rigid connections was investigated.

Results stated that mid span moment increases and end moment decreases, whereas horizontal displacement decrease in connection rigidity of semi-rigid connections. The redistribution of moments in EPC, EPC with stiffners and T-stub connection yields nearly equal mid-span and end-span moments with lateral displacements around 30% more than that of rigid connections, thus are suitable as moment connections in moment resisting frames. The ductility of the structures increases with decrease in rigidity of the connections and thus, enhances the seismic performance of the structure.

Jiwook Shin and Kihak Lee (2016) in the research paper, 3-, 9- and 20-story Steel Moment Resisting Frame (MRF) buildings were designed to satisfy the seismic requirements based on the IBC 2000 including the current value of 8 for the steel special moment resisting frame (MRF) buildings. Then, these analysis building models were redesigned using 6 different hysteresis models, which provide an ability to dissipate seismic input energy, for the beam-column connections. These models were also extended to account for the effects of period of the buildings. A total of 90 different building models were subjected to 20 ground motions representing a hazard level of 2% probability of being exceeded in 50 years to estimate the seismic demands. Pushover and nonlinear time history analysis were performed to calculate story drift and plastic rotation demands. The effects of hysteresis models and various periods of the steel special MRF was investigated.

Results stated that the dynamic structural behaviors of the buildings from the period effects were more sensitive than energy dissipation effects to the analytical models when various hysteretic connections effects and period effects.

III. CONCLUSION

objective of the research was to ensure that the effects of connection detailing, on the system-level response of the structure, is captured in the hybrid simulation. Authors in researches explained the utilization of jonts and seismic load.

IV. REFERENCES

[1]. Alfredo Reyes-Salazar, Edén Bojórquez, Achintya Haldar, Arturo López-Barraza, and J. Luz Rivera-Salas, [Seismic Response of 3D Steel Buildings considering the Effect of PR Connections and Gravity Frames], Hindawi Publishing Corporation e Scientific World Journal Volume 2014, Article ID 346156, 13 pages.

[2]. M. Ghassemieh and A.R. Bahadori, [Seismic Evaluation of a Steel Moment Frame with Cover Plate Connection Considering Flexibility by Component Method], Advances in Structure Engineering and Mechanics, August 2015.

[3]. Dr B. A. Shah, [Seismic Performance Evaluation of RC Frames with Semirigid Joints using Storey Drift as a Criterion], International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, Vol. 5 Issue 05, May-2016.

[4]. Iman Faridmehr, Mahmood Md. Tahir, Tom Lahmer, and Mohd Hanim Osman, [Seismic Performance of Steel Frames with Semirigid Connections], Hindawi Journal of Engineering Volume 2017, Article ID 5284247, 10 pages.

[5]. A. Moghadam, H.E. Estekanchi, and M. Yekrangnia, [Evaluation of PR steel frame connection with torsional plate and its optimal placement], Scientia Iranica A (2018) 25(3), 1025{1038.

[6]. Hardik M Paghadal, Dr. Darshana R. Bhatt and Dr. Snehal V. Mevada, [Ductility evaluation of

steel frames using semi-rigid connections, Journal of Emerging Technologies and Innovative Research (JETIR), November 2018, Volume 5, Issue 11.

[7]. Neema B.R., Shreyas S.C. and Dr. Chidananda G, [EFFECT OF CONNECTION RIGIDITY ON SEISMIC PERFORMANCE OF MULTI STOREY STEEL FRAMES], International Research Journal of Engineering and Technology (IRJET), Volume: 05 Issue: 07 | July 2018.

[8]. Harsh Rana, Dr. Darshana R. Bhatt and Dr. Snehal V. Mevada, [High Rise Long Span Steel Structure with Semi-Rigid Connection using Bracing System], International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, Vol. 9 Issue 03, March-2020.

[9]. Cinitha A, Umesha P. K and Nagesh R. Iyer, [Evaluation of Seismic Performance of Existing Steel Buildings], American Journal of Civil and Structural Engineering (2014) 23-33.

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