iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** I **Month of publication:** January 2018

DOI: http://doi.org/10.22214/ijraset.2018.1215

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor :6.887
Volume 6 Issue I, January 2018- Available at www.ijraset.com

Force Displacement Based Design of Steel Moment Resisting Frame

Ms.Joshilkar.P.D.[1], Mr.Patil.C.S.[2]
[1]P.G. Student, Department of Civil Engineering, Sanjay Ghodawat group of institutes, Atigre, Kolhapur, Maharashtra, India
[2]Assistant Professor, Department of Civil Engineering, Sanjay Ghodawat group of institutes, Atigre, Kolhapur, Maharashtra, India

***Abstract:** This paper presents a case study of seismic performance comparison of nine-story steel MRF designed with conventional and performance based design approach. The seismic performance of MRF is evaluated under a suit of various ground motion representing high to medium seismicity using nonlinear static pushover analysis and nonlinear time history analysis. The findings of evaluation study showed that the displacement based seismic design method for MRF is significantly more efficient in achieving a certain inelastic displacement for a given seismic hazards when compared to the existing design standards for this system.*
***Keywords:** Steel moment resisting frame, Performance based approach, Force based approach, Target drift yield mechanism, Nonlinear static pushover analysis, Nonlinear time history analysis.*

I. INTRODUCTION

Moment resisting steel frames comprise one of the most common forms used in modern building and industrial structures. Their main advantage for seismic resistance is that, they provide very ductile response. However, numerous moment resisting frames suffered beam to column connections and other failures in brittle manner during some recent earthquakes, particularly the 1994 Northridge and 1995 Kobe earthquakes. Although many experimental and analytical studies have been conducted to investigate the seismic behaviour of moment resisting frames for several decades, the lessons learned from recent earthquakes indicated that the current earthquake resistant design concept and methods could not prevent the failure of the frames subjected to severe earthquakes. To prevent the failures during severe earthquakes that can occur in the future, the seismic behaviour of moment-resisting frames should be investigated in a more rational manner and new and better methods of designing the structures need to be developed.

II. PROBLEM STATEMENT

Present research involves the study of the parameters related to design a steel moment resisting frame for examine the performance of the model. Review and study of a force displacement based plastic design procedure for steel moment resisting frame. The parametric study included study of a force displacement based design of steel moment resisting frame.

III. FORCE BASED DESIGN OF 9 STORY FRAME

The building is assumed to have seismic weights of 2500kN per floor. For the seismic force calculation the study building is assumed to be located in high seismic region. The soil at the site is considered to be site medium soil .The equivalent lateral force at each floor level is obtained by distributing base shear.

Force based method specifies elastic analysis of steel MRF with beam and column under gravity load and lateral load combination. For the design of lateral load resisting steel MRF considered in this study gravity load is less than lateral load and hence neglected. The design method as per AISC seismic provision. Inelastic deformation capacity of MRF system cannot be fully utilized as the seismic force calculation is based on force method..The forced based design method is most applicable and popular method in current seismic design method. In FBD method, the equivalent static force acting on structure.Considering a high seismic design scenario, the value of *R* and *Ωo* are taken as 8 and 3, respectively. Thus implicitly this design is for target displacement ductility ratio μ = 2.67. The seismic response coefficient, *Cs* as per ASCE 7.

The design base shear *Vb*,

$$V_b = C_s W \tag{1}$$

Where, *W* is total seismic weight. The equivalent lateral forces, *Fi* at each floor level is obtained by distributing the design base shear, *Vb*.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor :6.887
Volume 6 Issue I, January 2018- Available at www.ijraset.com

IV. DISPLACEMENT BASED DESIGN OF 9 STORY FRAME

Performance based plastic design (PBPD) method for steel MRF by Lee and Goel (2001) considers pre-selected yield mechanism and uniform target drift as performance objectives. This design method based on modified energy balance equation. In this concept, the inelastic energy demand on a structural system is equated with the inelastic work done through the plastic deformations resulted from the unidirectional monotonic to the target drift.

$$\frac{V_{by}}{W} = \frac{-\alpha + \sqrt{\alpha^2 + 4\gamma\left(\frac{S_a}{g}\right)^2}}{2} \quad Where\ ,\alpha = \left(\sum_{i=1}^{n} \lambda_i h_i\right)\frac{\theta_p 8\pi^2}{T^2 g} \qquad (2)$$

A steel moment resisting frame of five bays each 8.0 m distance and 9 stories each at 4.0m.Using the proposed design method by Lee & Goel, the frame is to be designed for a maximum target displacement ductility ratio, damping ratio is to be 5%, medium soil strata. A36 steel confirmed with AISC (US Standard).

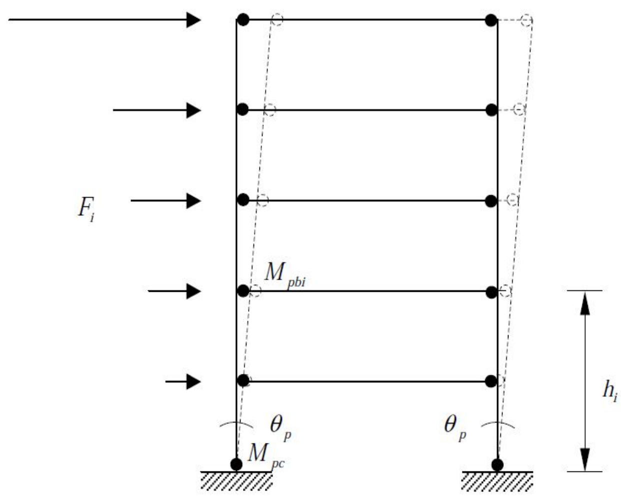


Figure 1: One-bay frame in the maximum drift response state with a selected mechanism.

V. SEISMIC EVALUATION BY USING SAP2000

A. *Nonlinear static pushover analysis*

Nonlinear static pushover analysis is used to evaluate the expected performance of a structural system by estimating its strength, deformation demands in design earthquakes and failure pattern. This evaluation is based on an assessment of important performance parameters, including global drift and inelastic element deformations. The model of design is subjected to the unidirectional monotonic push till the respective target displacement to induce significant inelastic deformations in the system. This type of curve is closer to an elastic plastic type. The initial slopes of the pushover curves are marginally same. The capacity curve roof displacement versus base shear plot and the approximate one and yield point (yield displacement, Dy; yield base shear, Vby) is obtained for each design.

B. *Nonlinear time history analysis*

Non-linear structural analysis is becoming more important in earthquake resistant design, which requires more information about the drifts, displacements and inelastic deformations of a structure than traditional design procedures. In non-linear dynamic analysis, the non-linear properties of the structure are considered as part of a time domain analysis. This approach is the most rigorous, and is required by some building codes for buildings of unusual configuration or of special importance. However, the calculated response can be very sensitive to the characteristics of the individual ground motion used as seismic input; therefore, several analyses are required using different ground motion records. The time history analysis is an actual dynamic analysis that can be done for both linear and nonlinear systems.

VI. RESULT AND DISCUSSION

A. Nonlinear static pushover analysis (NSPA)

In this PBPD design compare to AISC design from in Table1, it can be observed that compare model A with model D. Results obtained shown in below fig.2, it can be observed that maximum displacement 1.83m and yield displacement 0.44m and calculated displacement ductility ratio by maximum displacement to yield displacement is 4.1 for model 'A' using performance based plastic design method.Results obtained shown in fig.3, it can be observed that maximum displacement 3.93m and yield displacement 1.99m and calculated displacement ductility ratio by maximum displacement to yield displacement is 1.96 for model 'D' using force based method.

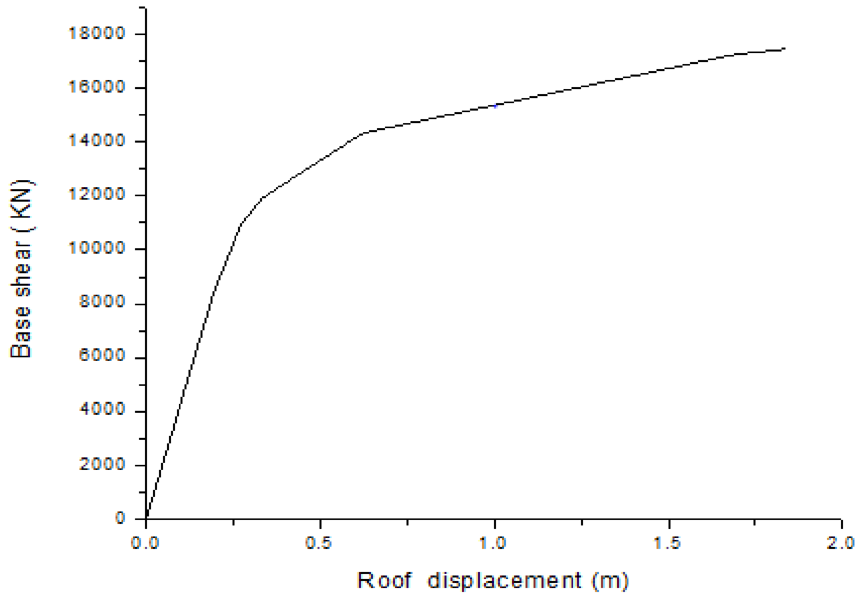


Figure 2: Capacity Curve of Nine Story Steel MRF for PBPD $\mu = 4$ (Model A).

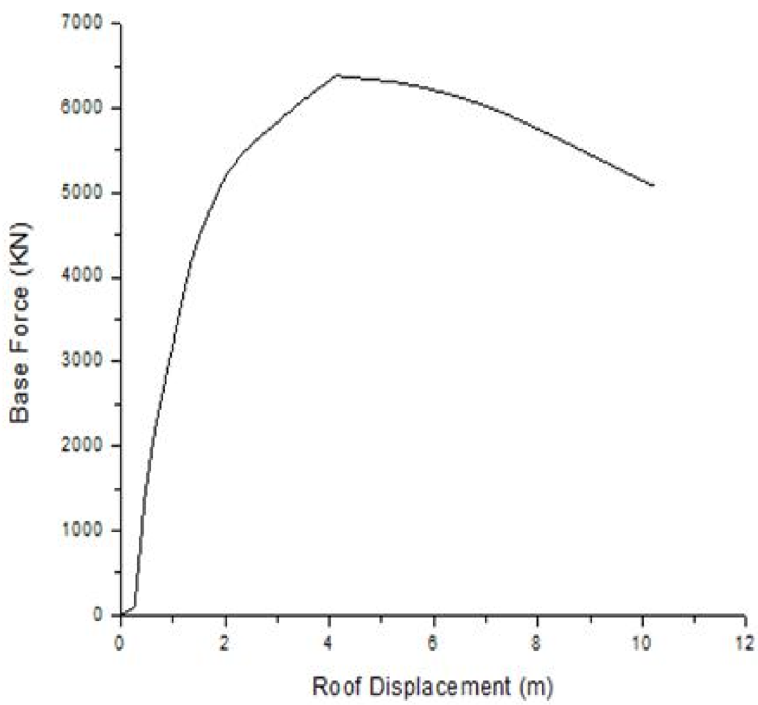
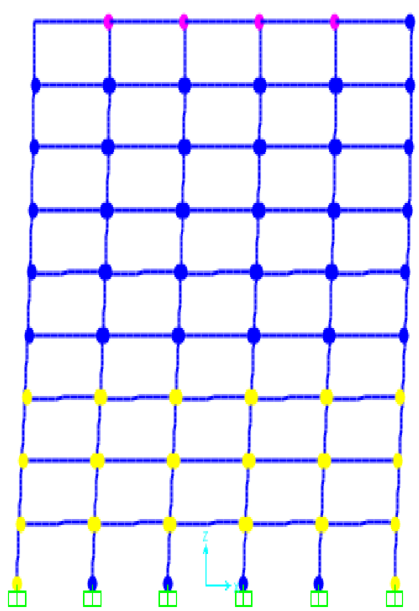


Figure 3: Capacity Curve of Nine Story Steel MRF for AISC$\mu = 1.96$ (Model D).

Table 1: Results of Nonlinear Pushover Analysis (NLPA)

Model	T (Sec)		Yield Displacement (m)	Max Displacement (m)	Base Shear (KN)	Ductility Ratio ($\boldsymbol{\mu}$)
	1stMode	2ndMode				
A	1.24	0.43	0.44	1.83	17465	4.1
B	1.83	0.59	0.75	2.28	11000	3.0
C	1.90	0.64	0.58	1.42	8499	2.40
D	2.94	0.96	1.99	3.93	6381	1.96



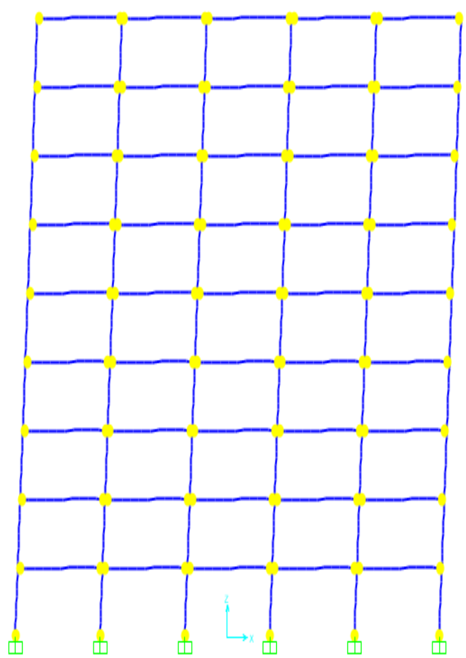


Figure 4: Yield mechanism for PBPD (Model A).Figure 5: Yield mechanism for AISC (Model D).

This can be achieved by allowing for the formation of a preselected desirable yield mechanism so that the structure has adequate strength and ductility during design level ground motions. The preselected yield mechanism can be defined as a strong column weak beam mechanism to prevent formation of collapse mechanisms with poor energy dissipation capacity for the structure. However, elastic design procedures used in most current seismic codes cannot guarantee to design the structure with a desirable mechanism and to predict the predominantly inelastic nature of the structure response during severe earthquakes. Therefore, use of plastic theory in seismic design procedure, especially in performance-based design, is necessary to avoid undesired collapse mechanisms. For AISC design collapse is poor as compare to PBPD approach.

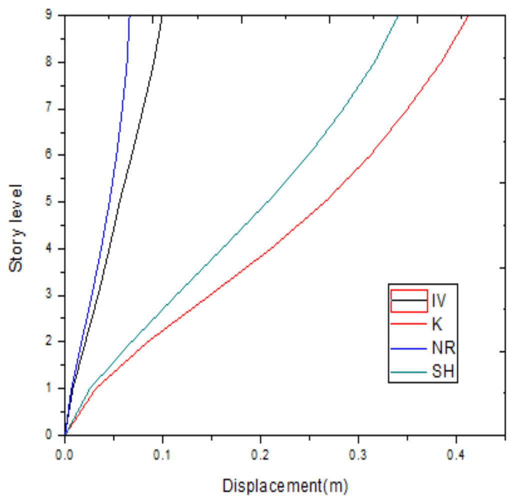
B. Nonlinear time history analysis (NTHA)

Results obtained from NLTHA. On the basis of these results, seismic analysis by both designs of nine storey steel MRF is discussed. In Table 2, it can be observed that ductility achieved in PBPD model is more than AISC model. Dynamic analyses of for 9-story, frames were carried out for selected ground motions. For NLTHA of each design under specific record, the acceleration time history of each earthquake is scaled through scale factor so as to have the same design spectral acceleration at the fundamental period gives calculation of typical scale factor. In order to investigate the performance of MRF in high to medium seismicity, Nonlinear Time History Analysis is performed under the ground motion records of 1979 El Centro, 1984 Northridge, 1987 Superstition hills and 1995 Kobe earthquakes.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor :6.887
Volume 6 Issue I, January 2018- Available at www.ijraset.com

Table2: Results of Nonlinear Time history Analysis (NLTHA)

Earthquake	μ_t	AISC design (Model D)			PBPD design (Model C)		
		Dm(m)	Dy(m)	μ_a	Dm(m)	Dy(m)	μ_a
EL Centro	2.67	0.79	1.99	0.39	0.92	0.58	1.58
Kobe	2.67	0.44	1.99	0.22	0.412	0.58	0.73
Northridge	2.67	0.429	1.99	0.21	0.8	0.58	2.0
Superstition	2.67	0.48	1.99	0.25	0.44	0.58	0.75



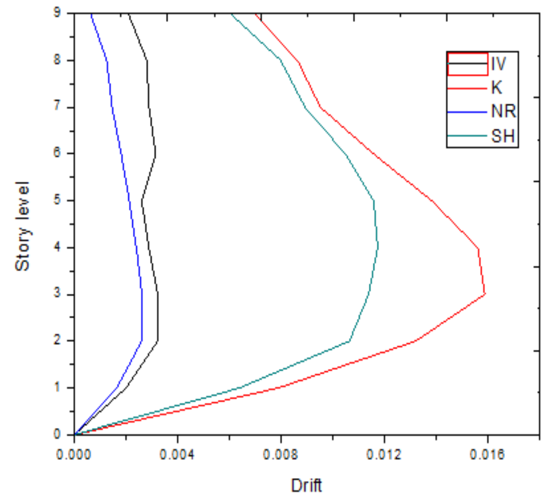
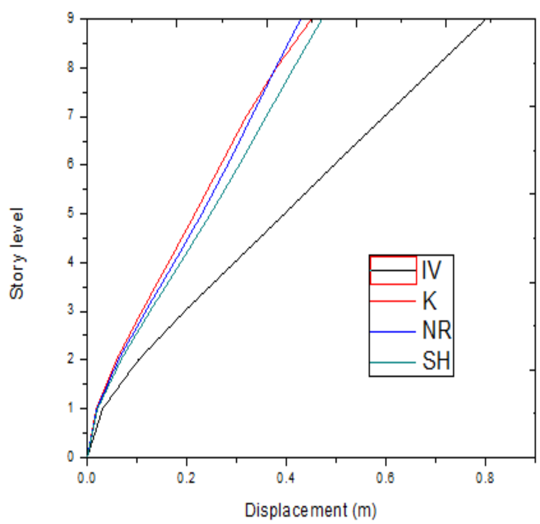


Figure 6: Displacement profile ductility2 for PBPD (Model C).Figure 7: Inter story drift ductility 2for PBPD (Model C).



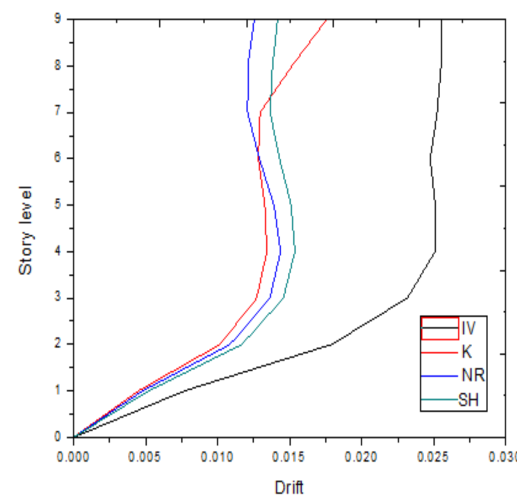


Figure 8: Displacement profile ductility2 for AISC (Model D).Figure 9: Inter story drift ductility 2 for AISC(Model D).

Results obtained for ductility ratio2 from displacement profile as shown in fig.6., it can be observed that El Centro, Kobe, Northridge, Superstition hills earthquake displacement is 0.099m, 0.411m, 0.065m,0.3401m. Inter story drift shown in fig .7, it can be observed that El Centro, Kobe, Northridge, Superstition hills earthquake inter story drift is 0.00208m, 0.00695m, 0.000614m,0.00602m. For AISC design, Results obtained for ductility ratio2 from displacement profile as shown in fig.8, it can be observed that El Centro, Kobe, Northridge, Superstition hills earthquake displacement is 0.0255m, 0.0175m, 0.0125m,0.0141m.Inter story drift shown in fig.9, it can be observed that El Centro, Kobe, Northridge, Superstition hills earthquake inter story drift is 0.0255m,0.0175m,0.0125m,0.01416m.

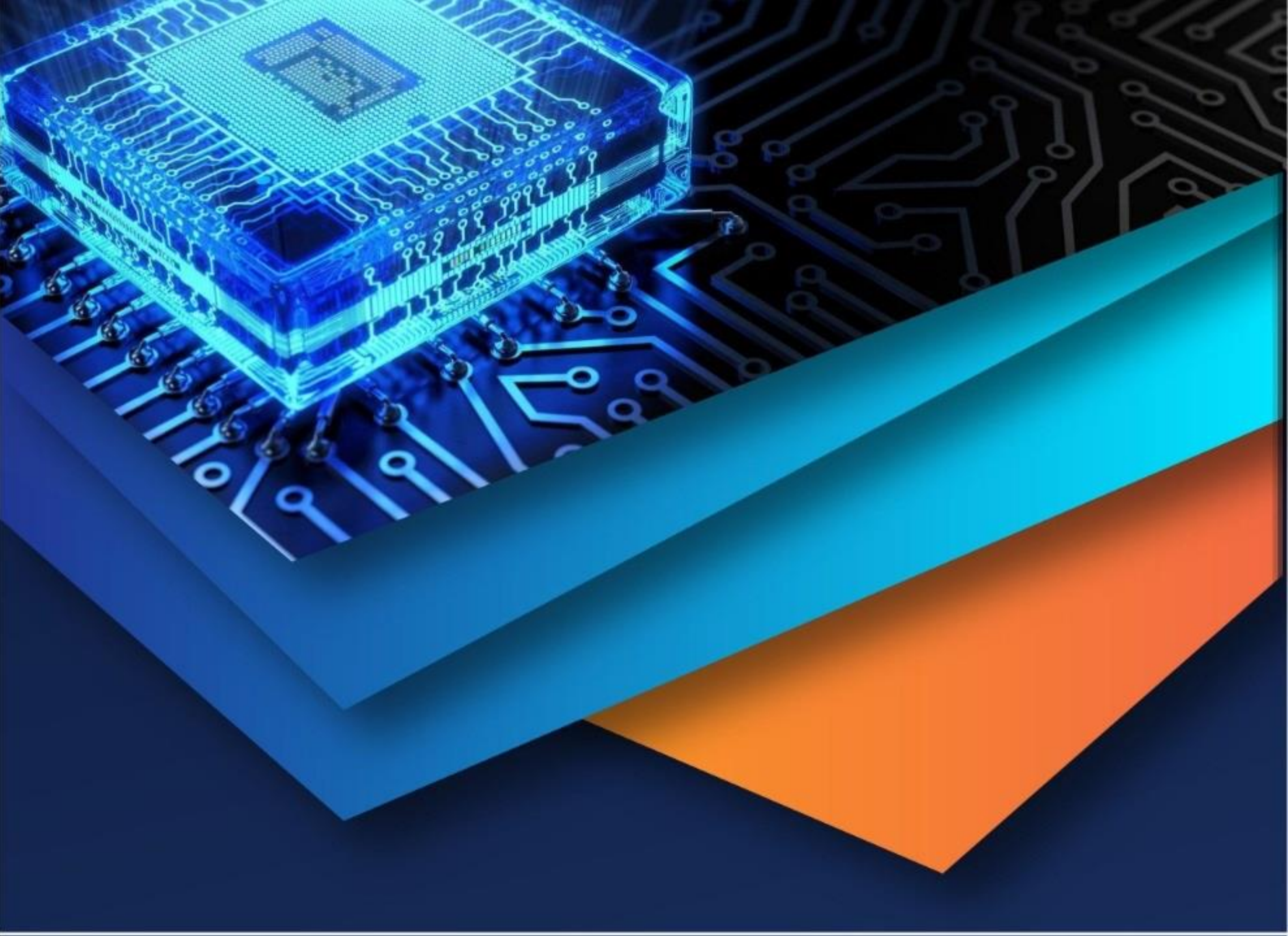
VII. CONCLUSION

The concluding remarks on the seismic performance of these designs are summarized as follows:-

A. The force based approach lacks in including the actual inelastic deformation capacity of MRF in design seismic force calculation and hence unable to achieve the specified displacement ductility ratio.
B. In this study shown the use of plastic design method in combination with the proposed design forces and distribution leads to structures that meet a pre-selected performance objective in term of yield mechanism and target drift that PBPD model is better in achieve to ductility ratio as compare to AISC model by using NSPA and NTHA.
C. The results of the yield mechanism study showed that strong column and weak beam. Plastic hinges developed in beam and at the column base.
D. The results obtained from NTHA showed that maximum displacement developed in force method as compare to displacement method. Inter story drift ratio maximum at intermediate story of structure for PBPD design and for AISC design drift ratio is maximum at throughout structure.
E. The displacement based approach includes actual inelastic target drift and an energy based formulation in the design procedure thus, it is found to be very effective in achieving a certain inelastic displacement for a given earthquake.
F. The displacement based design is prevent structure from collapse mechanism and also in ground motion records. Displacement based method is satisfied criteria for earthquake resisting structure.

VIII. REFERENCES

[1] Ashfaqul S.M., Sabbir A.H. (2012) “Innovative Moment Resisting Frame for Earthquake” International Journal of Emerging Technology and Advanced Engineering, Volume 2, (Issue 9)
[2] Austin M. A., Mahin S. A., Pister K. S. (1987) “Probabilistic Design of Moment Resistant Frames Under Seismic Loading.” This paper is part of the Journal of Structural Engineering, Volume 113, (Issue 8)
[3] Asgarian B., Sadrinezhad A., Alanjarib P.,(2009) “Seismic Performance Evaluation of Steel Moment Resisting Frames”Journal homepage: 2009 Published by Elsevier Ltd.
[4] ASCE7-2010, Code of practice for design of steel structure, American Standards of civil engineers.
[5] AISC (2010a), Specification for Structural Steel Buildings, ANSI/AISC American Institute for Steel Construction, Chicago, IL.
[6] ASCE (2005), SEI/ASCE 7-05, Minimum Design Loads for Buildings and other Structures, American Society of Civil Engineers, Reston, USA.
[7] Dalal S.P., Desai A.K., Vasanwala S.A. (2012) “Applying Performance Based Plastic Design Method to Steel Moment Resisting Frame in Accordance with the Indian Standard Code” International Journal of Engineering and Technology, Volume 2, (Issue 3)
[8] Dalal S.P. , Desai A.K., Vasanwala S.A. (2012) “Comparison of Steel Moment Resisting Frame Designed By Elastic Design And Performance Based Plastic Design Method Based On The Inelastic Response Analysis” International journal of civil and structural engineering Volume 2, (Issue4)
[9] Federal Emergency Management Agency, Washington DC, 1997 (FEMA), NEHRP guidelines for the seismic rehabilitation of buildings, Building Seismic Safety Council, Washington DC, Report No. FEMA-273, FEMA-356, FEMA p695.
[10] Kharmale S.B., Patil V.B., Revankar V.S.(2012) “Seismic Performance of Steel Moment Resisting Frames Designed With: Displacement-Based and Strength-Based Approaches” Indian Society of Earthquake Technology Department of Earthquake Engineering Building IIT Roorkee, Roorkee. Paper No. D013.
[11] Lalitha G.K., Bhaskar R., Vijaya S.K. (2013) “Optimum Design of Steel Moment Resisting Frames Subjected to Seismic Excitation” International Journal of Innovative Research in Science, Engineering and Technology Volume 2,(Issue 10)



10.22214/IJRASET