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Application of Performance Based Seismic Design Method to Column discontinued RC frames

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Abstract: *A performance-based seismic design (PBSD) method is aimed at controlling the structural damage based on precise estimations of proper response parameters. PBSD method evaluates the performance of a building frame for any seismic hazard, the building may experience. Use of this method for vertical irregular building is verified with comparison of conventional method. Vertical irregular frame is subjected to failures due to stiffness and strength reduction. This paper deals with application of performance based seismic design method for vertical irregular RC building frames(10 storied).Performance evaluation of conventional frames designed by conventional code method is compared with performance based seismic designed frames. The evaluation is carried out by Nonlinear Time History Analysis and Nonlinear Static analysis. The vertical irregular frames considered for study are with column discontinuity.*

Keywords-*Keywords are your own designated keywords which can be used for easy location of the manuscript using any search engines.*

I. Introduction

It is very clear that major contribution to structural damage is discontinuities or irregularities in the load transfer path. This path is important to transfer of seismic force, which develops due to accelerations of individual elements to ground. Development of distress is result of vertical irregularity may lead to complete collapse of structure. The examples of load path irregularities are discontinuous columns, shear walls, bracing etc. To study the effect of discontinuities we have considered 10 storey building frame with column discontinued in each storey which were modified into 10 different model cases.

Table 1: Column discontinued cases

Case/Mode	Type
Case 1	Column discontinued in first floor
Case 2	Column discontinued in second floor
Case 3	Column discontinued in third floor
Case 4	Column discontinued in fourth floor

Building model details-The basic plan and elevation for all 10 models is kept same. Frames are considered of 12m x 09m area. Height of building is 30m. Following table gives generalized details of frame considered for dimensions of the frame

Table 2: Design Parameters

Type of frame	Moment Resistant frame
Size of column	500x500mm
Size of beam	300x600mm
Thickness of Slab	125mm
Bay	4mx3m
Reinforcement	Fe500
Concrete Grade	M30
Load Type(D.L)	Self Weight
Load Type(L.L)	2KN/m^2
Floor finish	1KN/m^2
Earthquake Loads	I.S 1893-2002
Response Reduction Factor	5
Importance Factor	1
Damping	5%

II. ETABS Overview Page Size

Innovative and revolutionary software by Computers and Structures, ETABS (Extended Three Dimensional Analysis of Building Systems) is regarded as ultimate software package for structural analysis and design of buildings. It offers unmatched 3D object based modeling and visualization tools, fast linear and non-linear analytical power, sophisticated and comprehensive design capabilities for wide range of materials, and insightful graphic displays ,reports and schematic drawings that allow users to decipher and understand analysis and design results. Taking into account all these features this software is used as design aid for this study.

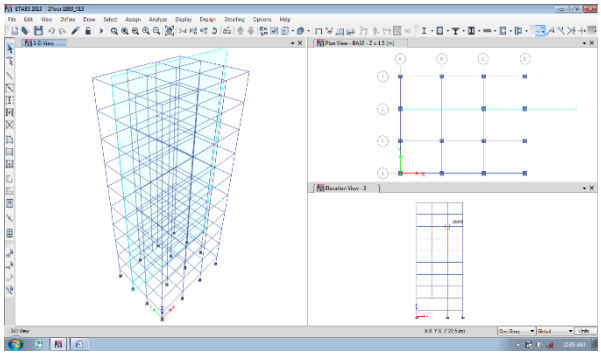

Fig.1. Plan and Elevation of 10 storied irregular frame considered for ION

2.1Performance Evaluation using Non-Linear Response Spectrum Analysis

In order to get still clear picture of the performance enhancement Nonlinear Dynamic Analysis is proposed for verification of result. Response Spectrum method estimates the forces in the members of a building corresponding to each natural periods and mode shapes. It requires free vibration analysis to determine natural periods and mode shapes. Peak spectral acceleration of building corresponding to each natural mode is computed using same design spectrum. Peak responses of individual modes are then combined using a suitable modal combination rule to estimate the total peak response of the building. Number of modes to be considered must be such that sum total of modal masses is atleast 90%of total seismic mass of the building

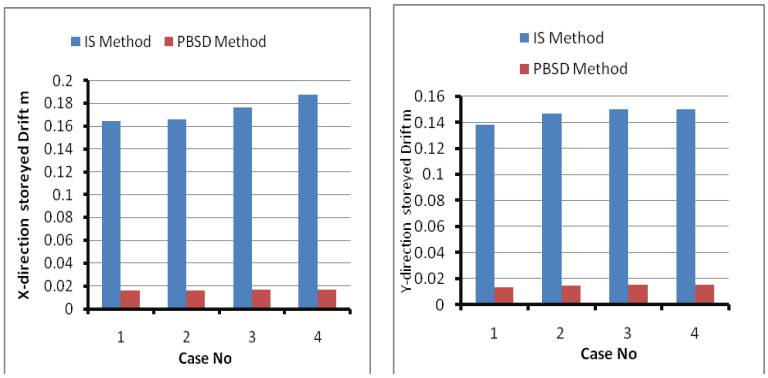

Fig.2. Comparison of Storey Drift in X,Y direction I.S 1893-2002 (force based method) method and PBSD

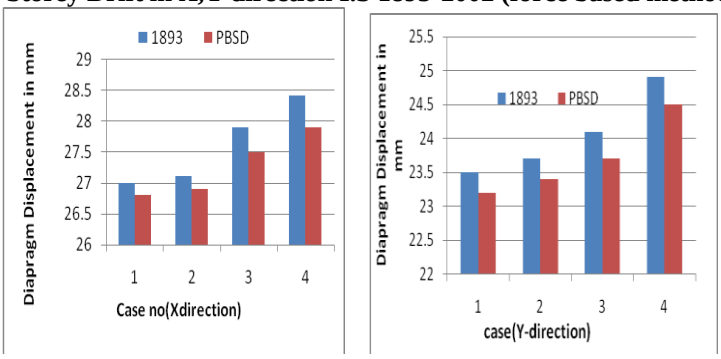

Fig 3 Comparison of Diaphragm Displacement in X and Y direction I.S 1893-2002(force based method) method and PBSD

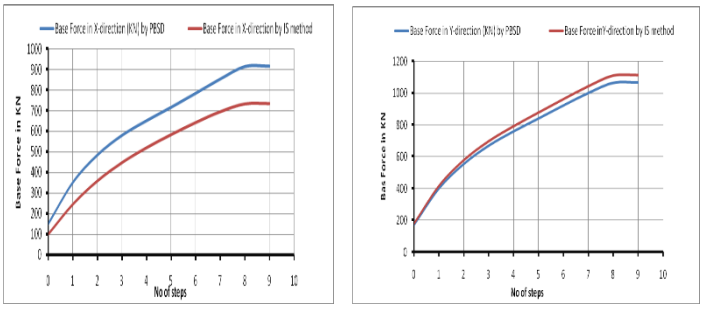

Fig4 Comparison of Base shear inXand Y direction I.S 1893-2002(force based method) method and PBSD

2.2 Comments on results from Response Spectrum Analysis

In case of Response Spectrum Analysis, Base force for PBSD method in all 5 models is more than IS method .The major difference is seen in first floor model having a difference of 100kN in X Direction and 150 kN in Y direction Inversely the displacement is reduced in PBSD models to a range of 0.025m in both direction .Displacement in both directions of PBSD models is 5mm less than IS models, which interprets the enhanced performance of the building frame. Story Drift which is major concern is directly reduced to 0.02m in all 5 models for PBSD in both directions .Diaphragm displacement in all models is considerably low in PBSD method compared to IS models in both directions. Diaphragm displacement is reduced by 2mm for all models in PBSD models than I.S models in both direction. Roof drift reduction in all models is also considerable i.e 10mm in all models. As static over strength ratio is governed by member sizes it is less in PBSD method than IS method .For the columns which are discontinued on the floors above sixth floor level ,there is no proper significant difference achieved in design done by I.S 1893-2002 method and Performance based Seismic Design method. Hence models having column discontinuity up till fifth floor level are considered for detail study. Response Spectrum Analysis gives mode shapes after analysis. These depend on geometrical parameters of model.

2.3 Performance Evaluation using Non-Linear nonlinear time history analysis
Non-Linear Time History analysis for Bhuj Time history is shown to compare with RS analysis.

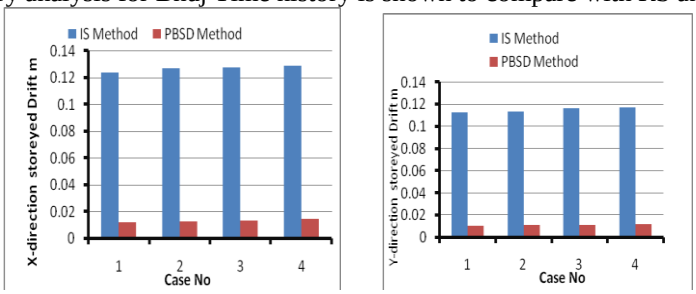

Fig5 Comparison of Story Drift in X and Y direction I.S 1893-2002(force based method) method and PBSD

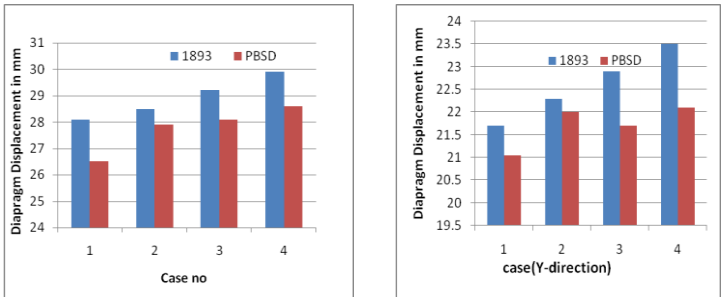

Fig6 Comparison of Diaphragm Displacement in X and Y direction I.S 1893-2002(force based method) method and PBSD

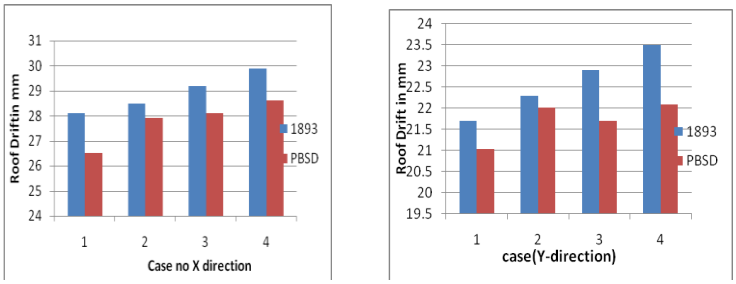

Fig7 Comparison of Roof Drift in X and Y direction I.S 1893-2002(force based method) method and PBSD

2.4 Comments on results from Non-Linear Time History Analysis

In case of Time History Analysis also Base force for PBSD method in all 5 models is more than IS method .The major difference is seen in first floor model having a difference of 109kN in Xdirection and 155 kN in Y direction. Inversely the displacement is reduced in PBSD models to a range of 0.05m in both direction. Displacement in both directions of PBSD models is 5mm less than IS models, which interprets the enhanced performance of the building frame. Story Drift which is major concern is directly reduced to 0.02m in all 5 models for PBSD and 0.12m in I.S method in both X and Y directions. Diaphragm displacement in all models is considerably low in PBSD method compared to IS models in both directions. Diaphragm displacement is reduced by 2mm for all models in PBSD models than I.S models in both directio.Roof drift reduction in all models is also considerable i.e 10mm in all models in both directions. For the columns which are discontinued on the floors above sixth floor level, there is no proper significant difference achieved in design done by I.S 1893-2002 method and Performance based Seismic Design method. Hence models having columndiscontinuity up till fifth floor level are considered for detail study.

2.5 Comparison of Response Spectrum and Non-Linear Time history Analysis

Comparative analysis is done in order to whether the values of both the methods are having any co relevance or not .It is seen that through both the analysis e get same trend which is shown in following figures. Overall values in both the methods have difference of about 2mm respectively. to 23.5mm for Response

Spectrum Analysis in X direction. Diaphragm displacement in I.S models have values from 21mm to 22mm for Time History Analysis and 23mm to 25mm for Response Spectrum Analysis in Y direction Roof values from 21mm to 22mm for Time History Analysis and 23mm to 25mm for Response Spectrum Analysis in X and Y direction are seen. Inversely the displacement is reduced in PBSD models to a range of 0.025m in both direction .Displacement in both directions of PBSD models is 5mm less than IS models ,which interprets the enhanced performance of the building frame. Story Drift which is major concern is directly reduced to 0.02m in all 5 models for PBSD in both directions.

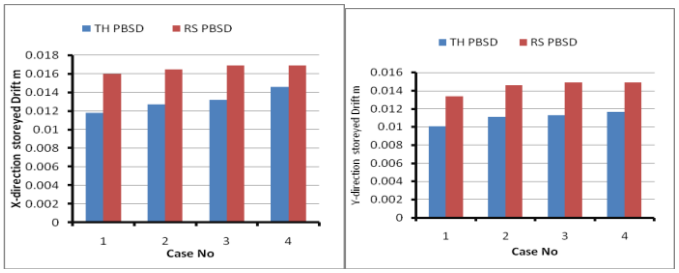

Fig8 Comparison of Storey drift in X and Y direction in Response Spectrum and NLTH analysis.

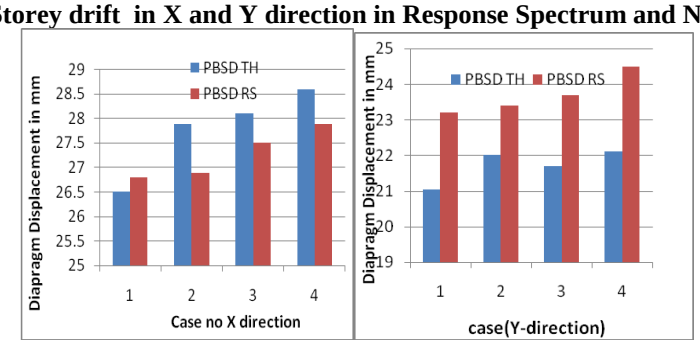

Fig 9Comparison of Diaphragm displacement in X and Y direction I.S 1893-2002(force based method) method and PBSD method for model with floating columns

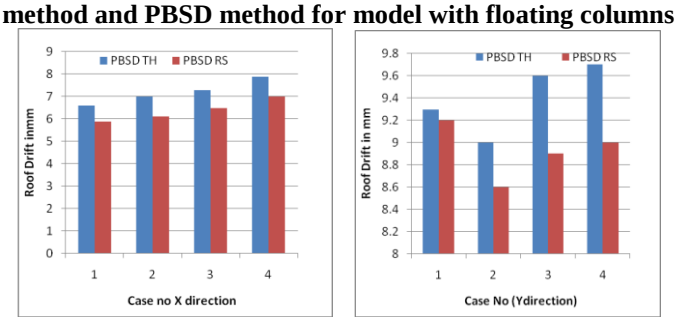

Fig 10 Comparison of Roof drift in X and Y direction I.S 1893-2002(force based method) and PBSD method for model with floating columns

As static over strength ratio is governed by member sizes it is less in PBSD method than IS method. As member size ratio is less in PBSD than member sizes in I.S method the over strength ratio is plotted in graph below

Table 3: Static Over strength Ratio

Case no.	Static Over Strength as per I.S 1893;2002	Static Over Strength as per PBSD
05	0.512	0.28
04	0.9	0.28
03	0.32	0.0095
02	0.932	0.36
01	0.5	0.147

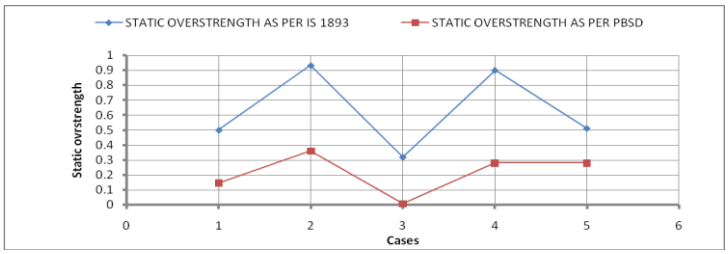

Fig 10 Comparison of Roof drift in X and Y direction I.S 1893-2002 (force based method) method and PBSD method for model with floating columns

III. Conclusion

Performance Based Seismic Design method implements proper distribution of lateral forces which is dependent on nonlinear behavior and stiffness degradation of material which is not addressed by any conventional method practiced up till now. Performance Based Seismic Design when used to column discontinued frames or floating column frames give better performances as that of frames designed as pr I.S method.

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