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Performance based design of RCC structure

Md. Rehan
rehan.alph@gmail.com
Al-Falah University, Dhouj, Haryana

Faiyaz Azam
faiyazazam303@gmail.com
Al-Falah University, Dhouj, Haryana

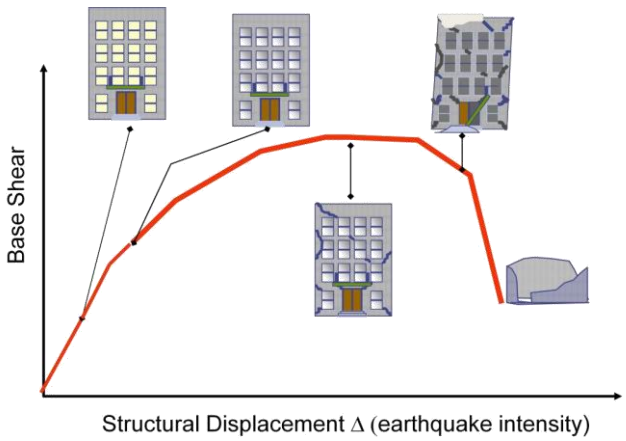
ABSTRACT

The prediction of inelastic seismic responses and the evaluation of seismic performance of a building structure are very important subjects in performance-based seismic design. The seismic performances of reinforced-concrete buildings evaluated by nonlinear static analysis (pushover analysis) and nonlinear time history analysis are compared in this research. A finite element model that can accurately simulate the nonlinear behavior of building is formulated by considering several important effects such as p-delta can be considered rigid zones with joint failure due to the poor detailing of joints. Both global responses such as system ductility demand and local response such as inter-story drift are investigated in this research. A numerical example is performed on a 20-story reinforced concrete building in ZONE V. Finally, the global and local responses obtained from the pushover analysis are compared with those obtained from the nonlinear dynamic analysis of MDOF system. The results show that the PA is accurate enough for practical applications in seismic performance evaluation when compared with the nonlinear dynamic analysis of MDOF system.

Keywords— *Performance based design, Non-linear elastic method, RCC model, Kobe earthquake*

1. INTRODUCTION

The promise of performance-based seismic engineering (PBSE) is to produce structures with predictable seismic performance. This approach is not new using this approach/model Turbine, Airplanes & Automobiles are made. In these applications, one or more prototype is built and subjected to extensive testing. To incorporate the lessons learned from the experimental evaluations the design and manufacturing process is then revised, once the cycle of design, prototype manufacturing, testing, and redesign is successfully completed, the product is manufactured in a massive scale. In the automotive industry, for example, millions of automobiles which are virtually identical in their mechanical characteristics are produced following each performance-based design exercise. Performance-Based Earthquake Engineering/Design is not that popular because the scale of output is not large in comparison to the Automobile industry and others. Each building designed by this process is virtually unique and the experience obtained is not directly transferable to buildings of other types, sizes, and performance objectives. Therefore, up to now, PBSE has not been an economically feasible alternative to conventional prescriptive code design practices. In the coming few years we can say that Performance-Based Design will become the standard method of delivering Earth Quake resistant designs.



2. METHODOLOGY

The general methodology adopted for this study was as follows:

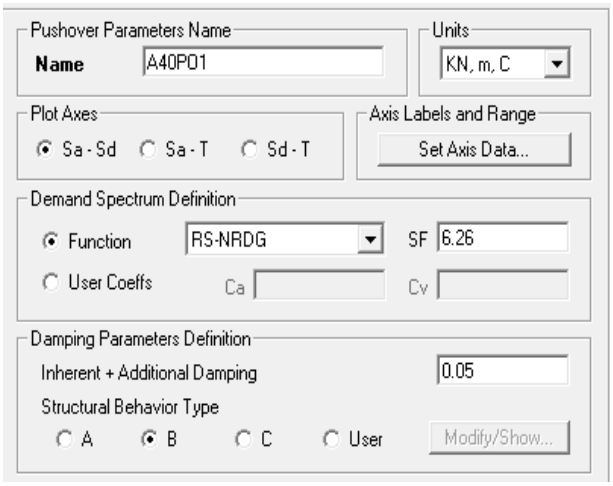
- A model of 20 storey RCC frame was made using the structural analysis software SAP2000 V14. For this study, code design methods IS Code 456:2000 were used.

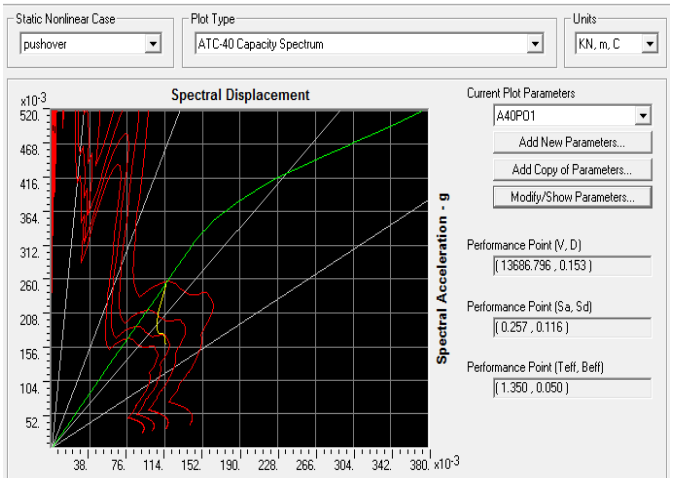
- Modal analysis was performed and actual fundamental period of the structure found out.
- Static response spectrum analysis was carried out in accordance with code methods of IS1893:2002.
- Dynamic time history analysis of the structure was performed. El Centro, Kobe and Northridge was used as input earthquake.
- Pushover analysis of the structure was performed. El Centro, Kobe and Northridge was used as input response spectra.
- Non-linear static Analysis and Non-Linear Time History Analysis were performed on the structures.

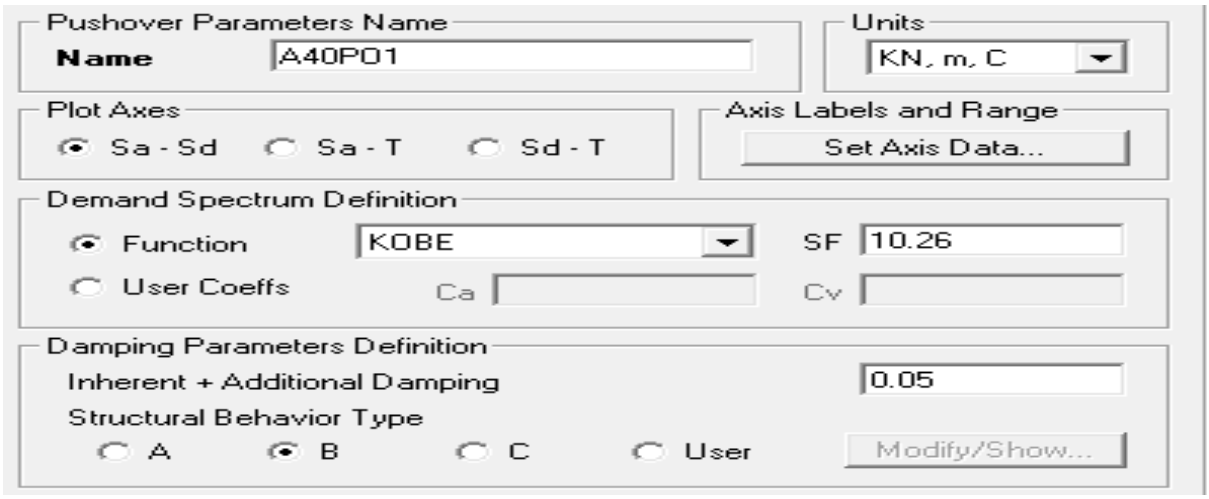
3. RESULTS FOR PUSHOVER ANALYSIS FROM CAPACITY SPECTRUM

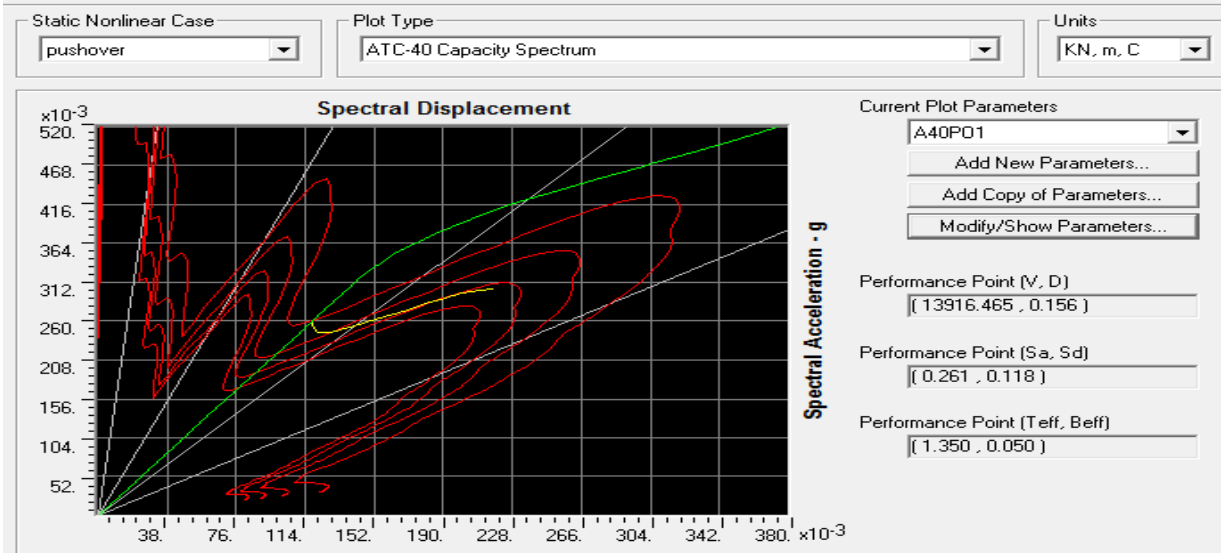
3.1 Performance point as base shear vs. top roof displacement

S. No	Response Spectrum	Base Shear, V(KN)	Top Roof Displacement, D(mm)
1.	Northridge	13599.3	152
2.	Kobe	13924.6	156
3.	El-Centro	11815.9	132









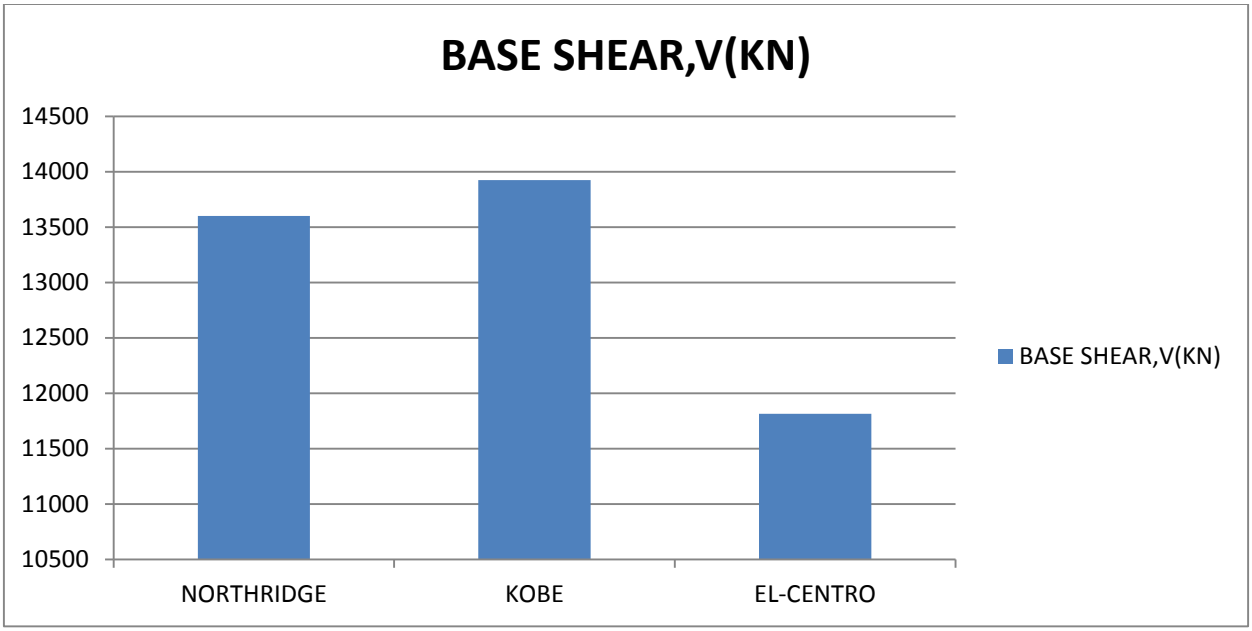


Fig. 1: Base shear from pushover analysis results for different response spectra

3.2 Performance point as spectral acceleration vs. spectral displacement

S. No	Response spectrum	Spectral acceleration, Sa (g)	Spectral displacement, Sd (mm)
1.	Northridge	0.255	115
2.	Kobe	0.261	118
3.	El-Centro	0.22	100

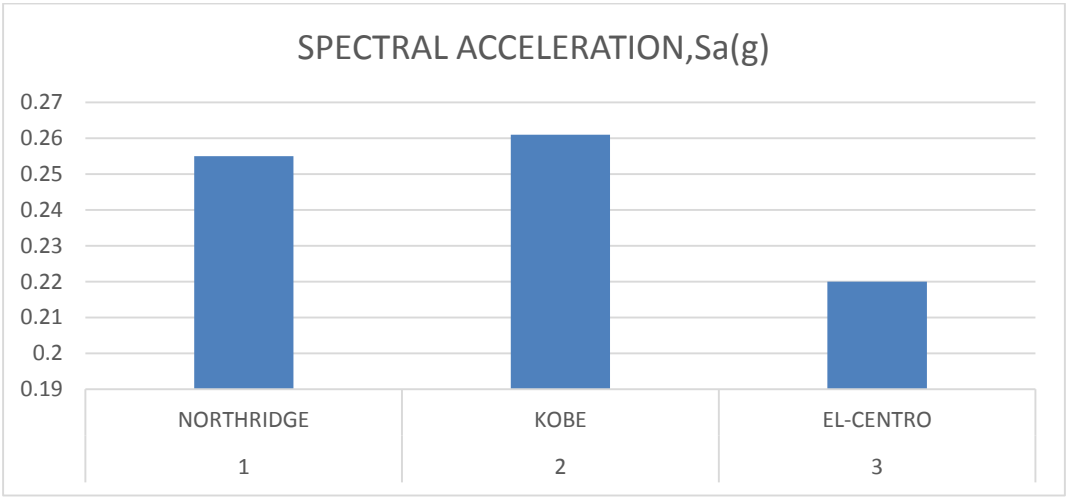


Fig. 2: Performance point in terms of spectral acceleration

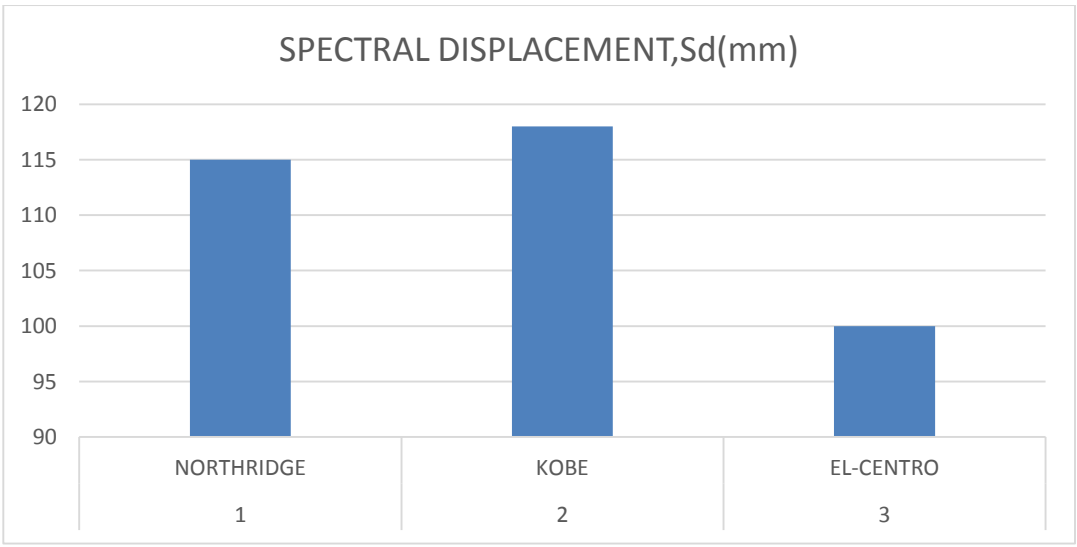
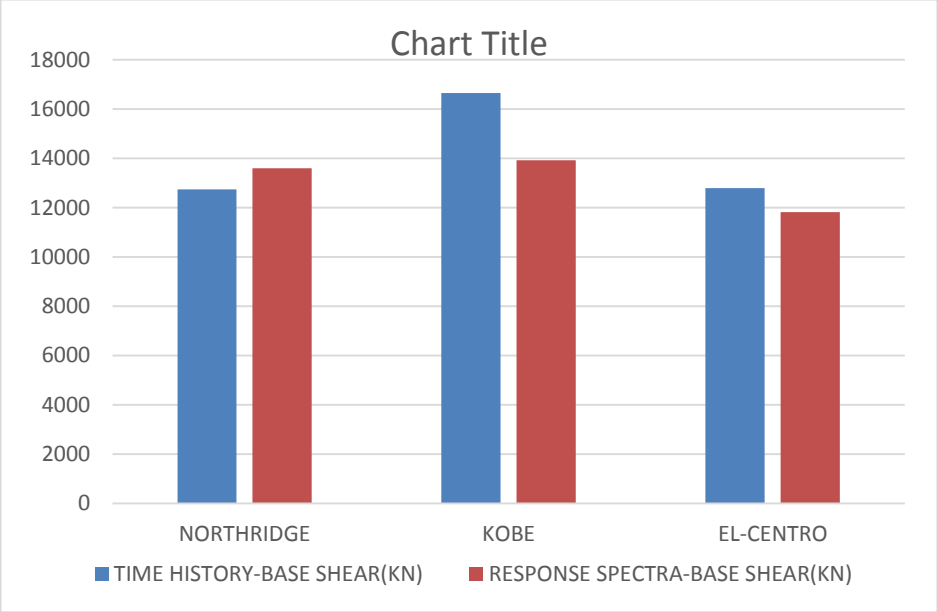


Fig. 3: Performance point in terms of spectral displacement

3.3 Comparison of base shear by pushover and time history analysis

Earthquake	Time History-Base Shear (KN)	Response Spectra-Base Shear (KN)
Northridge	12744	13599.3
Kobe	16659	13924.6
El-Centro	12798	11815.9



Comparison of base shear by time history and pushover

- Maximum base shear was observed for kobes earthquake and was more than elcentros earthquake by 15.14% and was more than Northridge by 2.34% for pushover analysis.
- Maximum top floor displacement was observed for kobe's earthquake and was more than elcentros earthquake by 15.13% for pushover analysis.
- Performance point in terms of spectral acceleration was observed maximum for kobes and varied from el-centro by 15.71% and by 2.3% from North-ridge earthquake.
- Performance point in terms of spectral displacement was observed minimum in the case of El Centro and was lesser than Kobe's by 18% and by 15% for Northridge.
- Maximum base shear was observed Kobe's earthquake and was more than el-centro's earthquake by 23.17% and was more than Northridge by 23.5% for non-linear time history analysis.
- Maximum top floor displacement obtained for Kobe's earthquake and varied with elcentro by 32.64% for non-linear time history analysis.
- Maximum inter storey drift is in case of Northridge and had a value of 13.5mm while in case of el centro it was observed to be 12.2 mm and for Kobe's, it was 13.1 mm.
- The base shear was found to be more for pushover analysis than non-linear time history analysis by 6.3% when the Northridge earthquake was applied.
- The base shear was found to be more for non-linear time history analysis by 16.4% than pushover analysis when Kobe earthquake was applied.
- The base shear was found to be more for non-linear time history analysis than pushover analysis by 7.67% when El Centro earthquake was applied.

4. CONCLUSION

- The 1st mode alone provides adequate estimates of floor displacements but it is inadequate especially in estimating the storey drift.
- First mode pushover analysis is unable to identify the plastic hinges in upper stories where the higher contribution of response is known to be more significant. The higher modes are necessary to identify hinges in upper stories.
- The selection of an appropriate load shape for any non-linear static procedure is the key issue in accurate prediction of the structural responses.
- The 20 storey Reinforced concrete building deforms into the inelastic range which leads to yielding of some of the beams and columns for the seismic intensity of 0.36 peak ground acceleration.
- To evaluate the seismic behavior of structure with significance higher modes effects, the non-linear dynamic analysis method generally provides a more reliable assessment of earthquake performance than the other methods.

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