Nonlinear Static Analysis of Reinforced Concrete Building

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***Abstract-* A nonlinear response is observed when a building is subjected to a medium-high intensity earthquakes. In the majority of cases at design stage this phenomenon is not properly modelled and only elastic design methods are effectively used. In past two decades various alternatives are developed for inelastic modelling and analysis. The objective of the study is to understand the behavior of static nonlinear analysis. A pushover analysis is done by using a computer program SAP2000, on a frame with different nonlinear hinge properties and element models and observed the response and effect on the structure.**

Keywords—concentrated plasticity, nonlinear static analysis, pushover analysis,

I. INTRODUCTION

During recent years a great advances have been made towards a more complete understanding of the behavior of structures subjected to earthquake excitations. Generally elastic analysis is used for building design, most will experience significant inelastic deformations under large earthquakes. For Modern performance-based, methods required to determine the realistic behavior of structures under different conditions. Advancements in available test data, nonlinear analyses provide the means for calculating structural response beyond the elastic range, which includes strength and stiffness deterioration with reference to the inelastic material behavior and large displacements. Nonlinear analysis can play an important role in the design of new and existing buildings. It means linear analysis can only approximate the real nonlinear behavior of structure. Sometimes, such an approximation is acceptable, and linear analysis can provide valuable insight into structures characteristics. However, in many cases linear assumptions differ too much from reality and provide inaccurate or misleading information. Using the results of linear analysis to decide whether a structure will fail under its operating loads may lead to overdesign. Once an engineer gains enough experience to recognize nonlinear problems, it becomes obvious that application of this technology isn't restricted to some situations. Designs that need or may benefit from nonlinear analysis flourish in every industry and in everyday design practice.

II. STATIC NONLINEAR ANALYSIS

The existing building may become seismically deficient since seismic design code requirements are constantly upgraded and advancement in engineering knowledge. In India buildings built over past two decades are seismically deficient because of lack of awareness regarding seismic behavior of structures. The extensive damage especially to RC buildings during earthquakes exposed the construction practices being adopted around the world, and generated a great demand for seismic evaluation and retrofitting of existing building.

We can evaluate the expected performance of structural systems by using static nonlinear analysis. The inelastic static pushover analysis can be viewed as a method for predicting seismic force and deformation demands, which accounts in an approximate manner for the redistribution of internal forces that no longer can be resisted within the elastic range of structural behavior.

Pushover analysis allows tracing the sequence of yielding and failure on member and structural level as well as the progress of overall capacity curve of the structure.

III. LITERATURE REVIEW

Goncalo carvalo, Rita Bento and carlos bhatt[1], tested some models with an existing structure and observed the performance with nonlinear static and dynamic analysis. They used computer programs SAP 2000 and Seismostruct for modeling and analysis. These models focus on the element flexural mechanism with both lumped and plasticity element models. Results obtained show the difficulties that may be met, not only in performing nonlinear analyses, but also on their dependency on both the chosen nonlinear structural models and the adopted computer programs.

Ray W.Clough, K.L. Benuska and E.L. Wilson[2], used a digital computer procedure for evaluating the inelastic forces and deformations developed in each column and girder of any arbitrary building frame subjected to earthquake motions. Two different 20 story building frames by the "EI Centro 1940 earthquake", computed by this program and further they are compared with result obtained in purely elastic analysis.

SERMİN OĞUZ[3], performed Pushover analyses by both DRAIN-2DX and SAP2000. Similar pushover results were obtained from the two different softwares employed in the study provided that similar approach is used in modeling the nonlinear properties of members as well as their structural features. The accuracy of approximate procedures utilized to estimate target displacement was also studied on frame structures. The accuracy of the predictions was observed to depend on the approximations involved in the theory of the procedures, structural properties and ground motion characteristic

IV. METHODOLOGY

To study the static nonlinear response of the building structure, displacement controlled pushover analysis was carried out. Pushover analysis was firstly performed on a structure shown in figure 1-a, 1-b &1-c. Capacity curve is obtained. As the geometry is very large and hence it was difficult to understand the behavior, a 2 bay frame, figure 2, of the building was taken and analysis is performed for that frame.

Element models:

For analysis 3 different models were considered, each composed by a different finite element formulation,

a) SAP2000 elastic element coupled with two frame hinge elements modeled with the externally computed moment-curvature relationship

b) SAP2000 elastic element coupled with two frame hinge elements modeled with the default values of moment-curvature relationship

b) SAP2000 elastic element coupled with two frame hinge elements, with the use of the fiber models of the cross sections

Pushover curves i.e. capacity curves are obtained from analysis.

Default and User-Defined Hinge Properties for Concrete Sections are given in Table 1 & Table 2 respectively.

Table 1: Moment-Rotation Relationship of Default concrete moment & PMM Hinges for 5 story R/C Frame

		BEAMS	COLUMNS
Point	Moment/SF	Rotation/SF	Rotation/SF
E-	-0.2	-0.035	-0.025
D-	-0.2	-0.02	-0.015
C-	-1.1	-0.02	-0.015
B-	-1	0	0
A	0	0	0
B	1	0	0
C	1.1	0.02	0.015
D	0.2	0.02	0.015
E	0.2	0.035	0.025

Table 2: Moment-Rotation Relationships of User-Defined Moment &PMM Hinges for 5 story R/C Frame

		BEAM1	BEAM2	COLUMNS
Point	Moment/SF	Rotation/SF	Rotation/SF	Rotation/SF
E-	-0.2	-0.040	-0.040	-0.030
D-	-0.2	-0.028	-0.029	-0.027
C-	-1.1	-0.028	-0.029	-0.027
B-	-1	-0.008	-0.011	-0.004
A	0	0	0	0
B	1	0.007	0.009	0.004
C	1	0.035	0.037	0.027
D	0.2	0.035	0.037	0.027
E	0.2	0.040	0.040	0.030

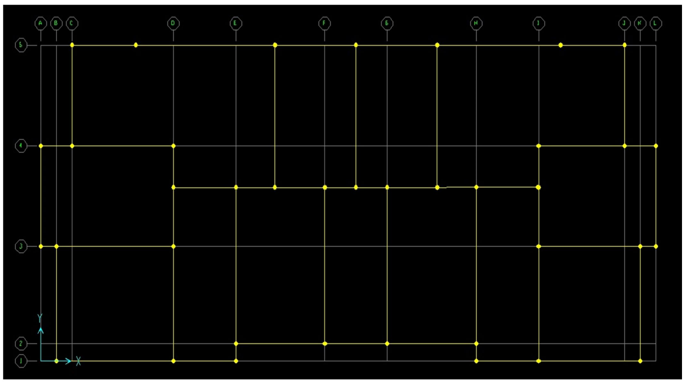


Figure 1-a: Plan of Building

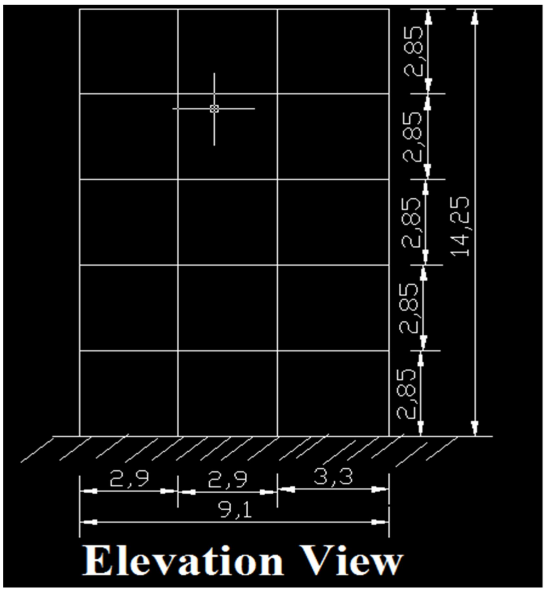


Figure 1-b: Elevation of Building

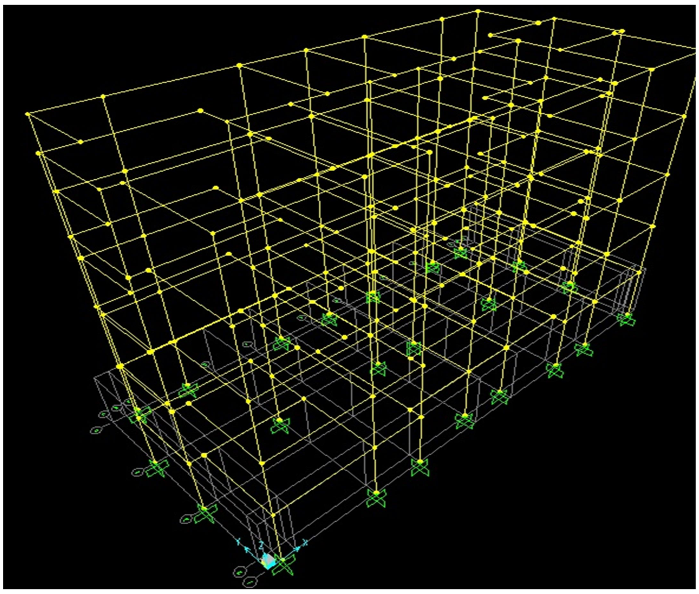


Figure 1-c: 3-D view of the Building

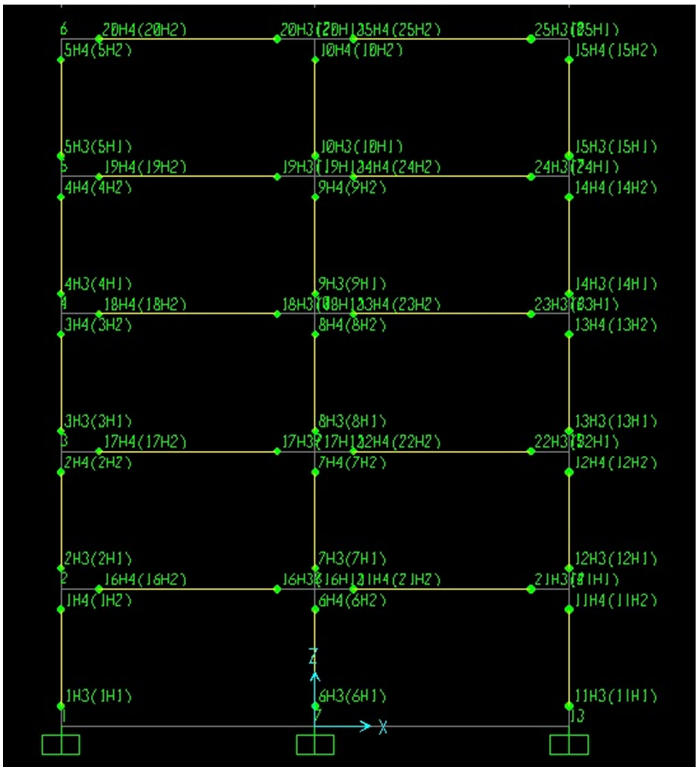


Figure 2: 2 Bay – 5Story Frame with User Defined Values of Hinges.

V. RESULT AND DISCUSSION

Number of push steps are less for less for default values of hinge properties, as hinges are formed.
Displacement and base shear is more for default values of hinge properties because number of push steps are more.

Graph 1: Capacity Curve for Main Building

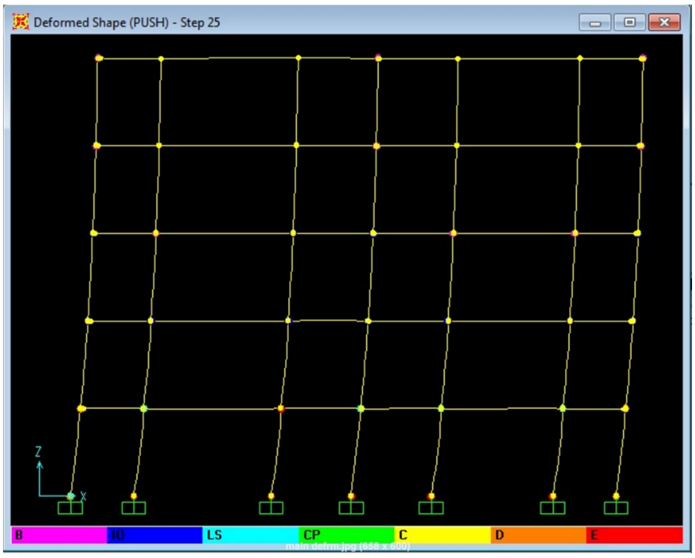
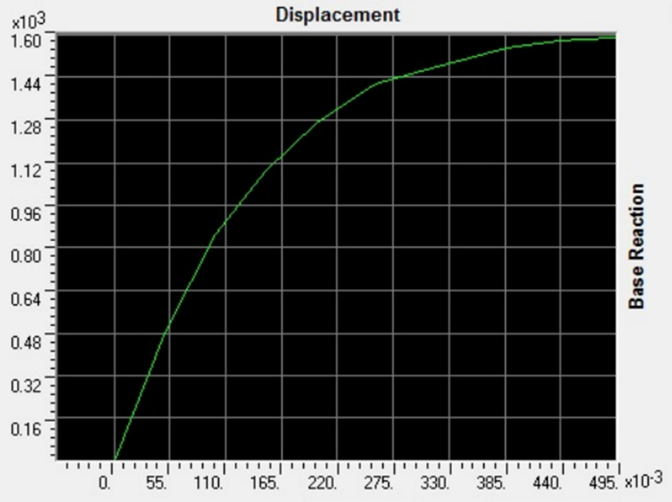
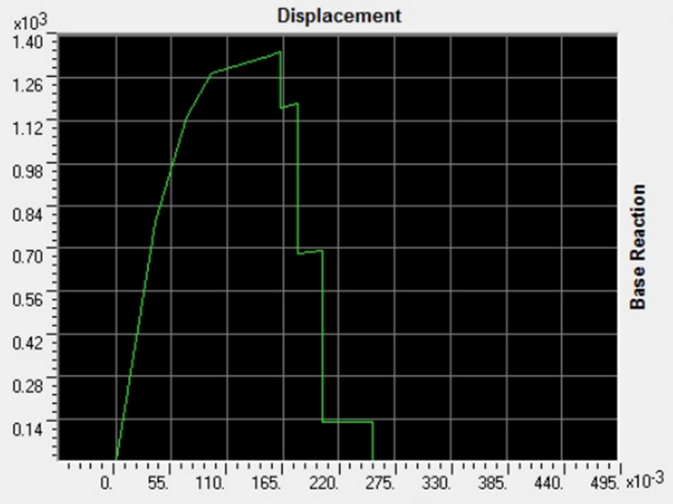


Figure 3: Deformed shape of the Main Building



Graph 2: Capacity Curve for Defult Fiber hinge Model



Graph 3: Capacity curve for Default Hinge Properties

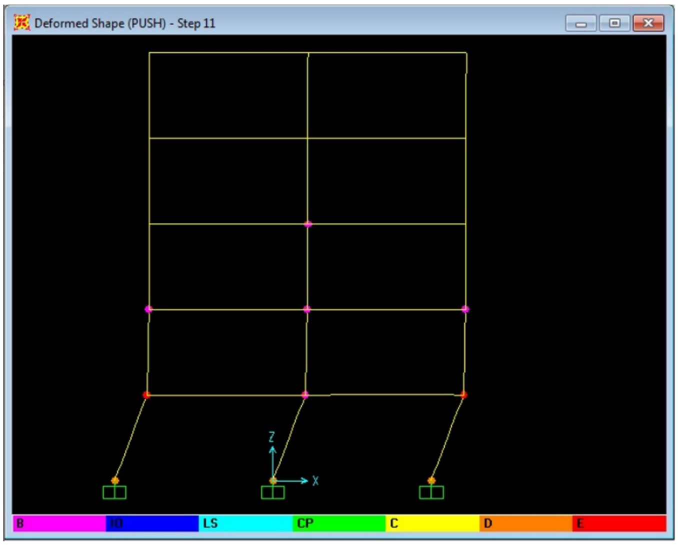
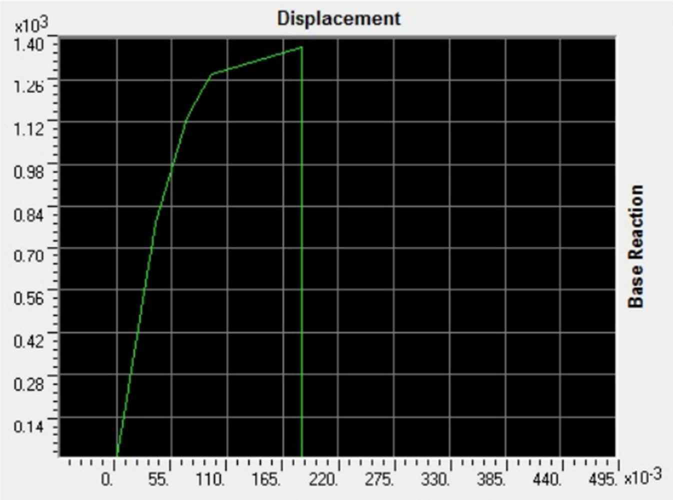


Figure 4: Deformed Shape of Frame (Default Hinge Properties)



Graph 4: Capacity Curve for User Defined Hinge Properties

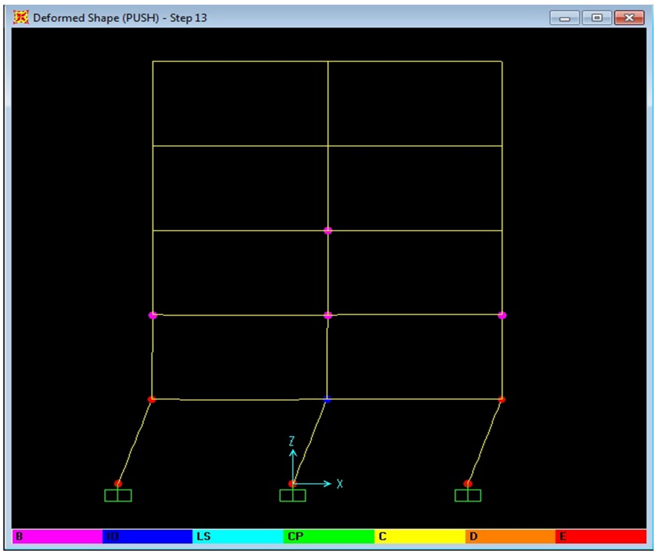


Figure 5: Deformed Shape of Frame (User Defined Hinge Properties)

VI. CONCLUSION

- Displacement is less for User defined hinge properties but base shear is same for both user defined and default models.
- No of push steps are more for User defined model.
- Displacement and base shear is more for fiber hinge element model

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