Non-Linear Static Analysis of Multi Storeyed Building–A Modified Approach

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***Abstract*–The development in the computer application has helped the structural engineering field significantly. The amount of time and efforts required has decreased drastically with the development of civil engineering software. The Non linear Time history analysis of seismic evaluation of a structure is very precise, but tedious and requires a lot of data and human skill to perform. Research has been put in to develop Non-Linear Static Procedures which can yield results close enough to the NL-THA procedure In the present work Non Linear Static analysis (popularly known as push over analysis) is performed. Buildings with varying number of stories viz., 4, 8 and 12 stories are analysed by considering the real time time-history displacement and traditional displacement (4 % of height of the building) as monitored displacement. For obtaining the performance point of the buildings, the demand curves were also modified by considering the response spectra of Bhuj earth quake time history data. In the study, parameters such as displacements; base shear, performance point and status of the building are compared for different stories with this modified push over analysis approach. The modified approach gives better results when compared to conventional pushover analysis approach. From the said work it was found that the base shear in x-direction increases with time history displacement by 4%, 2% and 1% similarly in y-direction increases by 4%, 1.5% and 1% for 4, 8 and 12 respectively. However, this difference reduces as number of storeys increases. The buildings with real time demand curve falls under immediate occupancy level where as for conventional demand curve the building are falling under life safety level hence conventional demand curve method over estimate the performance level of the building.**

***Index Terms*—linear time history analysis, non linear static analysis by (conventional) and (modified approach) SAP2000V15, Bhuj ground motion data, seismic coefficients, real time demand curve.**

I. Introduction

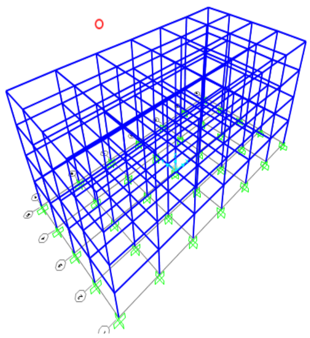
The conventional procedure of pushover analysis is based on arbitrary value of monitored displacement up till which the building is pushed. The performance point which signifies the condition of the building, depend not only on capacity curve but also on demand curve. In traditional push over analysis, the demand curve is plotted based upon seismic co-efficient parameters which are defined in ATC40 [7].

From the previous studies[3-6], it can be seen that lot of work has been done on buildings by conventional pushover analysis to evaluate seismic response and also to study the behavior of high frequency model responses. In the conventional method the monitored displacement for performing the pushover analysis is kept as an arbitrary value like 4% of the height of the building. The demand curves in usual practice are plotted by considering seismic co-efficients(Ca and Cv) given in ATC 40.

This paper aims at considering real time displacement and also at modifying the demand curves by considering real time response spectra data.

II. Buildings Under Study

The buildings considered are reinforced concrete ordinary moment resisting space frames of 4-storey, 8-storey and 12-storey with storey height as 3m. It consist of six bays of length 4m each in X- direction and four bays of 3.5m in Y-direction with storey height as 3m. The load cases for the structure is defined in the SAP2000[8] as Dead load, Live load and Earthquake loads in x and y directions according to IS 1893:2002[2]. The lumped mass is given on each floor using floor diaphragm with Dead load and 25% of live load. The static analysis is performed and the members are designed for the above said loads and their combinations according to IS-456:2000[1] design specifications.



Four Storey Building

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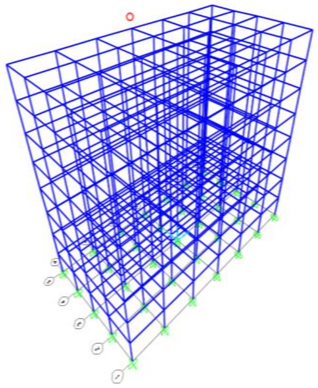
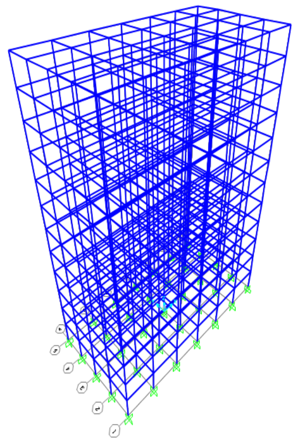


Eight Storey Building



Twelve Storey Building

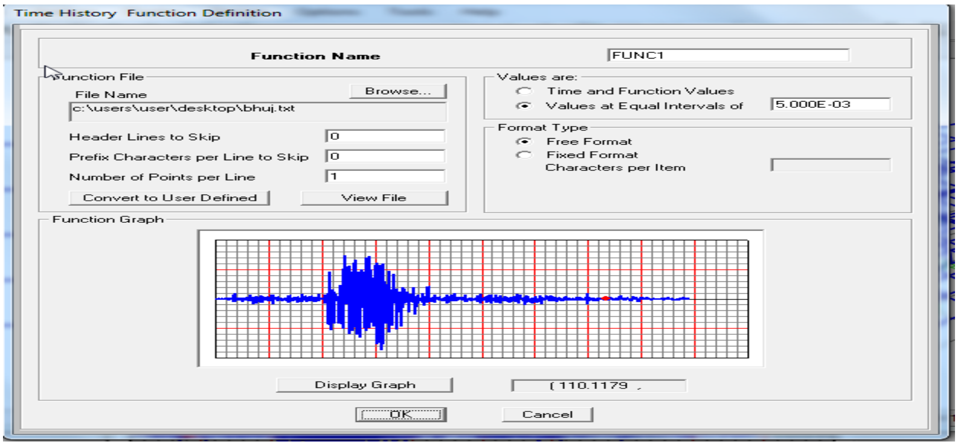


Figure. 1. Acceleration time-history of BHUJ earthquake

III. LINEAR TIME HISTORY ANALYSIS

The structural performance of the reinforced concrete building in this study is estimated based on considering natural ground motion of Bhuj earthquake. This record is obtained from the strong ground motion database of the earthquake station Bhuj in Gujarat on 26 January 2001. The following figure shows the acceleration time history for earthquake. Load cases are defined for the time history in SAP2000 and nonlinear dynamics analysis is performed for the structure and the joint displacement are obtained as shown in the Fig. 2-Fig. 4.

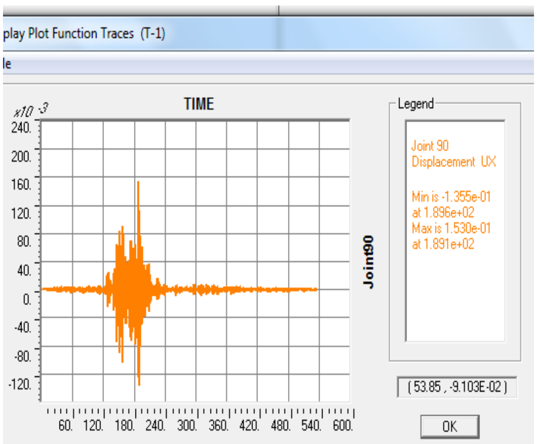


Figure. 2. Time-versus-roof displacement data

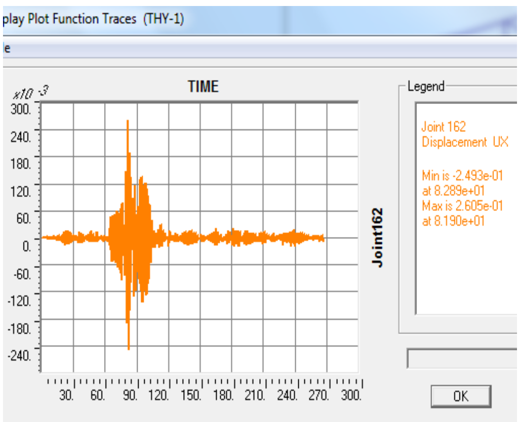


Figure. 3. Time-versus-roof displacement data for 4 storey building. for 8 storey building.

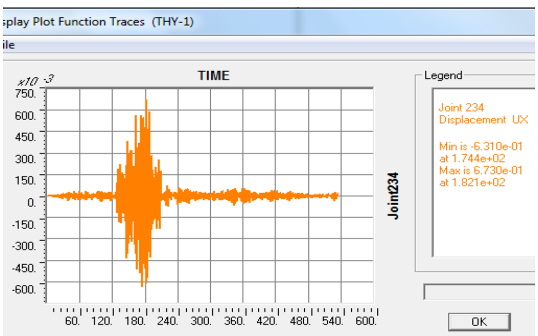


Figure. 4. Time-versus-roof displacement data for 12 storeys

The following table shows the maximum displacement obtained for linear time history analysis.

Building	Max. Roof Displacement (mm)
4-Storey	154
8-Storey	260
12-Strorey	463

IV. Nonlinear Static Analysis

Pushover analysis is then performed on the buildings with monitored displacement equivalent to that obtained from Linier Time history analysis in the same direction. To compare the results, the pushover analysis is also performed with monitored displacement as an arbitrary 4% of the height of the building. The following table shows the comparison of the base shear values with both pushover analyses.

Figure. 5. Base shear comparison

V. Demand Curve

The demand curve which is usually taken from the default values of the program, is an important parameter for deciding the performance level of the building. In conventional method the demand curve is used from the seismic co-efficient values from the codes like ATC40. However these co-efficient does not depict the real time behaviour of the Earthquake for which the structure is tested. Hence, in the present work the demand curve is also modified by using the real time response-spectrum curve. The Time history data which was used to obtained the max. displacement in the building is converted into Response Spectrum Curve using the software Seismospect[10]. Then this spectrum is used to generate the demand curve of the pushover analysis.

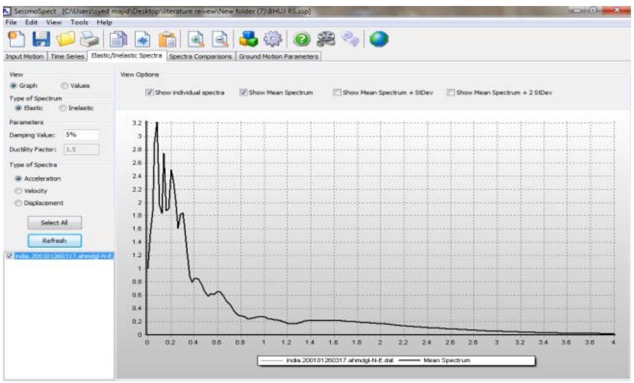


Figure. 6. Conversion of accelerogram into response spectra in seismospect

The pushover curve which is a plot between the capacity curve and demand curve is thus obtained and the performance point of the buildings is then evaluated.

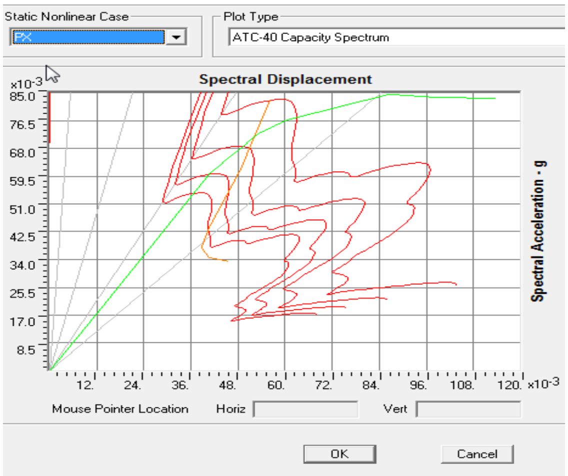


Figure 7a. Pushover curve with modified demand curve for 4-storey building

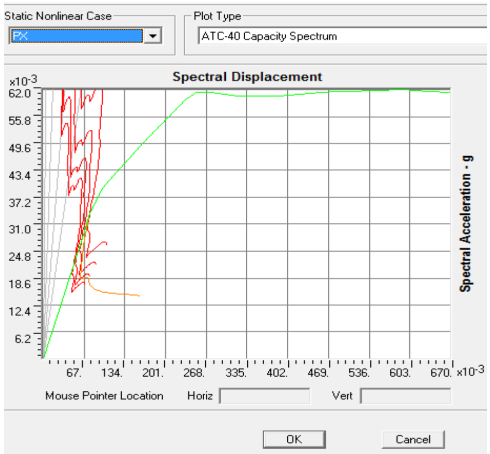


Figure. 7b Pushover curve with modified demand curve for 8-storey building

VI. Hinge Patterns

The following are the buildings with varying number of stories viz, 4, 8 and 12 are analysed by defined spectrum function. It is observed that the buildings with real time demand curve are falling under immediate occupancy level where as the buildings with seismic co-efficient are falling under life safety level.

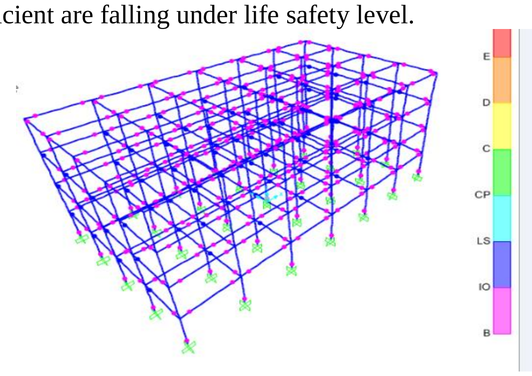


Figure. 8a Using seismic coefficients

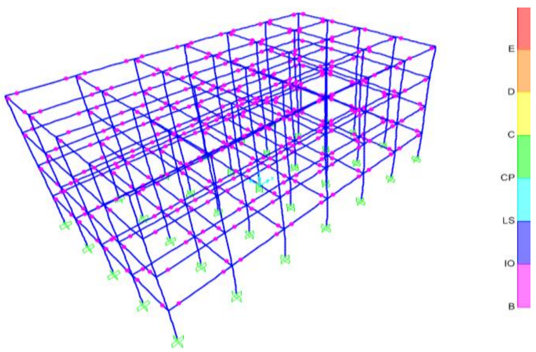


Figure 8b Using modified demand curve

Hinge pattern at performance point for Four storey building

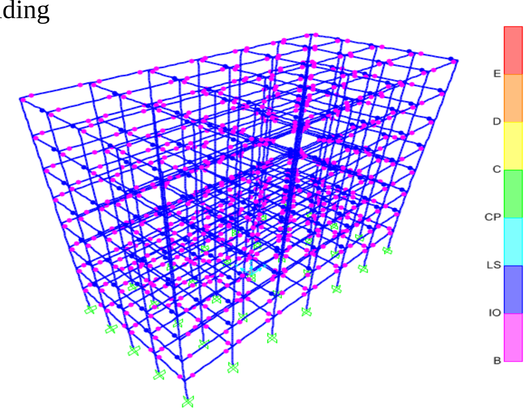


Figure. 9a: Using seismic coefficients

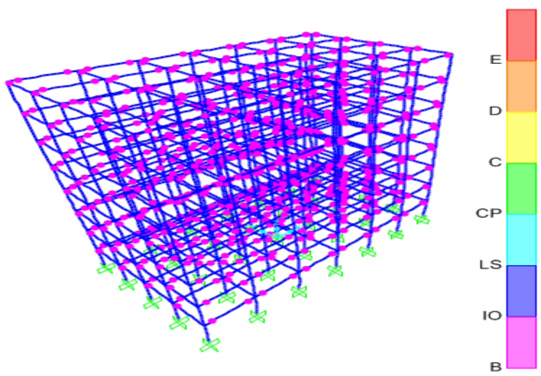


Figure. 9b Using modified demand curve

Hinge pattern at performance point for Eight storey building

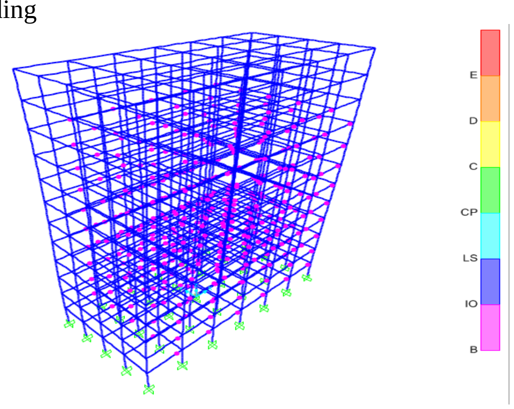


Figure. 10a Using seismic coefficients

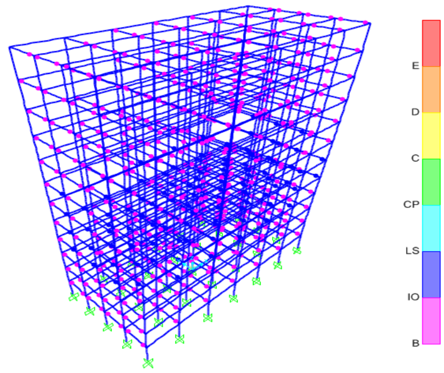


Figure. 10b Using modified demand curve

Hinge pattern at performance point for Twelve storey building

VII. Conclusions

The following are the conclusions of the present work:

- The maximum displacement obtained for 4 storey building with real time displacement is 0.154m.and that for 8 storeys and 12 storeys are 0.26m and 0.463m respectively when compared to 0.48m , 0.96m, and 1.44m in the traditional 4% of the height of the building.
- From the Fig. 5 it can be concluded that the base shear of building with linear time history analysis displacement increases when compared to that with conventional (4% displacement) procedure however this difference reduces as number of storeys increases.
- The performance point of the building with linear time history displacement arrives at the later step when compared to that with 4% displacement structure in both the directions.
- The building with real time demand curve falls under immediate occupancy level where as for conventional demand curve. the building are falling under life safety level hence conventional demand curve method over estimate the performance level of the buildings.

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