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Non Linear Analysis of RC Building under Seismic Loading using SAP2000

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Abstract
The present study highlights the Base shear and displacement relationships of the RC structure and Nonlinear static Pushover Analysis (POA) of a RC frame structure. Even though the problems with respect to structural design of structure are more usually solved by dynamic analysis but the assessment of vulnerability of seismicity of the structures, for which POA is more significant. POA has several procedures in which the well-known are displacement co- efficient method (FEMA 273) , capacity spectrum method (ATC 40) and N2 method (Euro code 8) and today FEMA 273 is preferred in this analysis.

The conduction of seismic risk evaluation of RC building has done with the help of SAP2000 and treating uncertainty in mechanical properties of materials. We define the performance level of the structure by obtaining the capacity curves. The discussion of procedure to develop the fragility curves of the particular building is done here. According to uncertainty of material properties the seismic fragility curves were developed and damage state threshold are calculated. Also the analytical and experimental results are compared.

Keywords: Pushover curve; Demand curve; Capacity curve, Displacement; Base shear etc.

Introduction

Predominantly two unspecified variables are included in seismic risk assessment specifically vulnerability of structures and strength of earthquake action. The uncertainty associated to first one depended on mechanical properties of materials, and involvement structures surrounded by others and weight beard by structure. The second one is depended on condition of soil and fault mechanism. Hence the examination of uncertainty plays an indispensable role in computing the performance of structures under seismic loads. This is finished with the help of pushover analysis by using SAP2000. To understand the non-linear response of structure it assigns default or user defined hinge properties.

Pushover analysis is inexact method in which structure subjected to monotonically raising horizontal forces with never changing height wise diffusion occurred till targeted displacement is reached.

The seismic analysis method can be divided into linear method (linear static or equivalent static force & linear dynamic or response spectrum method) and non linear methods (non linear static or pushover analysis and non linear dynamic or time history method). The analysis performed in this study is discussed below.

Non linear static pushover analysis

A static nonlinear pushover evaluation is a method which is used to gauge seismic structural deformations. In this method the applied shear force and the corresponding displacements are organized by applying monotonically raising the horizontal loads in a predetermined way on the structure, till the structure reaches the failure standard The implementation of the incremental horizontal load on the structure is given in the below figure:

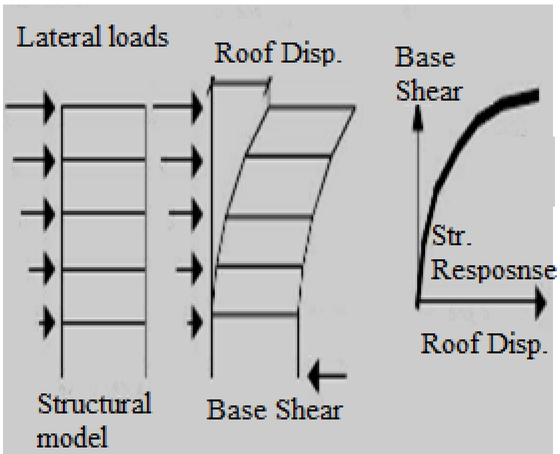

Figure 1: Pushover curve

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Significance of pushover analysis

The linear methods which used for the analysis of structures will not provide legal information regarding the actual forces reserving on the structures when earthquake occurs. Since structures reveal nonlinear performance during earthquakes, by using nonlinear analysis is still essential in order to find that either the structure is able to fulfill the required performance levels or not. Legal use of the pushover analysis provides vital information about the awaited behavior of structural constituents and its systems. The basic goal of using pushover analysis is to find the expected behaviors of structures by estimating its strength and deformation requirement in design earthquakes and differentiate them with the available limits at the performance levels. Global codes, for example, ATC 40, FEMA 273 gives complete method and actual directions to takes place the nonlinear static pushover analysis and use it to obtain the behavior of the buildings under a considering earthquake situation.

Force deformation characteristics

In instance of pushover evaluation models are forcibly moved monotonically in ascending manner till aimed displacement is gained. Pushover curve is a plot of base shear force v/s roof displacement. The up most of the curve illustrates the ultimate lateral load having capability of the building. The tangent at zero load level represents the actual stiffness of building. The break down is received if a building drops its 75% strength and equal roof displacement is defined as "maximum roof displacement". A normalized force-displacement curve of a non-demeaning sleeve member is shown in fig 1.

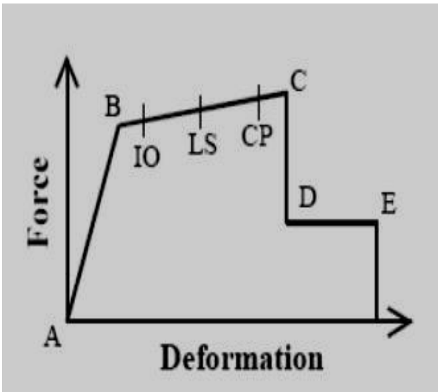

Figure 2: Typical force deformation curve

In figure 2, Point A indicates the offload situation in other hand point B represents yielding of member. The point C refers to formal strength and abscissa at C differentiates to the displacement at which demeaning of the strength begins. The break down from C to D says to prior break down of the component. The remaining resistance from D to E allows the frame elements to retain gravity loads.

Objectives

- To study and understand Nonlinear by using SAP2000 software.
- To investigate response of 4 storey building which is located in Bangalore under seismic loading
- To evaluate various seismic assessment parameters such as capacity curve and demand curve
- To evaluate performance of the building with uncertainties.
- To validate experimental investigation with analytical approach.

Outline of experimental building

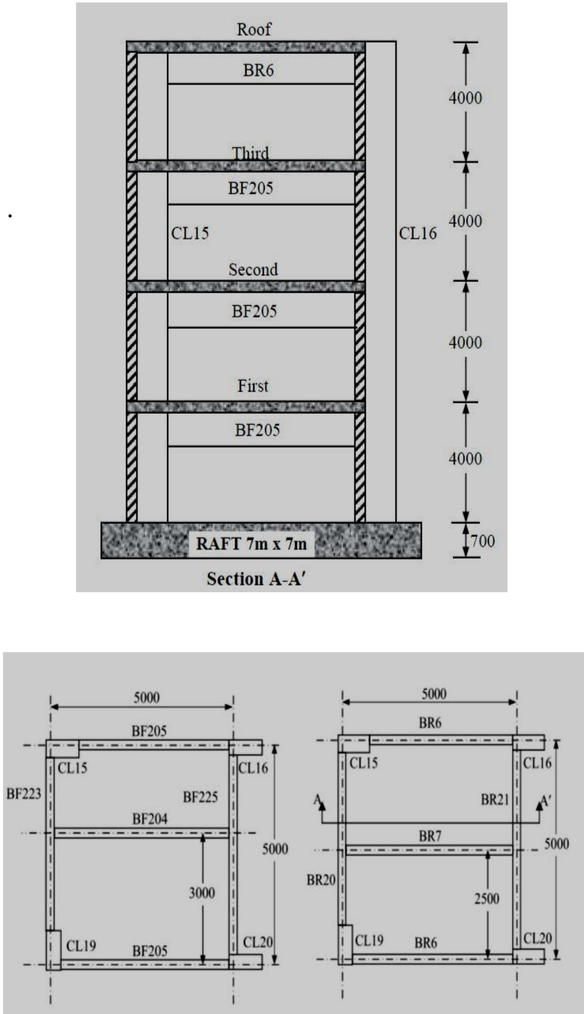

Figure 3: Overall geometry of structure (a) Elevation of the structure (b) Floor plan (c) Roof plan

Material properties

Table 1: Material Properties

Material	Characteristic strength (MPa) F_{ck} and F_y	Modulus of elasticity (MPa) - E_c
Concrete	20	22360
	30	27386
	40	31622
Steel	415	200000
	500	200000
	550	200000

Load combination

As per IS 1893 (Part 1): 2002, in the limit state design of RC structures the following load combinations are accounted for the analysis.

- 1.5 (DL + LL)
- 1.2 (DL + LL ± EQX)
- 1.2 (DL + LL ± EQY)
- 1.5 (DL ± EQX)
- 1.5 (DL ± EQY)
- 0.9 DL ± 1.5 EQX
- 0.9 DL ± 1.5 EQY

Results and Discussions

In this chapter, the results of pushover analysis of RC frame under seismic loading are presented. The variation of total base shear corresponding roof displacement for different values of fck and fy is included and discussed. Push-over curves of uncertainties of material properties are presented. Base shear and displacement at the performance levels is presented

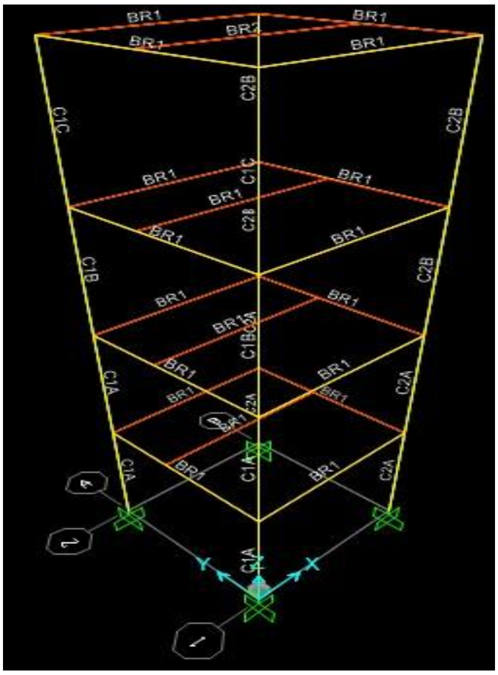

Figure 4: Model with column and beam numbers

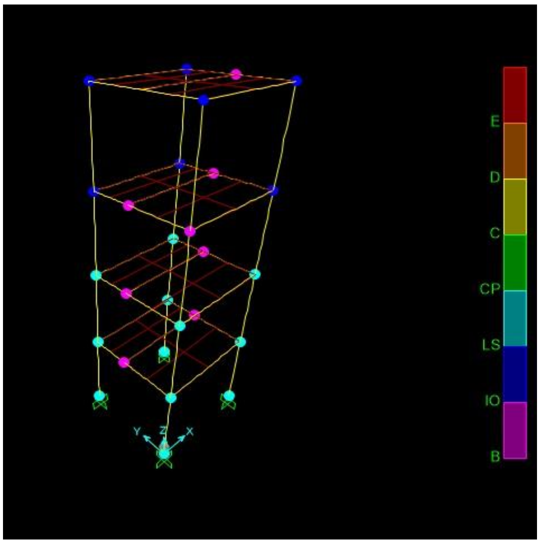

Figure: 5: SAP2000 model for pushover analysis

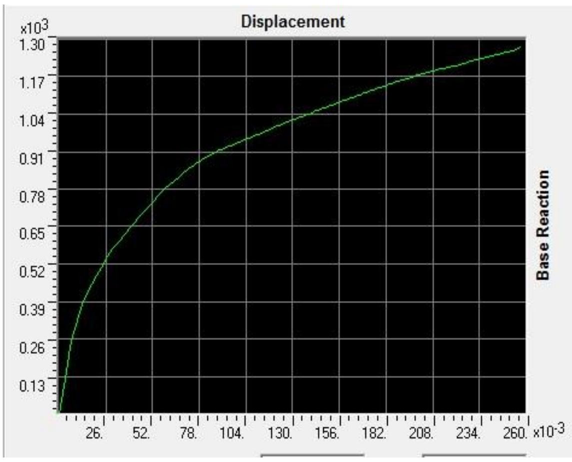

Figure 6: Displacement (m) vs. Base Shear (kN)

Table 2: Performance point evaluation for varying values of fck(MPa) and fy (MPa).

		$f_{y=415}$	$f_{y=500}$	$f_{y=550}$
$f_{ck=20}$	V_B(kN)	653	685	699
	Δ (m)	0.04	0.03	0.034
$f_{ck=30}$	V_B(kN)	661	686	701
	Δ (m)	0.033	0.029	0.027
$f_{ck=40}$	V_B(kN)	661	688	703
	Δ (m)	0.029	0.025	0.024

Conclusions

From the usage of advanced software package that is SAP 2000 as per the guidelines the pushover analysis is carried out for the seismic risk evaluation of reinforced concrete building where the structure is subjected to an monotonic loading with the inverted load profile.

From the pushover analysis results, The value of base shear also increases with the increases in the tensile strength of the steel up to a certain extent, later it becomes constant.

The analytical modeling approached base shear values are almost closer to the experimental results having a slight difference.

Scope for the future work

In current study, the monotonic loads along with inverted load profile is applied for the frame and is tested and analyzed, where as a frame can also be analyzed under parabolic and uniformly distributed loading.

For more accuracy, the study can be extended to non-linear time history analysis and the results can be verified.

The results can be further established with models like Mander's model, Kent and Park model, Ibbara and Krawinkler model, in order to have more realistic picture about the actual behaviour of structure.

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