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A Case Study on Inelastic Seismic Analysis of Six Storey RC Building.

Mohit Gupta
M.Tech (Str.) Final Year
Gateway Institute of Engineering and Technology,
Sonipat, Haryana

The aim of master thesis is to determine the non-linear response of reinforced concrete frame using SAP2000 that has been carried out with the intention to investigate the relative importance of several factors in the non-linear analysis of RCC frames. This includes the variation in load displacement graph. In order to find out the various structural performance levels of the building, a symmetrical model of G+5 storey building with SAP 2000 has been developed. Along with such model a seismic evaluation followed by information about various strengthening techniques for beam and column are also examined. The study includes the pushover analysis of G+5 storey building using SAP 2000. For structural design and assessment of reinforced concrete members, the non-linear analysis has become an important tool. The method can be used to study the behaviour of reinforced concrete structures including force redistribution. This analysis of the nonlinear response of RC structures has to be carried out in a routine way. It helps in the investigation of the behavior of the structure under different loading conditions such as load deflection behavior and the crack pattern. In case of the reinforced cement concrete frames the parameters that determine the response are the stiffness and ductility of the structure and the constituent material, the geometry of the structure and nature of the force imposed on to the structure. The major parametric study in a push over analysis is that the force is applied in increments and the response for each step is found out and plotted out on graph depicting the capacity curve. Similarly the demand curve that has been provided by the respective codes is overlapped with the capacity curve obtained from the push over analysis. The point of intersection of the capacity curve and the demand curve becomes the performance point of the structure. Such is the work carried out in this thesis.

INTRODUCTION

1.1 General

Earthquake is generated by sudden release of energy in earth's crust that creates seismic waves. It has the capability for causing damages, by the natural hazards. In nature, earthquake forces are accidental & uncertain natural hazards. An engineer requires the tools for analyzing structures under the effect of these types of forces. Performance based design have attained the new dimension in the area of seismic design ideology. Performance based design is a technology which is used to assess the behavior of field ground motion. Earthquake loads are modeled to assess the action of structure with a clear understanding that hazard is to be anticipated but it should be regulated. Pushover analysis is an iterative procedure shall be looked upon as an alternative for the orthodox analysis procedures and the inelastic analysis. Performance-based seismic engineering (PBSE) create structures with certain seismic performance. For analyzing of seismic performance, a mathematical model of the structure is required to determine the force and displacement demands in various components of the structure. There are several methods of analysis, to analyze the seismic performance of the structures using elastic and inelastic methods. The force demand of each component of the structure is obtained and compared with available capacities by performing an elastic analysis. Elastic analysis methods are based on static lateral force procedure, dynamic procedure and elastic procedure using demand-capacity ratios. These methods are also known as force-based methods which assume that structures respond elastically to

earthquakes. Inelastic analysis procedures basically include inelastic static analysis and inelastic time history analysis which is also known as pushover analysis. Building model is analyzed by using inelastic static analysis. Inelastic static analysis, or pushover analysis, has been the preferred method for seismic performance evaluation due to its simplicity. It is a static analysis that directly incorporates nonlinear material characteristics. Inelastic static analysis procedures include Capacity Spectrum Method, Displacement Coefficient Method and the Secant Method(Sermin,2005).The performance based earthquake engineering (PBEE) also known as performance based seismic Engineering (PBSE) is rapidly growing concept that is present in all guidelines that were published: VISION 2000 (SEAOC,1995) ATC-40(1996), FEMA-273(1997) and FEMA-356(2000). PBEE involve design, construction, evaluation, monitoring the function and maintenance of engineered facilities whose performance under seismic loads responds to several needs and objectives of owners, users and society.

2. Experimental Programme

The primary objective of this work is to study the seismic response of RC framed building using nonlinear analysis. The effect of earthquake force on six storey building with the help of pushover analysis, for various different sets of reinforcement at different levels has been investigated.
The main objective of this study are as follows:
1.To design a six-storied RC framed building using Sap 2000 v15.1.0 and analyzing the same using pushover analysis procedure, using SAP2000 v15.1.0 for ascertaining the seismic load carrying capacity of that structure.
2. Determination of performance point of a building.
3. The resultant roof displacement is compared with target displacement. If it is lower than target displacement then the design is known as performance based design. In this study, the R.C building of symmetrical in plan (designed according to IS 456:2000) is analyzed using Pushover Analysis of G+5 storey building using SAP 2000 with default and user-defined hinges. It is a non-linear static analysis methods which shows the various structural performance levels of the building. Seismic evaluation provide the information about various strengthening techniques for beam and column.

2.2 Methods of Analysis

Several analysis methods, both elastic and inelastic, were carried out to predict the seismic performance of the structures. (Sermin, 2005)

2.2.1 Elastic methods of analysis

The force demand on each portion of the structure is obtained and compared with available capacities by performing an elastic analysis. Elastic analysis methods include static lateral force procedure, dynamic procedure and elastic procedure using demand-capacity ratios.

2.2.2 Inelastic methods of analysis

Structures suffer significant inelastic deformation under a strong earthquake and dynamic characteristics of the structure change with time, so investigating the performance of a structure requires inelastic analytical procedures accounting for these features.

RESULTS AND DISCUSSIONS

3.1 General

This chapter represents the results of analysis of RCC frame. Analysis of RCC frame under the static loads has been performed using SAP2000 software.

3.2 Analysis Results of R.C.C Frame

In the present study, non-linear response of RCC frame modeled using modeling under the loading

has been carried out. The objective of this study is to see the variation of the load- displacement graph and check the maximum base shear and displacement of the frame. After running the analysis in the last chapter, now the pushover curve is obtained as shown in Fig. 3.1.

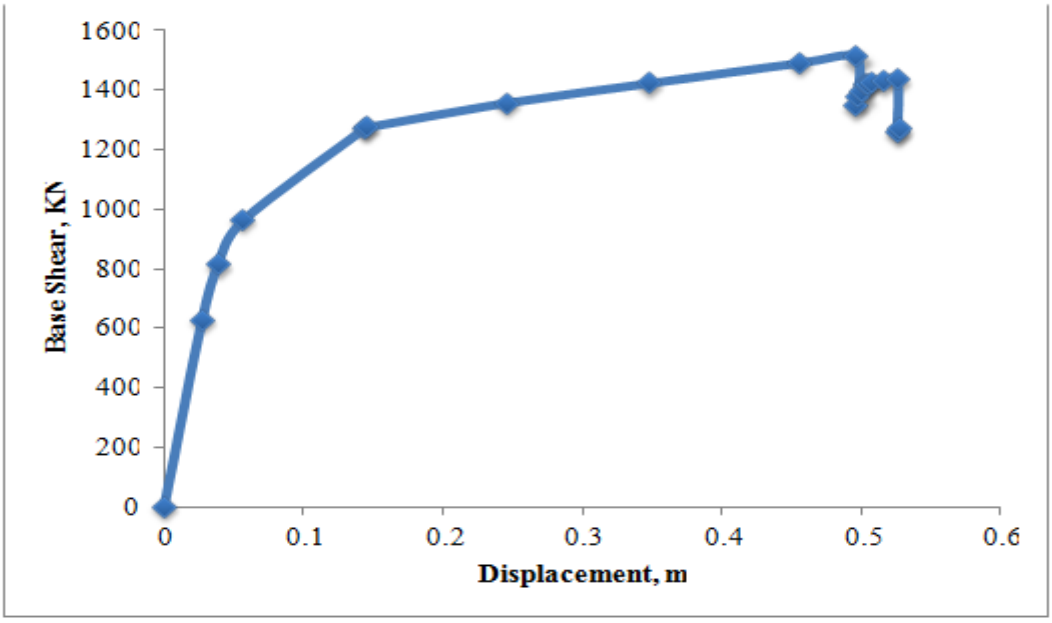

Fig. 3.1 Pushover curve of a building

3.3 Results According to ATC-40 (1996)

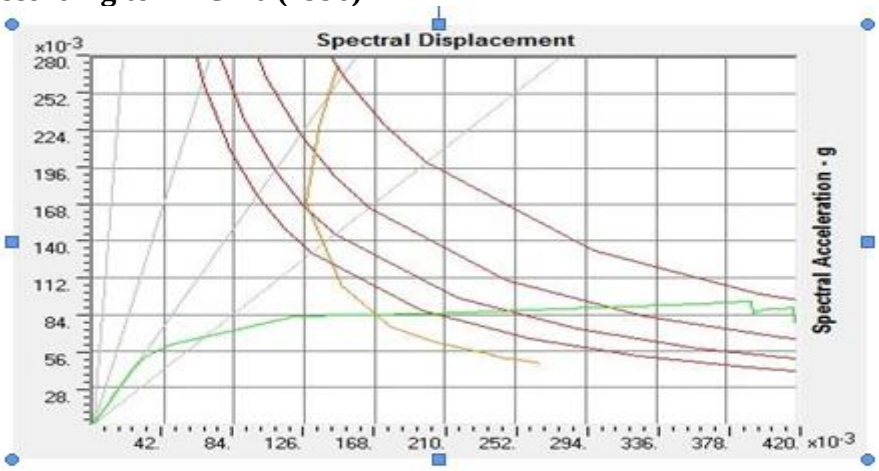

Fig. 5.2 Capacity spectrum curve

Performance point is the intersection of capacity and demand spectra.

V, D = 1321.666, 0.204

Sa, Sd = 0.084, 0.165

Teff, Beff = 2.793, 0.253

The performance point of the structure can be now determined by using the pushover curves obtained. The performance point is the point where the capacity and demand of the structure are equal. The performance point is determined automatically by SAP 2000, using the procedure mentioned in ATC-40(1996).

The point at which the capacity curve intersects the reduced demand curve represents the

performance point at which capacity and demand is equal. As displacement increase, the period of the structure lengthens and reduces demand. Hence, optimum point should have a higher capacity for a lesser displacement. Figure 5.2 shows that performance point is at T_{eff}= 2.793 sec which is close value of T_{eff} at step no. 5. Hence, it is required to see the hinge formations at step no. 5. From Figure 5.3, it also becomes clear that hinges formed in beams and columns are below immediate occupation level. Hence, structure is very safe to use.

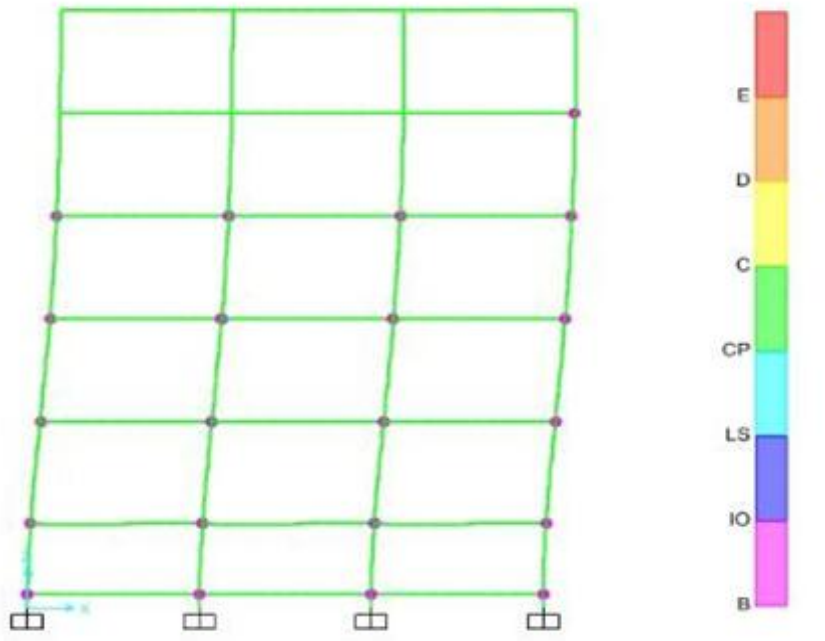

Fig. 3.3 Step 5 hinge mechanism in x-z direction

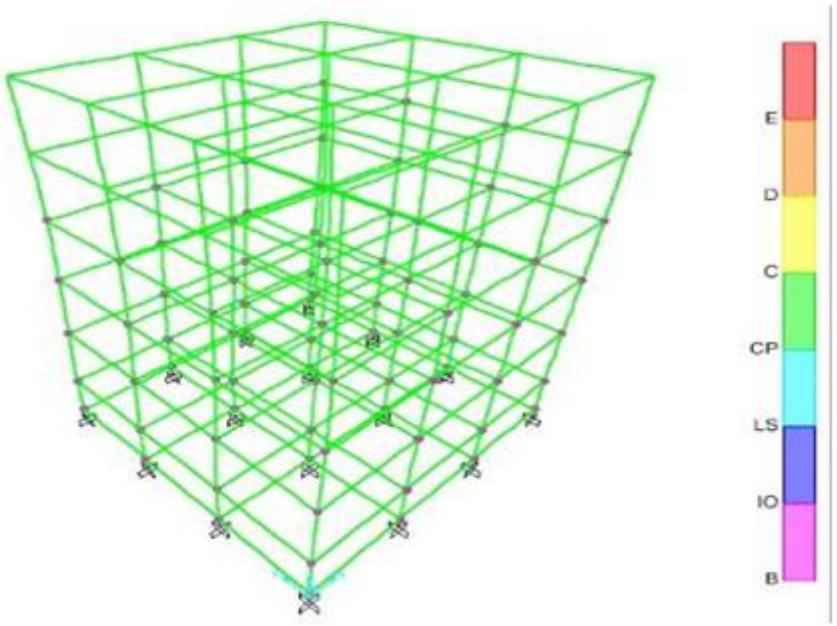

Figure 3.4 Step 5 hinge mechanism in 3-D view

3.4 Results According to FEMA 356 (Coefficient Method)

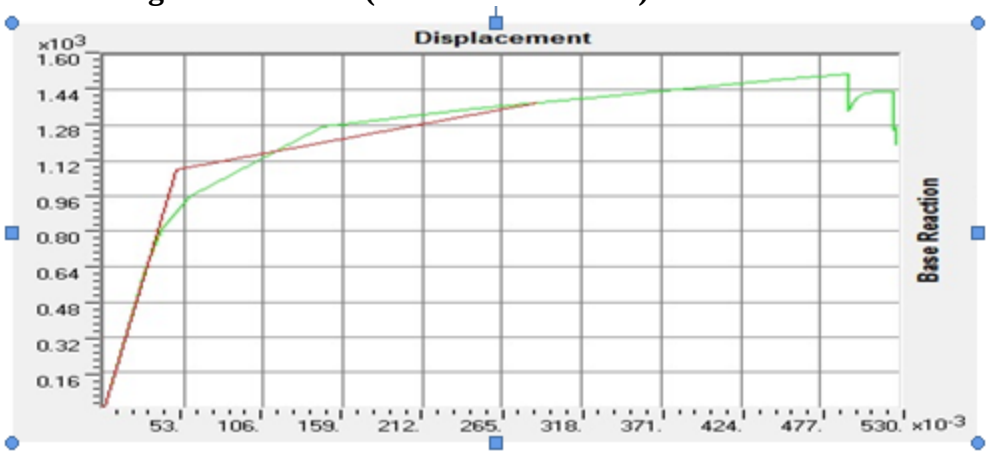

Fig. 5.5 Displacement coefficient curve

Target displacement (V, D) 1340.161, 0.289

Table 5.3 Tabular data for capacity spectrum curve

Step	Displacement, (m)	Base Force, (kN)
0	0	0
1	0.027195	626.645
2	0.038493	812.892
3	0.056859	962.396
4	0.143651	1269.985
5	0.145789	1274.359
6	0.246559	1356.466
7	0.348705	1422.632
8	0.455601	1490.032
9	0.496137	1510.566
10	0.496147	1345.599
11	0.498092	1378.051
12	0.499579	1393.537
13	0.503786	1415.954
14	0.504936	1419.58
15	0.508075	1424.37
16	0.515478	1429.752
17	0.525908	1434.414
18	0.525918	1257.718
19	0.527204	1268.99

Conclusion and Scope for Future Work

The procedure of analyzing any structure requires the thorough understanding of the deportment of the parameters that determines the outcome and reaction of the structure under consideration. In case of the reinforced cement concrete frames the parameters that determine the response are the stiffness and ductility of the structure and the constituent material, the geometry of the structure

and nature of the force imposed on to the structure. In case of the highly random and unpredictable dynamic loads such as seismic forces the structure tends to respond in a way where the depiction involves the approximation of the components causing the response. Push over analysis is one such a way of analyzing the structure and finding out the response of the structure involves the determination of the relationship between various parameters such as spectral displacement, spectral acceleration and member forces. The work carried out on six Stories RC frame using Push over analysis indicates few of the following inferences, The member forces in the frame tend to behave in highly non-linear function of the imposed forces as the forces tend to reverse in relatively short amount of time.

- The capacity curve for the structure which has been obtained by numerical iterative procedure indicates the response of the structure in terms of the storey drift or the member displacement in reaction to the external dynamic load. The intersection of the capacity curve and the demand curve is the performance point where the structure safely carries the load that has been applied to the structure. Also, this is the point where the structure performs its intended function more optimally than any other capacity points.

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