Pushover Analysis of RC Buildings Using SAP-2000

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ABSTRACT: In this investigation the analysis of G+4, G+11 and G+21 building is situated in New Delhi (Zone IV). The seismic analysis of G+4, G+11 and G+21 building as per IS 1893-2002. In this research pushover analysis was performed in SAP 2000 and after that is designed as per IS 456-2000 for different loads. This analysis gives better understanding seismic performance of building & also shows damage or failure of buildings. The building performance level is determined by pushover curve & demand curve. The result shows that the failure is noticed in the column of ground storey of the building. After that enlarged amount of reinforcement in the ground story the buildings have reached life safety performance level.

Keywords: Pushover curve, capacity spectrum, demand spectrum, IS 1893:2002, STAAD Pro, SAP2000

I. INTRODUCTION

To ensure the safety purpose the different IS codes of buildings define design requirements of structure. We usually witness the natural disaster effects on buildings even designed based on building codes. Before constructing the structure we have to check the story drift, nodal displacement at the roof level and the capacity before the building fails for certain ground motions. The safety of non-structural elements can be ensured through PBE with enhance in expenditure of the construction. Therefore, PBE is the method or approach used by design specialists to construct buildings that possess functionality and the continued availability of services.

The PBE methodology is not going to be the instant replacement for design to the traditional code methods

II. OBJECTIVE OF STUDY

The objective of the present study is as follows:


2. The main objective is to perform pushover analysis in SAP2000 to get the seismic response of the structure.

3. The main objective is to check whether the building designed by standard codes is safe under earthquake loads.

III. MODELLING APPROACH

Modelling

The Building is designed as per IS 456-2000. The dimensions of building is

- Dimension of Beams: 600x800mm
- Ground floor columns: 1000x1000mm
- Other floors: 800x800mm
Figure 3.1 showing the plan the building

Figure 3.4 Section A-A of 12 Story Building
3.5 Loads on the structure

As per IS 456-2000 & IS 1893-2002 the structure is analyzed and designed for live load, seismic load. The subsequent figures show the different loads acting on the building.
Figure 3.10 illustrating the floor load acting on the slabs.

Figure 3.11 Illustrates the Live Load acting on the Roof.

Figure 3.12 illustrates the live Load acting from 1st floor to the 4th.
IV. RESULTS

Results of RCC Design:

RC Design of G+4 Building

The details of 5 story building are given below:

Beams=300mmx450mm
Columns=450mmx450mm
Concrete Grade=M30
Steel Grade=Fe415 HYS diesel bar

Detailing of beams

Dimension of Beam= 450mmx300mm.
Grade of concrete= M-30
FE-415 Steel is used

![Figure 4.2 showing the reinforcement detailing of beam of G+4](image)

**Figure 4.2 showing the reinforcement detailing of beam of G+4**

**Detailing of columns**

Dimension of Beam = 450mm x 450mm.
Grade of concrete = M-30
FE-415 Steel is used

![Figure 4.3 showing the reinforcement detailing of column of G+4](image)

**Figure 4.3 showing the reinforcement detailing of column of G+4**

**RC Design of G+11 Building**

![Figure 4.4 Showing the STAAD pro Model of G+11](image)

**Figure 4.4 Showing the STAAD pro Model of G+11**
Detailing of beams

Dimension of Beam= 450mmx300mm.
Grade of concrete= M-30
FE-415 Steel is used

![Figure 4.5 showing the reinforcement detailing of beam of G+1](image)

Detailing of columns

Dimension of Beam= 450mmx450mm.
Grade of concrete= M-30
FE-415 Steel

![Figure 4.6 showing the reinforcement detailing of column of G+1](image)
RC Design of G+21 Building

**Detailing of beams**

Dimension of Beam = 450mm x 300mm.

Grade of concrete = M-30

FE-415 Steel is used

**Figure 4.7 Showing the STAAD Pro Model of G+21**

**Detailing of columns**

Dimension of Column = 800mm x 800mm.

Grade of concrete = M-30

FE-415 Steel is used

The following figure shows the reinforcement details taken from STAAD Pro.

The following figure shows the column reinforcement for G+22 Building, this column developed the first plastic hinge.
Pushover Analysis Results:

The Pushover analysis of G+4 RC Building

The graph plot between the Pushover curve base shear vs lateral displacement.

The Design base shear (VB) was found to be 1742 in chapter 3 and the capacity is 2900KN which is much higher, hence the building is safe for this level of earthquake.

<table>
<thead>
<tr>
<th>Base shear(KN)</th>
<th>2679.179</th>
<th>Roof displacement (m)</th>
<th>0.108</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spectral Acceleration, Sa (m/s)</td>
<td>0.488</td>
<td>Spectral displacement, Sd(m)</td>
<td>0.082</td>
</tr>
<tr>
<td>Effective time period, Teff(s)</td>
<td>0.823</td>
<td>Effective damping, βeff</td>
<td>0.189</td>
</tr>
</tbody>
</table>
Figure 6.4 showing the performance point

The Pushover analysis of G+11 RC Building

The graph plot between the Pushover curve base shear vs lateral displacement.

From the graph value of base shear was found to be 4364KN and the capacity from the plot is 4800KN which is higher, hence the performance of the building for this level earthquake is acceptable.
Table 6.2 the conclusion from Performance point of G+11

<table>
<thead>
<tr>
<th>Base shear (KN)</th>
<th>4415.444</th>
<th>Roof displacement (m)</th>
<th>0.166</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spectral Acceleration, Sa (m/s)</td>
<td>0.140</td>
<td>Spectral displacement, Sd (m)</td>
<td>0.137</td>
</tr>
<tr>
<td>Effective time period, Teff (s)</td>
<td>1.986</td>
<td>Effective damping, βeff</td>
<td>0.170</td>
</tr>
</tbody>
</table>

Figure 6.8 showing intersection of Demand and Capacity curve (Performance point)

6.4 The Pushover analysis of G+21 RC Building

The graph plot between the Pushover curve base shear vs lateral displacement.

From the graph the value of base shear was found to be 11421 KN and the capacity from the plot is 12382 KN which is higher, hence the performance of the building for this level earthquake is acceptable.
Figure 6.9 Pushover curve (base shear vs displacement) for 22 Story Building

Table 6.3: The conclusion from Performance point of G+21

<table>
<thead>
<tr>
<th>Base shear (KN)</th>
<th>12021.25</th>
<th>Roof displacement (m)</th>
<th>0.381</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spectral Acceleration, $S_a$ (m/s)</td>
<td>0.138</td>
<td>Spectral displacement, $S_d$ (m)</td>
<td>0.236</td>
</tr>
<tr>
<td>Effective time period, $T_{eff}$ (s)</td>
<td>2.131</td>
<td>Effective damping, $\beta_{eff}$</td>
<td>0.168</td>
</tr>
</tbody>
</table>

6.5 Comparing the Results

From the above results, it is clear that the capacity of G+4, G+11 and G+21 RCC buildings are higher than design base shear. Hence the performance at this point is acceptable.

Table 6.4: Showing the comparison of capacity and design base shear of three building

<table>
<thead>
<tr>
<th></th>
<th>G+4 Building</th>
<th>G+11 RC Building</th>
<th>G+21 RC Building</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Base Shear ($V_B$)</td>
<td>1742 KN</td>
<td>4364 KN</td>
<td>11421 KN</td>
</tr>
<tr>
<td>Capacity of Performance Point</td>
<td>2679.179 KN</td>
<td>4415.44 KN</td>
<td>12021.25 KN</td>
</tr>
</tbody>
</table>
V. CONCLUSIONS

After analysis all the results the following conclusion has been drawn:

1. From the above results it is clear that the capacity of G+4, G+11 and G+21 RCC buildings are higher than design base shear

2. Considering three different RC building it was concluded if the buildings are designed with proper sections and reinforcement details as per standard codes will perform better under seismic forces.

REFERENCES


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