Assessment of Progressive Collapse on a Reinforced Concrete Framed Building

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Abstract—Progressive collapse of a structure is caused due to the removal of vertically load carrying member (typically columns). During their lifetime, civil engineering structures could be subjected to natural hazards such as earthquakes, hurricanes, tornadoes, floods and fires or manmade hazards such as blast and impact. Because structures are not usually designed for extreme loadings, when such events occur these can lead to catastrophic failure. In the present study demand capacity ratio, and vertical deflection and inter storey drift of a ten story RC framed building evaluated as per GSA guidelines. Linear static methodology is carried out using SAP2000 without column, longer side, shorter side, corner side and central column removal for all the seismic zones.

Keywords — Demand Capacity Ratio, Inter-storey drift, Linear static analysis, Progressive collapse, Vertical deflection.

I. INTRODUCTION

Progressive collapse of a R.C. building is an extensive structural failure initiated when one or more vertical load bearing carrying members are removed due to any kind of natural or man-made hazards. The collapse of ‘RONAN POINT’ in UK (1968), threw light on progressive collapse. In the present study, a ten storey RC framed building is considered and evaluation of progressive collapse is carried out by removal of column as per GSA guidelines. The analysis is done using linear static method for all seismic zones using software SAP2000.

II. METHODOLOGY

General Service Administration Guidelines:

General Service Administration (GSA) guidelines provides a detailed methodology and performance criteria required to assess the vulnerability of a new and existing building to progressive collapse. When analysing the structure for progressive collapse potential GSA (2003) recommends a general loading factor to be used for every structural member in the building being tested.

GSA (2003) factor the loading conditions using equation (1)

\[ \text{Load} = 2(\text{DL} + 0.25\text{LL}) \]  

Where,

\( \text{DL} \) = Dead Load, and \( \text{LL} \) = Live Load

The following are the exterior considerations for the study as per GSA guidelines:

1. Analysis for instantaneous loss of a column located at or near the middle of longer side of the building.
2. Analysis for instantaneous loss of a column located at or near the middle of short side of the building.
3. Analysis for instantaneous loss of a column located at the corner of the building.
4. Analysis for instantaneous loss of a column located at the center of the building.

The following are the interior considerations for the study as per GSA guidelines:

1. Analyze the building for the instantaneous loss of one column that extends from the floor of the underground parking area or uncontrolled public ground floor area to the next floor (1st story).
A ten storey symmetrical R.C. building is considered for the study. The structure consists of 8 bays in longitudinal direction in which first and last two bays are of 5m span and rest are of 6m span, 6 bays in transverse direction of 4m span each. Wall having 230 mm thickness is considered on all the beams. Slab thickness considered is 150mm. Beam sizes 200 mmx450 mm and column sizes are 200 mm x500 mm for C1, C2, C3, C7, C8 and C9, 200 mm x600 mm for C4, C5 and C6.

III. MODELLING

Loading considered on the building for the study are as follows:
Dead load as per IS875 part I
Floor finish=1.5kN/m²
Wall load on all beams = 7.13kN/m
Live load as per IS875 part II
On roof = 1.5kN/m²
On floors = 3.0kN/m²
Seismic loading as per IS: 1893
Zone II, III, IV&V
Soil type: II
Response Reduction Factor, R = 5
Importance factor, I = 1.5

IV. ANALYSIS AND RESULTS

For the assessment of progressive collapse of a R.C frame building, analysis is carried out as per GSA guidelines using linear static method; the results are discussed in terms of DCR, vertical deformation in beams and inter storey drift.
Demand Capacity Ratio:

DCR values for all the cases of column removal are present from figure 4 to figure 7.

It is observed that DCR is within permissible limit only in the case of shorter side column removal in all zones, when compared with all other cases.

Figure 4 A plot of DCR versus storeys for all zones-longer side column removed

Figure 5 A plot of DCR versus storeys for all zones-shorter side column removed

Figure 6 A plot of DCR versus storeys for all zones-corner side column removed

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Vertical Deflection:

It is observed from analysis that the vertical deflection is maximum when longer side and central columns are removed, analysis the variation was same in all the zones.

A plot of vertical deflection versus storey is shown in figure 8 for zone II. This proves that beam deflection is unaffected irrespective of zone.
Inter Storey Drift:
Storey drift have increased from zone II to zone V. From figure 9 to 13 it is observed that the drift has increased to 3.6 times in very severe zone (zone V) when compared to lower zone (zone II) in all the cases of analysis.

V. CONCLUSIONS
1. To assess the progressive collapse as per GSA guidelines, DCR values should be less than two for symmetrical structural configuration, in the present study DCR is within the permissible values only in the case of shorter side of column removal.
2. The vertical deflection is maximum when longer side column and shorter side columns are removed.
3. If adequate reinforcement is provided in beams and columns, this limits the DCR within the acceptable criteria, so as to avoid progressive collapse.

4. Inter storey drift is maximum in zone V in all the cases and are within the permissible limit.

REFERENCES


