PROGRESSIVE COLLAPSE ANALYSIS OF EXISTING RC BUILDINGS USING LINEAR STATIC ANALYSIS

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ABSTRACT

Progressive collapse analysis is an extent of damage damage or collapse that is disproportionate to the magnitude of the initiating event. A building undergoes progressive collapse when a primary structural element fails, resulting in the failure of adjoining structural elements, which in turn causes further structural failure. In this present study the behavior of existing RC framed building with 3 stories to progressive collapse located in seismic zone III is investigated.In the present study demand capacity ratio of existing RC building evaluated as per GSA guidelines. Liner static analysis is carried out using ETABS software. Building modeling and loading are assigned to model according to IS codes Analysis is carried out for member forces and reinforcement details.

Keyword: - *Progressive collapse, ETABS, Demand Capacity Ratio (DCR), Linear static analysis, General Service Administration (GSA) Guidelines*

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1. INTRODUCTION

Progressive collapse is the collapse of all or a large part of a structure precipitated by damage or a failure of a small part of it .It is sometimes also called as a disproportionate collapse, which is defined as a structural collapse disproportionate to the cause of the collapse. As the small structural element fails, it initiates a chain reaction that causes other structural elements to fail in a effect, creating a larger and more destructive collapse of the structure. A good example of progressive collapse is a house of cards; if one card fails near the top ,itcauses multiple cards to fall below it due to the impact of the first card, resulting in a full.

The concept of progressive collapse comes to image after the collapse of the 22 story Ronan Point Apartment Towerin1968[1].The gas explosion occurred on the 18th floor that vigorously rapped out the exterior load bearing panels of the kitchen near the corner of the building. This results in loss of support at that story (i.e., 18th floor) & triggered above floors to collapse. The potential of this collapsing floor causes, impact load on lower stories & set up a progressive collapse. The entire exterior corner of the building collapsed from top to bottom.

1.1 Guidelines by the U.S. General Services Administration (GSA)

The purpose of these Guidelines is to reduce the potential for progressive collapse in new and renovated Federal buildings. For the purposes of these Guidelines, a major modernization is defined as a major structural renovation, such as a seismic upgrade.

The following analysis case should be considered:

1. An exterior column near the middle of the long side of the building.
2. An exterior column near the middle of the short side of the building.
3. A column located at the corner of the building.
4. A column interior to the perimeter column lines for facilities that have underground parking.

2 LINEAR STATIC ANALYSIS

In the linear static analysis column is removed from the location being considered and linear static analysis with the gravity load imposed on the structure has been carried out. From the analysis results demand at critical locations are obtained and from the original seismically designed section the capacity of the member is determined. Check for the

DCR in each structural member is carried out. If the DCR of a member exceeds the acceptance criteria, the member is considered as failed. The demand capacity ratio calculated from linear static procedure helps to determine the potential for progressive collapse of building.

2.1 Analysis Loading

For static analysis purpose the following vertical load shall be applied downward to the structure under investigation:
Load = 2(DL + 0.25 LL)
Where,
DL = Dead Load, LL = Live Load

2.3 Permissible Criterion for Progressive Collapse: (As per GSA guidelines clause: 3.2.11.1.2)

The GSA guidelines adviced the use of the Demand–Capacity Ratio (DCR) which is defined as the ratio of the structural member force after the sudden removal of a column to the member strength (capacity) ,as a benchmark to determine the failure of major structural members by the linear static analysis procedure (GSA 2003).
DCR= Qud / Que …Eq 3
Where,
Qud = Acting force (demand) observed in member or connection
(shear, axial force, bending moment, and possible combined forces)
Que = Expected ultimate, unfactored capacity of the member or connection (axial force ,moment, shear and possible Combined forces)
The permissible DCR values for primary and secondary structural elements are:
• Demand capacity ratio (DCR) < 2.0 for typical structural configurations.
• Demand capacity ratio (DCR) < 1.50 for atypical structural configurations.

3. METHODOLOGY

Design input data:

- Material
  - Concrete Grade: M25
  - Grade of Steel: Fe 500
  - Poisson's ratio of Concrete: 0.20
  - No. of stories: G + 3
  - Storey Height: 3m
- Beam Size:B1 to B6,B10,B11,B14-B16,B24-B27,B35-B42 :200x450mm
  - Beam Size: B7, B9, B13, B28, B34: 200X600mm
  - Beam size: B17-B23, B45, B46, B61, And B6:200X530mm
  - Beam Size: B73 toB81:150 x450mm
- Column sizes:C1,C2 3,C6,C9,C12,C21,C24,C27,C28,C29,C30 :200X 530 mm
  - Column size:C4,C8,C10,C19,C7,C22,C23,C25 : 200X450mm
  - ColumnSize: C5, C11, C13, C14, C15, C16, C17, C18, C20, C26: 200X600mm
- Loading Consideration:
  - Dead load:
  - Roof and Floor finished load: 1.5KN/m^2
  - Live load:
  - For Floors: 3 KN/m^2
  - For Staircase: 3.75 KN/m^2
- Earthquake Consideration:
  - Zone: III
  - Zone factor: 0.16
  - Soil Type: II (Medium)
  - Importance Factor: 1.5
  - Response reduction factor: 5

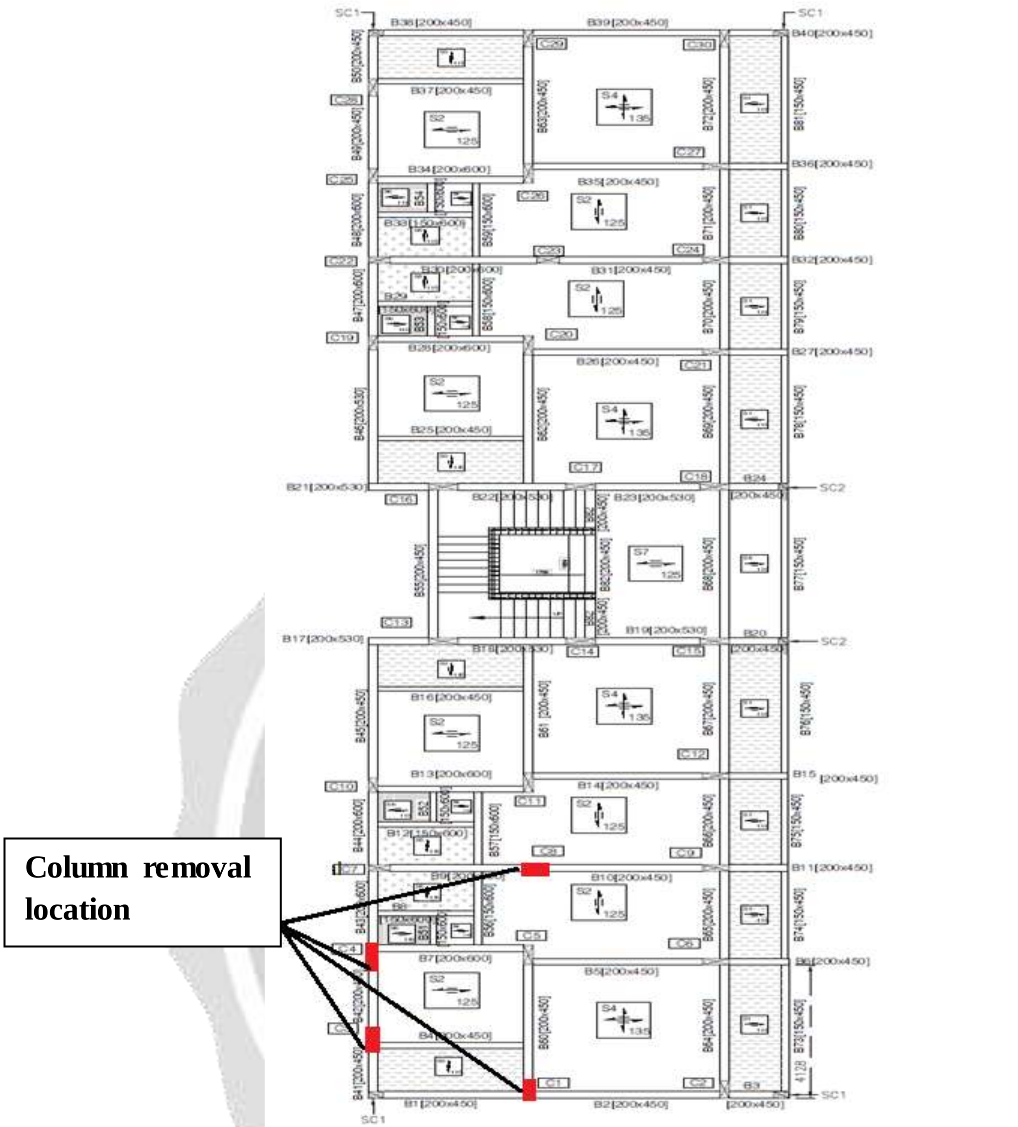

Fig -1 Typical floor plan

3. RESULT AND DISCUSSION

The DCR values for the columns in all four cases do not exceed the acceptance criteria value suggested by GSA guidelines and hence columns are safe against progressive collapse. But for a removed column adjacent beams DCR values exceed the acceptance criteria value suggested by GSA guidelines. The DCR values of unsafe beams are graphically represented.

Table -1DCRs for Beams Adjacent to Removed Columns (As per GSA guidelines)

Removed column	**Connected Beams**	**DCR ratios**	
		For flexure	**For shear**
Long side column eliminated C4	B42	1.0	1.0
	B43	1.0	0.165

	B7	1.2	0.99
Short side column eliminated C1	B1	3	1.9
	B2	3	2.0
	B60	2.25	2.2
Corner column eliminated C3	B41	3	1.9
	B42	3	2
	B4	2.66	2.25
Interior column eliminated C8	B9	1.0	0.89
	B10	1.2	0.99

3. CONCLUSIONS

Removal of column as per GSA guidelines shows failure of adjacent beams. The DCR values of beams are more than acceptance criteria value suggested by GSA for progressive collapse are unsafe .Among 4 cases of column removal, most damaging collapse occurs when corner column is removed and then short side column, long side column and finally interior column respectively. To avoid the progressive collapse failure of beams and columns, caused by failure of particular column, adequate reinforcement is required to limit the DCR within the acceptance criteria.

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