International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 12 | Dec 2020 www.irjet.net p-ISSN: 2395-0072

STUDY ON PROGRESSIVE COLLAPSE OF G+6 STOREY RC BUILDING

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Abstract - *A G+6 of reinforced concrete frame building was chosen for the present study. The structure was examined by different examiners for inspect its progressive collapse conduct, and the outcomes were distributed after this examination had been finished. In US, Comprehensive recommendations and protocols for progressive collapse are issued by the General Services Administration (GSA). A threat-independent approach to progressive collapse is included in the GSA criteria. For building structures to provide economical and safe design against progressive collapse. The demand capacity ratio is assessed in the critical region of the RC portion associated with column removed, as per the provisions of GSA guidelines. Member forces are obtained by analysis results carried out in ETABS 16.0. And result comparison is to be done for these parameters before and after the progressive collapse of the building. A RC framed structure was modelled and analyzed according to the Indian Standard Codes for the analysis. In this method the removal of column followed in order to check the beam capacity ratio and additional reinforcement required. Among three cases of column removal, most damaging collapse occurs when interior column is lost, next is corner column failure, finally middle column failure.*

Key Words: Progressive Collapse, DCR, ETABS, Column Removal.

1. INTRODUCTION

Progressive Collapse is the consequence of a local failure of a structural element of basic components that leads to a consistent movement of load that surpasses the limit of other encompassing components, in this manner starting the movement that lets the structure collapse altogether. Progressive collapse as a basic designing perspective began taking consideration when halfway breakdown as a basic designing perspective began taking consideration when halfway breakdown of 22 fractional collapse celebrated at Ronan Point high rise happened in London on 16 May, 1968. This collapse produced significant worry over the ampleness of existing construction regulations. After the halfway breakdown of Ronan Point high rise, number of different implodes far and wide occurred, which could be put in to classification of progressive collapse.

1.1 OBJECTIVES

The main objectives are to learn the potential ability of the RC structure to resist progressive collapse as per GSA guidelines which is achieved by following,

1. Understanding the mechanics of failure in structural building systems due to sudden loss of load bearing elements.
2. Develop measures of "robustness" to assess progressive collapse resistance.
3. Structural linear static analysis using ETABS 2016 tools.
4. Studying the demand capacity ratio of the framed system of G+6 as per GSA guidelines under static conditions.
5. To find the extra reinforcement needed in beams to avoid progressive collapse of the structure.

2. METHODOLOGY

The conduct of RC outlined structures to reformist breakdown situated in various seismic zones is concentrated in this current exploration. For various seismic zones, a structure with 5 stories is studied. In the basic locale of the RC partition related with the segment eliminated, the interest limit proportion is assessed as accommodated in the GSA rules. The arrangement of the reach and sort of progressive breakdown in various circumstance gives a lot of significant data with respect to reformist breakdown opposition, by supplementing extra measures in the plan. To make sure about basic security against progressive breakdown extra considered, for example, irregular loadings must be considered.

Table -1: Material properties

Material	Significance
Concrete	M-25
Rebar	HYSD550

Table -2: Sectional details

Parameter	Steel Structure
Column	750X750mm
Beam	230X500mm
Slab Thickness	150mm
Storey Height	3m

Table -3: Seismic Load Parameters

Parameter	Value
Importance Factor, I	1
Response Reduction Factor, R	3, SMRF
Soil Type	II, Medium
Zone Factor, Z	0.16 (Zone III)
Time Period in X direction	0.437sec
Time Period in Y direction	0.505sec

Load considered as follows

Live Load on floor 3 KN/m^2

Live Load on roof 1.5 KN/m^2

For Linear Static Analysis, the considered load is,
Load = 2(DL+ 0.25LL)

A symmetrical 7 storey RC building is modelled using ETABS. The building is analysed considering parameters from IS 1893 considering combinations of load from it. The column is removed at 3 locations. For every case of column removed, static analysis is done.

The building is analyzed and designed considering all the seismic zones and the gravitational load, super dead loads, live and wind. For this case of analysis column C1, C09, and C06 are removed. The specified GSA and IS 1893-2003 load combinations are applied and the resulting required parameters are calculated for all members using ETABS, and the additional reinforcement required is calculated so as to avoid the condition of progressive collapse.

The Demand Capacity Ratio (DCR), it is the ratio of the demand moment to the capacity. Furthermore, capacity moment is the value taken before this column is eliminated which is determined through the steel area which is directly available from the plan results from ETABS. For the calculation of capacity moment IS 456-2000 code is used. The demand moment value is obtained once the column is removed and the moment that is shown for the beams.

The results are drawn out and the ratio is calculated for each beam connected to the corresponding column removed

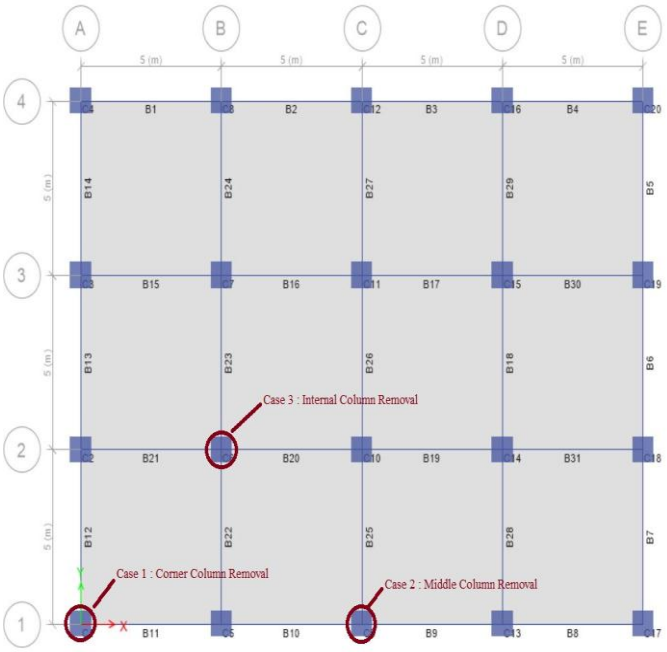

Fig -1: RC Frame structure plan

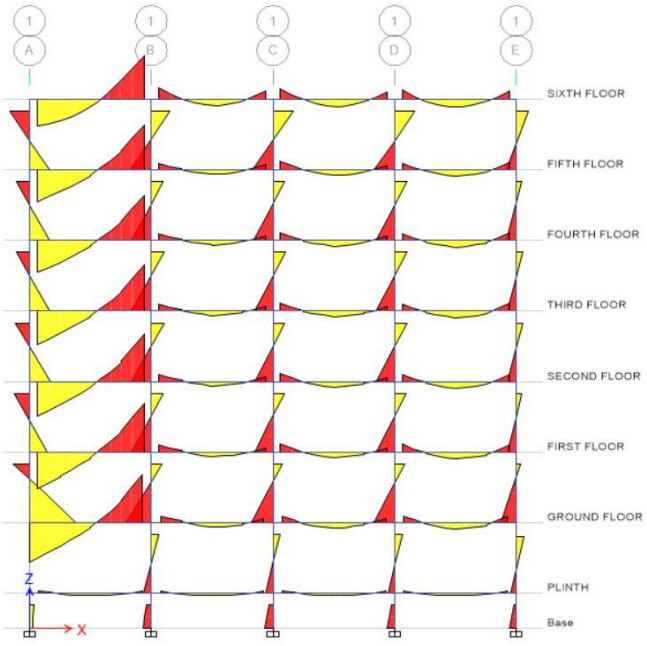

Fig -2: Elevation showing the bending moment of B11 and B12

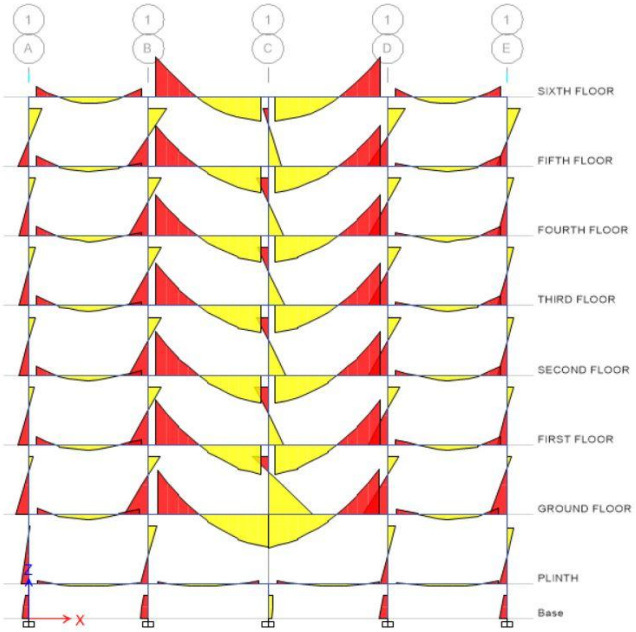

Fig -3: Elevation showing the bending moment of B10, B09 and B25

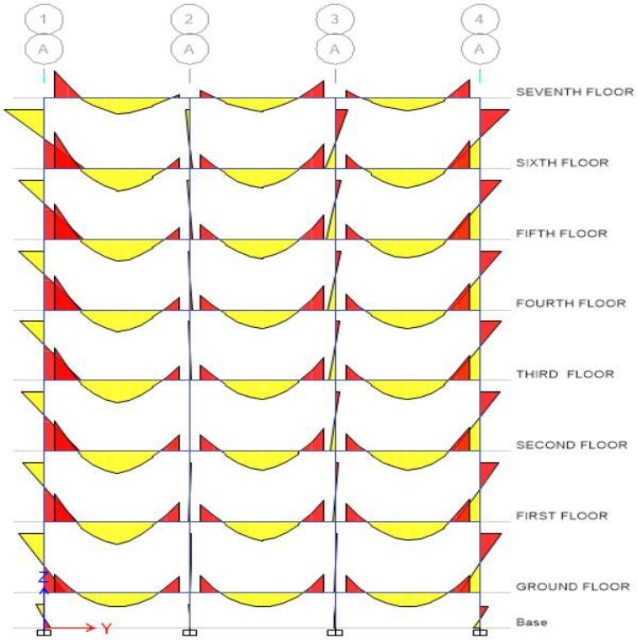

Fig -4: Elevation showing the bending moment of B21, B22, B20 and B23

3. RESULTS AND DISCUSSION

For the loads assigned and after the design done according to the codes, results are worked out. This section discusses with the results.

Table -4 Tables that display the DCR ratios and the additional reinforcement needed when column C01 is removed for beams B12

Column Removed	Beams	Storey	DCR	Additional reinforcement in mm²
C01	B12	1	6.58	1403
		2	6.80	1357
		3	4.67	1288
		4	4.39	1230.5
		5	4.20	1184.5
		6	4.05	1150
		7	3.80	1196

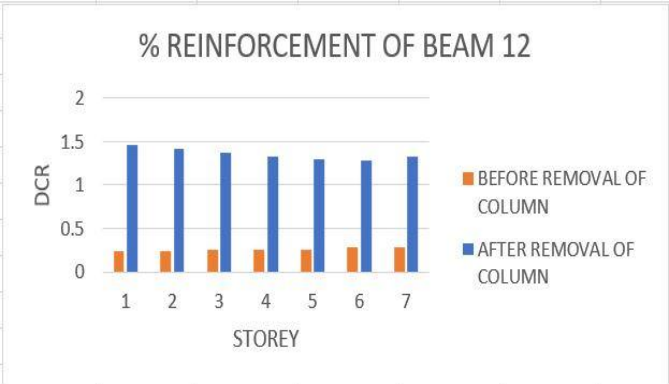

Fig -5: DCR value of B 12 when eliminating column 01

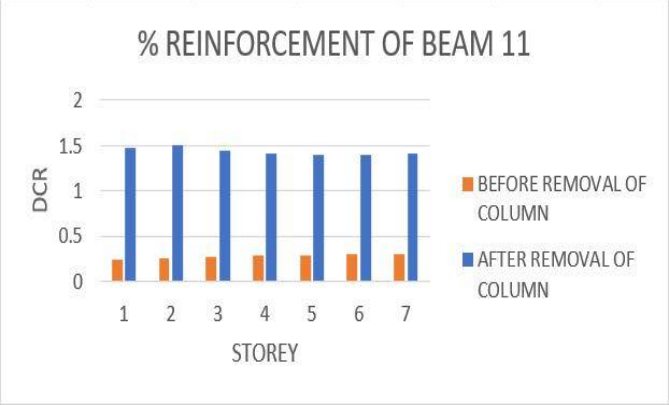

Fig -6: DCR value of B 11 when eliminating column 01

For column CO1 removed, the additional reinforcement required for the beams B12 and B11 is shown in graph. The reinforcement required to avoid progressive collapse, decreases storey wise the DCR ratio. When the ratio is more than 2 the extra reinforcement will be required for it to meet the desired condition. The maximum area of reinforcement required for beam is 1426mm² which are for beams of storey 2, which decrease storey-wise having the least at storey 6.

Table -5 Tables that display the DCR ratios and the additional reinforcement needed when column C09 is removed for beams B10

Column Removed	Beams	Storey	DCR	Additional reinforcement in mm²
C 09	B10	1	6.45	1380
		2	5.82	1368.5
		3	5.65	1322.5
		4	5.51	1288
		5	5.41	1265
		6	5.39	1253.5
		7	3.75	1161.5

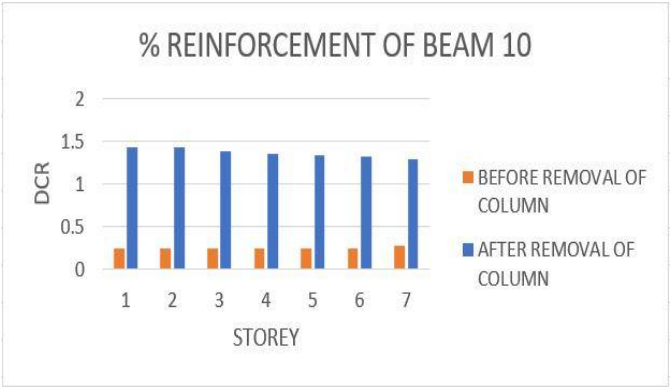

Fig-7: DCR value of B 10 when eliminating column 09

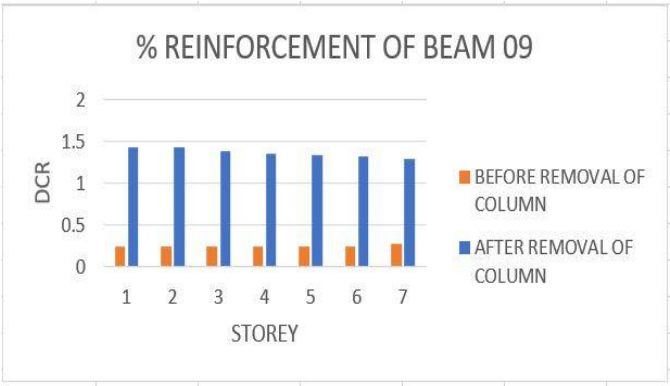

Fig-8: DCR value of B 09 when eliminating column 09

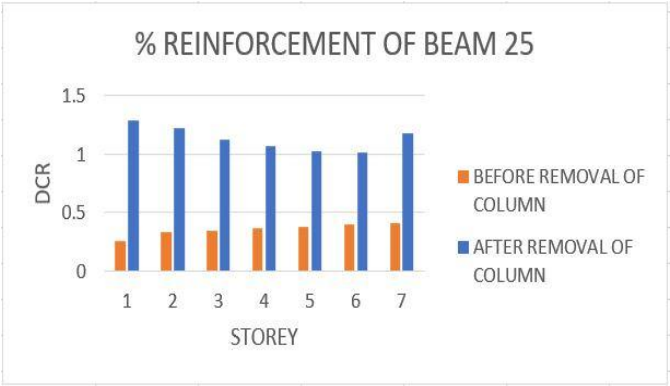

Fig-9: DCR value of B 25 when eliminating column 09

Table -6 Tables that display the DCR ratios and the additional reinforcement needed when column C09 is removed for beams B21

Column Removed	Beams	Storey	DCR	Additional reinforcement in mm2
C 06	B 21	1	4.24	1426
		2	3.7	1391.5
		3	3.42	1322.5
		4	3.23	1265
		5	3.11	1219
		6	3.01	1219
		7	2.63	1046.5

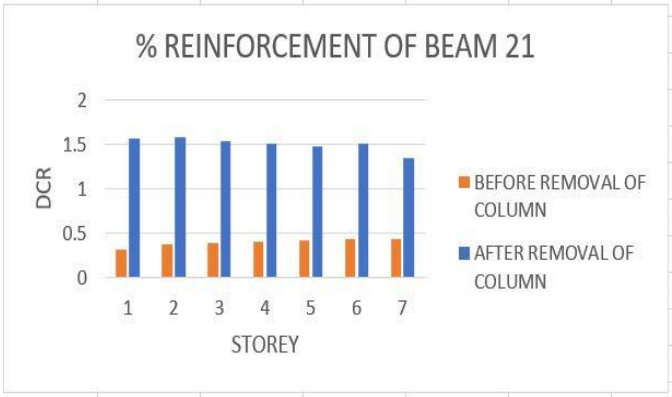

Fig -10: DCR value of B 21 when eliminating column 06

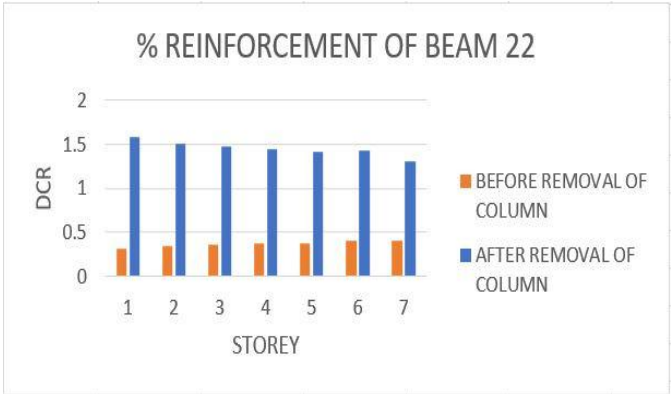

Fig -11: DCR value of B 22 when eliminating column 06

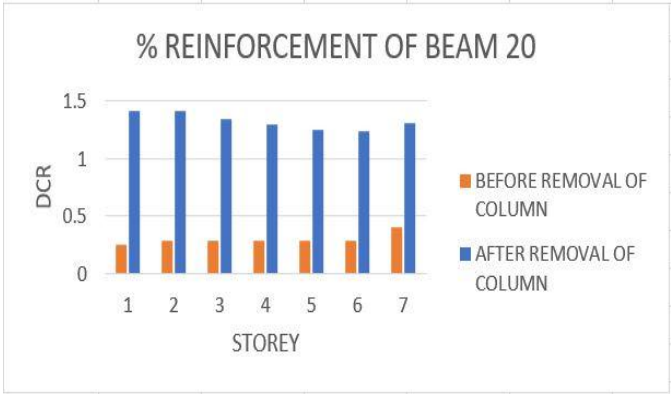

Fig -12: DCR value of B 20 when eliminating column 06

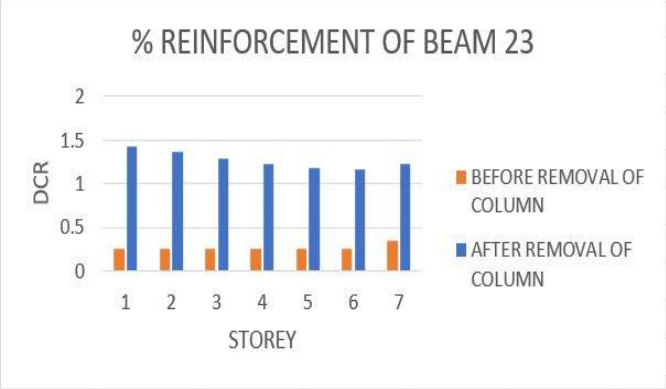

Fig -13: DCR value of B 23when eliminating column 06

For column CO6 removed, the additional reinforcement required for the beams B21, B22, B20 and B23 is shown in graph. The maximum area of reinforcement required for B22 is 1449mm^2 which are for beams of storey 1, which decrease storey-wise having the least at storey 7. The reinforcement required to avoid progressive collapse, decreases storey wise the DCR ratio.

The ratios of the beams analyzed with analysis of linear static are shown in these sections of paper. It is obvious observation is that the beams DCR value is far higher than the limiting value i.e., 2. To reduce the probability of failure in the beams. Adequate reinforcement is to be provided considering the envelope as loading.

4. CONCLUSIONS

1. Demand capacity ratio considering for flexure members at all floor level was determined for different cases belonging to column failing. We found that DCR value decreases as the storey rises.

2. Capacity ratio after elimination of vertical column is observed seeing the member force towards the load combination just as according to GSA guidance.

3. Furthermore DCR values of member are exceeded than approved benchmark value recommended by GSA for progressive breakdown guidance's are unsafe. These beams were found to be neighboring to the eliminated column in each case.

4. Expanding beam size will be more adequate in escaping or delaying destruction slighter than expanding column width.

5. To bypass the progressive failing of beams and vertical columns, induced by deterioration of particular column, suitable reinforcement should be enforced to limit DCR not beyond the acceptance criteria.

6. Among 3 instances of column elimination, most harming collapse happens when interiors vertical column is lost, next is corner segment failure, at last middle column failing.

7. To counter progressive breakdown, a structural system of the building shall be able to tolerate the removal of one or more structural member and redistribute their load on the surrounding member, so that disproportionate collapse would not take place.

8. For column CO1 removed, the additional reinforcement required for the beams B12 and B11. The maximum area of reinforcement required for beam is 1426mm^2 which are for beams of storey 2, which decrease storey-wise having the least at storey 6.

9. For column CO9 removed, the additional reinforcement required for the beams B10, B09 and B25. The maximum area of reinforcement required for B09 is 1180mm^2 which are for beams of storey 1, which decrease storey-wise having the least at storey 7.

10. For column CO6 removed, the additional reinforcement required for the beams B21, B22, B20 and B23. The maximum area of reinforcement required for B22 is 1449mm^2 which are for beams of storey 1, which decrease storey-wise having the least at storey 7.

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