STUDY OF PROGRESSIVE COLLAPSE IN G+8 MULTI-STOREY BUILDING

Shivam[1], Ankit Kumar[2]

[1] PG Student, Department of Civil Engineering, Radha Govind Group of Institutions, Meerut, Uttar Pradesh, India
[2] Assistant Professor, Department of Civil Engineering, Radha Govind Group of Institutions, Meerut, Uttar Pradesh, India

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Abstract - *Progressive Collapse denotes a global structural system breakdown disproportionally triggered by local structural deterioration. An uncommon occurrence involving local element removal criteria due to natural forces or artificial risks. When one or more vertical load-bearing elements are removed due to artificial (Explosions, Vehicular Collisions) or natural dangers (Earthquake, Tsunami), the progressive collapse of reinforced concrete structures is triggered. The weight of the building is transferred to adjacent columns in the structure, failing adjacent components and failing a portion of the entire structure system. In which the collapsing system constantly seeks other load pathways to survive. When one or more vertical load-bearing elements are removed due to artificial or natural dangers, the progressive collapse of reinforced concrete structures is triggered. The building's weight is transferred to adjacent columns and beams in the structure, failing adjacent components and failing a portion of the entire structure system. In which the collapsing system constantly seeks other load pathways to survive. Performing Linear static analysis in the G+8 storey R.C.C. building using ETABS Software Version 16.0. According to G.S.A. regulations, the demand capacity ratio is evaluated in the critical zone of the R.C. part connected with the eliminated column.*

***Key Words*: Progressive Collapse, Etabs, D.C.R. (Demand Capacity Ratio), G.S.A., Columns removal.**

1. INTRODUCTION

Progressive Collapse is the subsequent breakdown of a part of the entire structure caused by the loss of a vertical load-bearing element (mostly column). Failure of a primary load-resistant member redistributes forces to adjacent members, which fail if the redistributed load exceeds their capability. This process continues in the structure, and eventually, the building collapses. Collapses of this nature are of particular interest to structural engineers if there is a marked disparity between the initiation event and the resulting Collapse.

The potential irregular loads that can cause the dynamic breakdown are arranged that way

i) Pressure Loads

• Gas explosions

• Blast

• Excessive pressure due to the wind.

• Extreme environmental loads

ii) Impact Loads

• Vehicular collision

• Earthquake

1.1 METHOD OF ANALYSIS

Linear Static Analysis - The linear static approach establishes the possibility of structural failure by calculating the demand capacity ratios of structural parts (U.F.C., 2013). If there are no structural anomalies inside the structure, the analysis can be conducted, and it is not necessary to calculate the D.C.R.s. If structural anomalies occur, the analysis can only be undertaken if all member D.C.R.s are below or equal to two.

Nonlinear static procedure: The L.S.P. cannot accurately predict how a structure will behave after losing a primary member. A nonlinear method, albeit more complex, is required to advance our understanding of the performance of a building undergoing gradual Collapse. In an NLS analysis, material and geometric nonlinear behaviours must be considered.

$$DCR= Q_{ud} / Q_{ue}$$

Where,

Q_{ud} =Demand (Acting force) observed in member or connection (bending moment, axial force , shear force and possible combined forces)

Q_{ue} = Expected ultimate, unfactored capacity of the member or connection (shear, moment , axial force and possible combined forces) the permissible D.C.R. 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.

2. METHODOLOGY

In this work, the Linear static method is used for the assessment of progressive collapse in a multi-storey building. The structure under Instantaneous Removal of Columns from the different locations and compare their D.C.R. value to find out the most critical situation in R.C.C. Multi-Storey Building Using ETABS Software as per I.S. standards.

There are multiple methods for analyzing structures and investigating their reaction to the progressive collapse phenomenon for this research, and we employed G.S.A. for additional recommendations.

The purpose of these Guidelines is to:

• Assist throughout the reduction of the possibility of progressive Collapse in new buildings

• Progressive Collapse potential evaluation in existing buildings.

• Help with the development of future facility enhancements, if necessary.

The localised failure of one or more structural elements causes progressive collapse. This failure leads to a progression of load transfer that exceeds the capacity of other surrounding features, which in turn initiates the progression that ultimately results in the total or partial collapse of the structure. Progressive collapse can be caused by the structure's complete or partial failure.

ETABS is used to create a typical frame model for the study. All supports are modelled as being fixed. On each of these models, linear analysis is carried out. We use Linear Static Analysis in this paper. The first structure is designed using ETABS v16.0 using IS 1893 load combinations. Then, a separate linear static analysis is conducted for each column removal instance. The demand capacity ratio for shear at all stories is computed for various beam failure scenarios. The capacity of the member at any section is estimated in accordance with I.S. 456:2000 using the reinforcing data obtained following analysis and design. After removing the column, the DCR is determined by calculating the force of the member for the load combination following G.S.A. requirements. ETABS 16.0 analysis findings determine the member forces.

Location considerations for column removals

The following analysis aspects must be applied when evaluating progressive Collapse –

i) Exterior Column C3 removed from Ground Floor

ii) Exterior Columns C2 and C5 remove from Ground Floor

iii) Interior Column C17 Removed from Ground Floor

3. MODELLING AND ANALYSIS

Table 1: Specification of Building.

SPECIFICATION	DATA
Typical Storey Height	3
Base Storey Height	3
Concrete Grade	M30
Density of RCC	25 KN/M3
Density of Masonry	20 KN/M3
Columns Size	0.30 X 0.30 M
Beam Size	0.25 X 0.30 M
Slab Thickness	0.15 M
Bottom Support Condition	Fixed Support
Wind Speed	50 M / Second
Dead Load	0.52 KN/M2
Live Load	3 KN/M2
Seismic Zone	IV
Seismic Zone Factor	0.24
Importance Factor	1
Response Reduction	3
Site Type	II
Soil Type	Medium
Damping Ratio	5%, asper IS-1893: 2002 (Part-1)
Poisson Ratio	0.2

Table 2: General Data

Software	Etabs 2016
Building Configuration	Symmetric
Dimension	27.4256 X 8.6868 M
STOREY	9
CODES	IS 456:2000 IS18923:2002 IS 875:1987

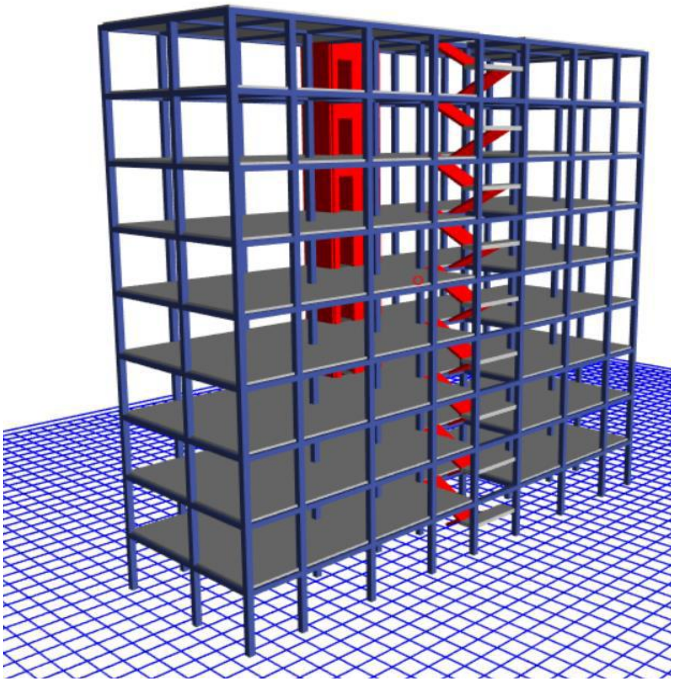

Figure 1: 3D view of the building

3.1 RESULTS AND DISCUSSION

The D.C.R. values acquired by the ETABS program for loadings assigned per G.S.A. are used to determine the behaviour of stilt floor members in the structure.

In this chapter, the results of the analysis and the D.C.R. values for the beams of the stilt floor are shown. The susceptivity of three case studies with various column removals to progressive Collapse has been evaluated. In each frame, the D.C.R. of the primary items (beams) is specified along with their particulars.

1) C3 Exterior Column removed from Ground Floor

D.C.R. increases in beams after removing column C3, but the value is under the permissible limit; therefore, no progressive collapse occurs.

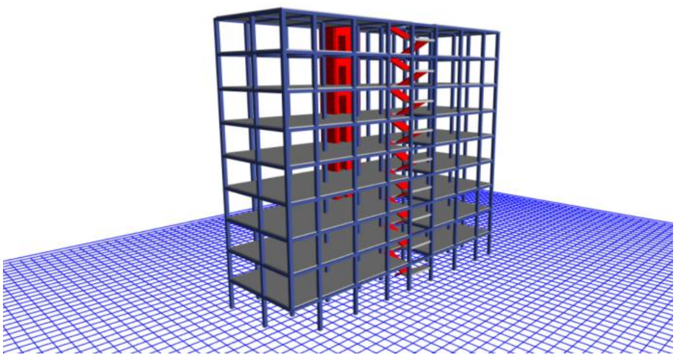

Fig -2: Exterior Column C3 removed

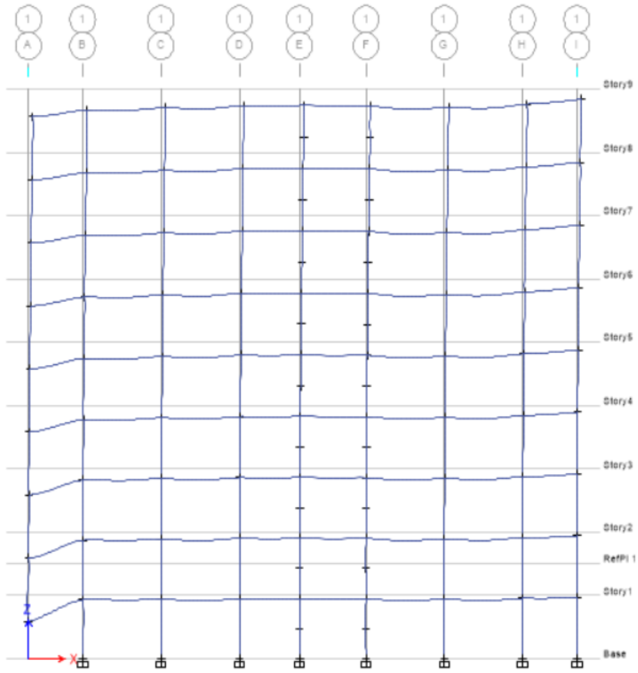

Figure 3: Displacement after Exterior Column C3 removed

We Calculate D.C.R. Values in beams B35, B27, B20, and B19 after the Column removal. The following Charts Shows the design capacity and demand capacity of beams under shear.

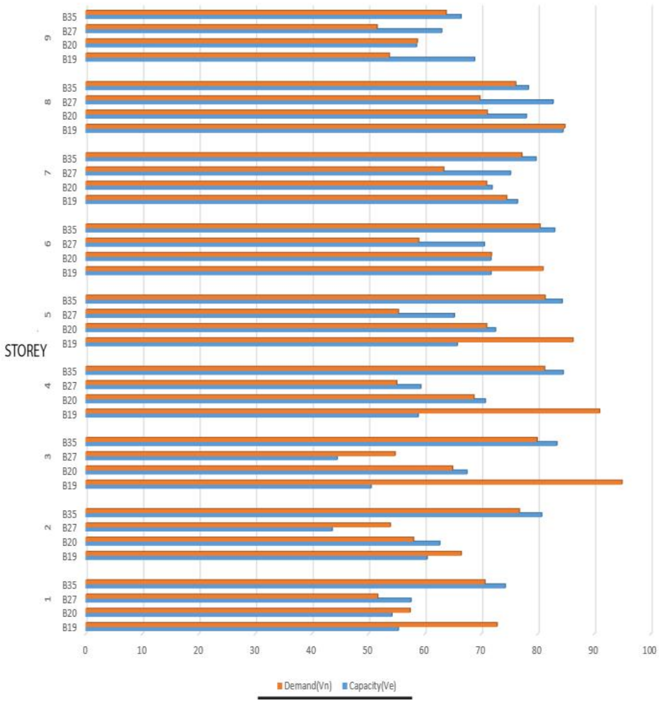

Chart 1: Shows Demand and capacity of Beams after removing Column C3

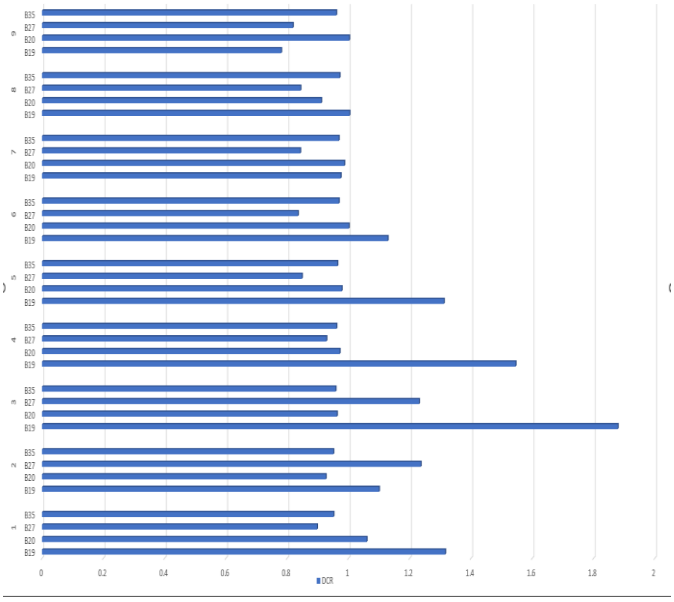

Chart 2: Shows D.C.R. Value in Beams after removing Column C3.

D.C.R. increases in beams after removing column C3, but the value is under the permissible limit; therefore, no progressive collapse occurs.

2) Remove Columns C2 and C5 from Ground Floor

We Calculate D.C.R. Values in beams B36, B29, B28, and B27 after the removal of Columns C2 and C5.

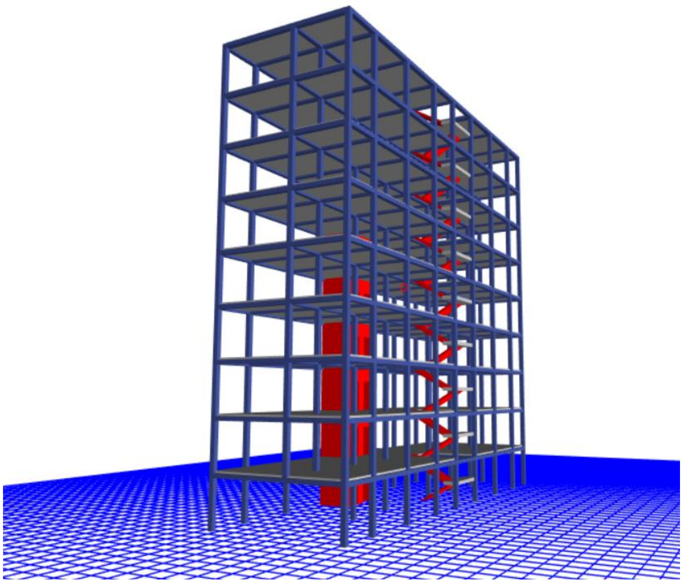

Figure 4: Columns C2 and C5 Removed

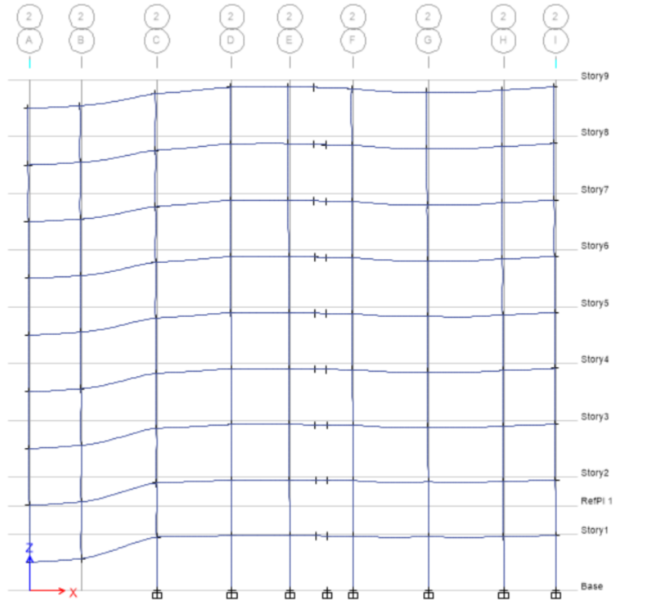

Figure 5: Displacement after Columns C2 and C5 Removed

The following Charts Shows the design capacity and demand capacity of beams under shear.

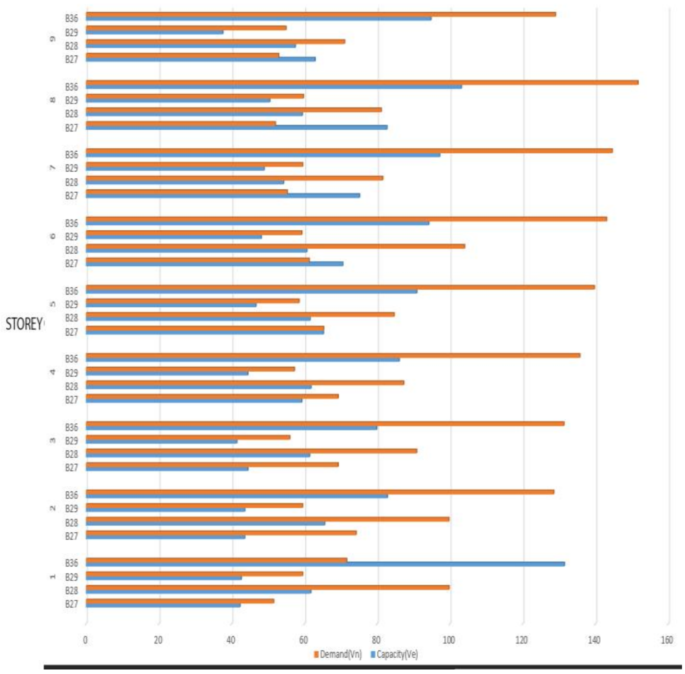

Chart 3: Shows the Demand and capacity of Beams after removing Columns C2 and C5.

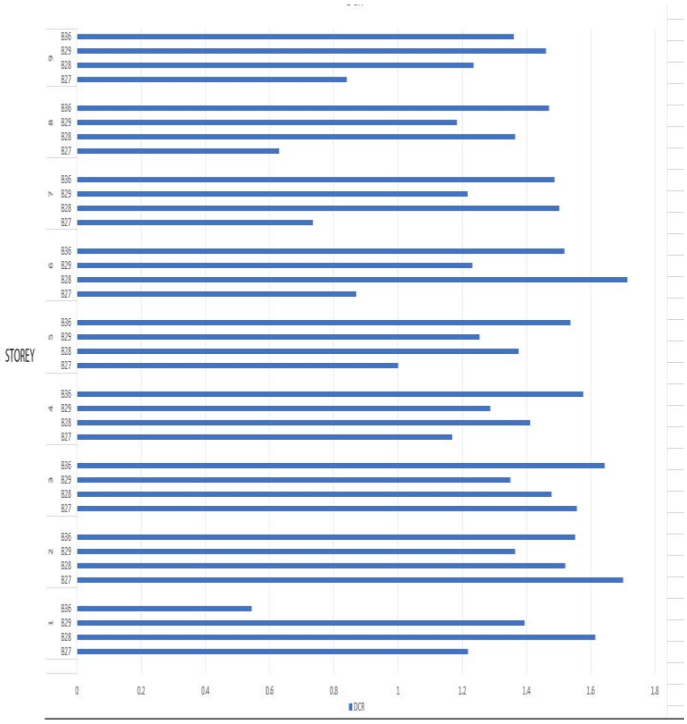

Chart 4: D.C.R. of Beams after removing Columns C2 and C5.

D.C.R. increases beams after removing columns C2 and C5, but the demand capacity ratio is under 2; therefore, no progressive collapse occurs.

3) Remove Interior Column C17 from Ground Floor

We Calculate D.C.R. Values in beams B23, B22, B32, and B31 after the removal of Column C17.

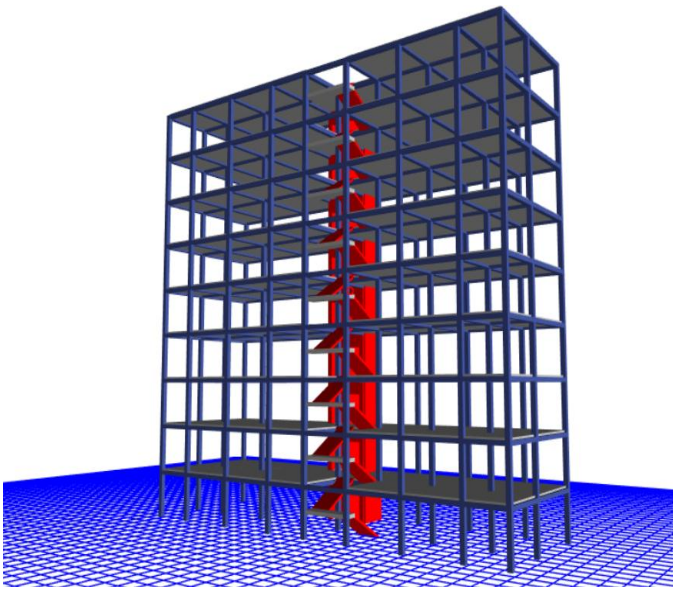

Figure 6: Interior Column C17 Removed

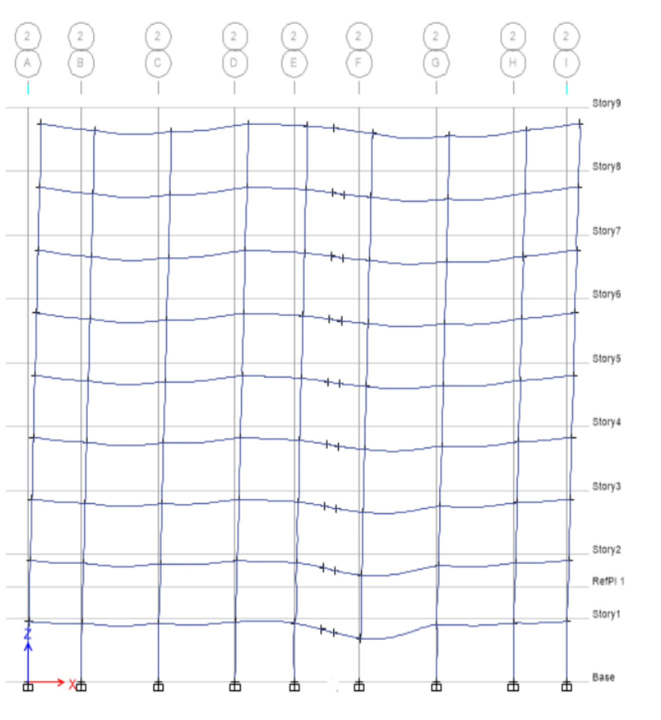

Figure 7: Displacement due to Interior Column C17 Removed

Following Charts Shows design capacity and demand capacity of beams under shear.

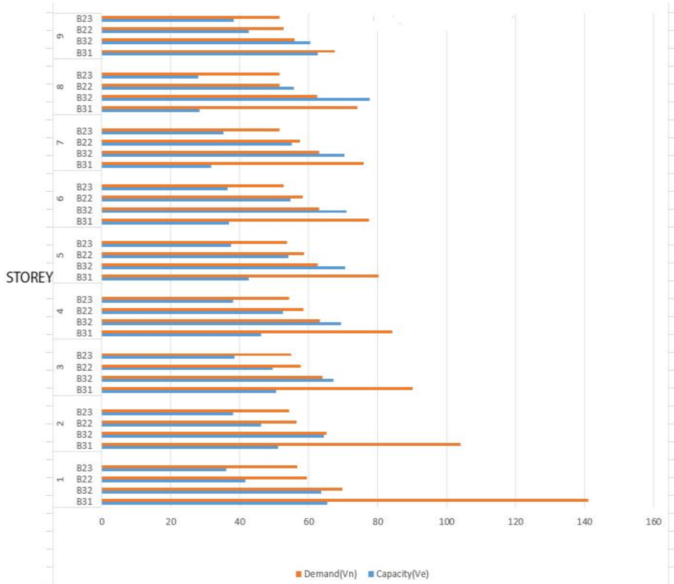

Chart 5: Shows Demand and capacity of Beams after removing interior Column C17

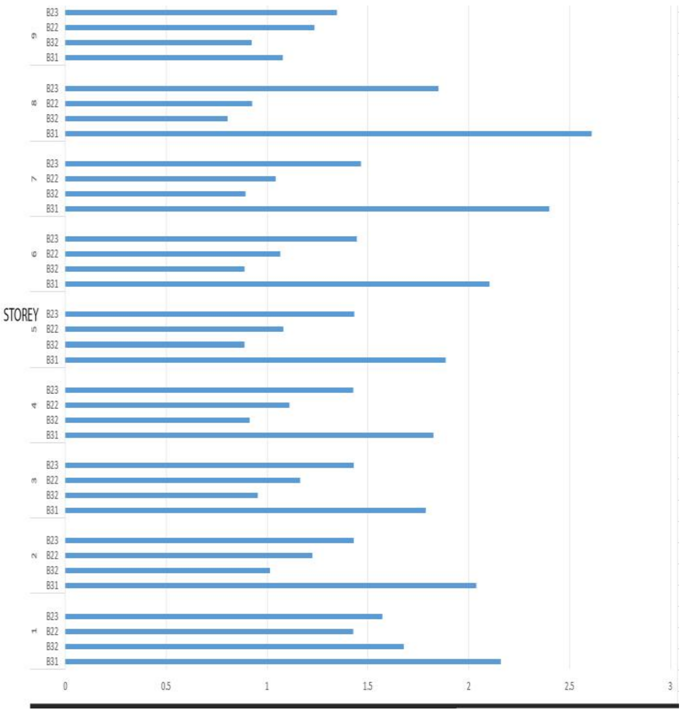

Chart 6: D.C.R. of Beams after removing Column C17

DCR increases in beams after removing column C17, and the demand capacity ratio is over 2 in Beam 31. Therefore, progressive Collapse occurs.

3. CONCLUSIONS

i. Demand Capacity Ratios for three conditions are calculated. In two conditions, they are less than 2 and exceeds 2 in one case, suggesting that interior column removal cause more damage.

ii. The axial parameter is crucial for understanding the progressive collapse process in columns.

iii. When peripheral columns are removed, the D.C.R. value of inner columns increases.

iv. Columns bear less damage than beams.

v. Increasing the beam size may be more beneficial than increasing the column size to prevent or delay Collapse.

vi. It was found that there is a constant drop in D.C.R. value from the bottom Story to the top Story, implying that the failure is more at the ground Floor story than at the top Story.

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