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Progressive Collapse of Reinforced Concrete Building

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ABSTRACT: Progressive collapse analysis of regular and irregular building is proposed to be taken out in this project. Standard building consists of 5X5 bay 5 m in both direction and irregular building consist of L-shape. Building structural model is developed in SAP2000 and loads are implemented in compliance with GSA guidelines to test progressive linear collapse static method of analysis. As per the GSA guidelines, different columns are removed one at a time and the DCR ratios are assessed for both building types. For the corresponding column removal scenario, member having a DCR ratio greater than 2 may fail in standard building. For irregular construction, member with a DCR ratio greater than 1.5 may fail for the corresponding case of removal of columns. The result indicates that Center column is more sensitive to progressive collapse in each of these construction methods.

KEYWORDS: Progressive collapse; Demand capacity ratio; Linear Static Method; GSA guidelines; SAP2000.

I. INTRODUCTION

The building was designed first and then built for resistance to ultimate forces or stresses. But if the load imposed on the entire structure or a structural element exceeds the specified value of that operating load or stress, the structure fails or any structural element failure occurs. If stress exceeds the operating loads, structure or any element like beams and column fails its effects result in failure of adjacent elements or higher storey members result in failure of the entire structure. The trend of systemic elements continuing to fail causes the entire system to fail. This technique is termed Progressive Collapse or Gradual Fault. In short, it can be defined as a series of action in which local failure is transformed into global failure.

When an abnormal load affects the structure, damage is primarily caused by any of the structural components i.e. column, beam and slab. The breakdown of the vertical structural component or part, i.e. column, is more vulnerable to damage than that of the horizontal member i.e. plate. When any vertical member i.e. column has been impacted due to impulsive load effect, it leads to load distribution to other adjacent or adjacent element components. If the adjacent members of the damaged member can carry extra load, they will be able to resist the load, but if not, they will not resist. If any of the adjacent structural members fails again, then their adjacent elements should have sufficient ability to bear or disaster continues to increase causing a series of failure action that causes structural damage.

II. LITERATURE REVIEW

[1] S. M. Marjanishvili and P.E (2004)

Clarified 4 assessment methods; Linear static and dynamic, Nonlinear static and dynamics for detailed testing of potential for progressive collapse. The observation's main objective shifted into formulating the most accurate and effective analytical process. With that, along with the design phenomenon, the author provided item overview of current layout guidelines defined in the USA. The benefits and drawbacks of that form of progressive collapse evaluation were explained in depth, and its successful methodological approach was conducted and finally completed.

[2] B. ShalvaMarjanishvili and Elizabeth Agnew (2006)

Continuous static, fluid, nonlinear dynamics were analyzed using SAP 2000 software compared to 4 methods of progressive collapse valuation; the findings suggest that the dynamic analytics method compared to the static approach was more successful. Author highlights the static and nonlinear dynamic analyses and discovered the accurate type with advantages and disadvantage. A framed resistant 9-story steel moment building dynamic amplification elements of 2.0 used in analyses is the best approximation for the method of static analysis.

[3] C. Digesh D. Joshi, Paresh V. Patel and Saumil J. Tank (2010)

The study on the progressive collapse resistance of 4 story and 10 story RC framed systems was carried out using GSA guidelines. The use of SAP2000 software was carried out on linear static and nonlinear static analyses. Vertical masses are distributed in a stepwise fashion in nonlinear static analysis technique. The demand capacity ratios observed the use of linear static assessment was contrasted with the hinge formulation got from nonlinear static assessment. The result shows that hinge formation starts with a maximum demand capacity ratio from the area, and then hinge formation remains through the areas with higher demand capacity ratios. This research suggests that the constructed and detailed structure with a good level of stability, redundancy, and ductility can set different load patterns regarding loss of individual members and reduce collapse.

III. OBJECTIVES

- To understand the progressive collapse analysis through Linear Static Analysis of the normal construction.
- To consider the gradual breakdown process of a plan and the construction of mass irregularity.
- Understanding the mechanism of progressive RC structure collapse in a sudden column failure scenario.
- The efficiency and reaction of a system under gradual collapse shall be calculated.
- Assumptions and recommendations for the appropriate analytical method shall be made on the basis of its accuracy and ease of use.
- To test whether or not an RC building designed and specified by Indian seismic load codes provides resistance to Progressive collapse.

General Service And Ministration Guidelines

According to this guideline, it is a matter of ensuring that when members fail at the beginning, this failure is referred to as local failure and this local failure can be restricted at some point in order to prevent global failure, i.e. the failure of the entire building.

A. Linear Static Method

The loading is taken as per GSA guidelines that are [DL+0.25LL] for before removal case. The design has been done as per IS: 456 code using SAP2000.

DL=Self weight and LL=Live load

B. Demand Capacity Ratio Value

Structural member according to G.S.A is said to be safe or dangerous depending on the DCR meaning. The members are safe if the value of the DCR is within the specified limit, or is unsafe. It is known as the ratio of force which the structural member demands to the structural member's ultimate power.

DCR = Demand by the member / Capacity of the member

= W acting / W capacity

W_{acting} = Force taken by the element. The forces like BM, SF and AL are considered.

$W_{capacity}$ = Ultimate force or capacity of the member in terms of BM, SF, AL or any combined force.

According to G.S.A, the permissible value of DCR value is limited to 2 for regular structure and 1.5 for irregular structures.

IV. METHODOLOGY

Regular Building

The study structure is 10 storey symmetric R.C. structure. The form consists of four 5 m longitudinal bays and three 5 m transverse course. Typical height is 3.1 m and 3.4 m for the 1st story. The details of the building are as follows

1. Material information

- M30 grade (fck-30N/mm2)
- Fe500 grade(fy-500N/mm2)

2. Slab thickness-150mm
3 .Wall thickness-115mm
4. Beam size- 300mm*550mm
5. Column dimensions-500*700mm
6. Load considered

Dead load= self-weight of the member

- Live load= 3kN/m2
- Floor finish= 1.5kN/m2
- Wall load= 7.13Kn/m2

The structure is analyzed by linear static method using SAP2000.

Cases considered for study

- Removal of Middle column on shorter side.
- Removal of edge base column.
- Removal of Internal base column.
- Removal of Middle column on longer side.

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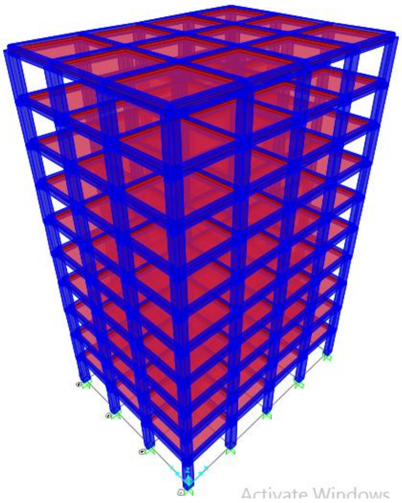

Fig.4.1 Model of a 10 storey Building

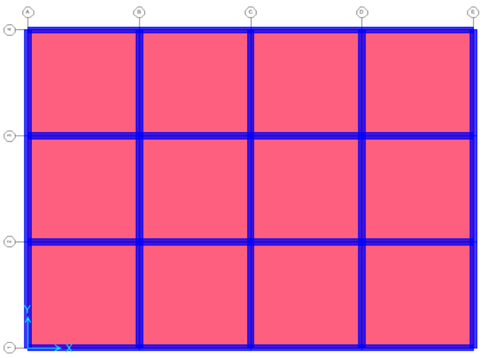

Fig.4.2 Plan of a 10 storey Building

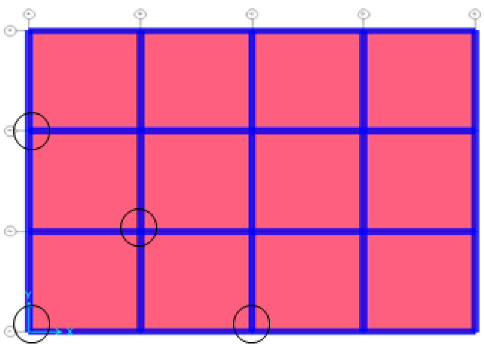

Fig.4.3 Location of the Column removal

Irregular Building

The structure is L shape having 12 storeys. The shape is composed of 5 bays of five m in the longitudinal course and 5 bays of 5 m within the transverse course. Floor height is 3 m.

1. Material information

- M30 grade (fck-30N/mm2)
- Fe500 grade(fy-500N/mm2)

2. Slab thickness-150mm

3 .Wall thickness-300mm

4. Beam size- 300mm*450mm

5. Column dimensions

- 300mm*750mm- 1st to 4th storey
- 300mm*600mm- 5th to 8th storey
- 300mm*450mm- 9th to 12th storey

6. Load considered

Dead load= self-weight of the member

- Live load= 3kN/m2
- Floor finish= 1.5kN/m2
- Wall load= 13.8Kn/m2
- Parapet load= 3.75kN/m2

Linear static analysis and design of building for the loading is performed using SAP2000.

Cases considered for study

- Removal of Middle base column on shorter side
- Removal of cornerbase column
- Removal of interior base column
- Removal of Centre base column

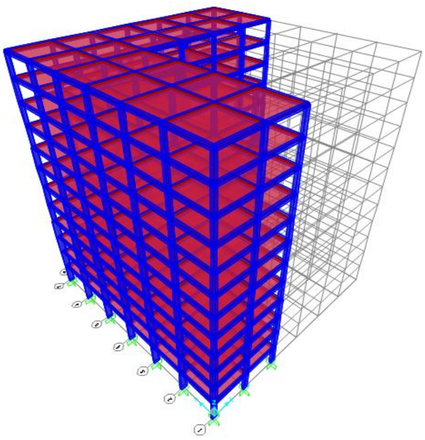

Fig.4.4 Model of a 12 storey Building

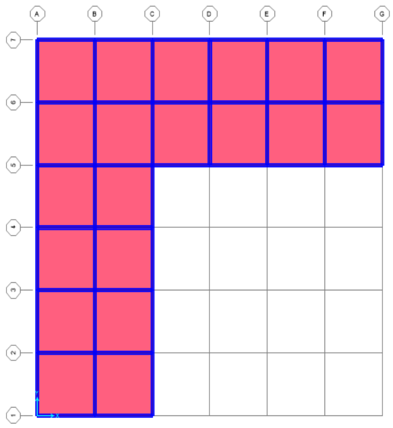

Fig.4.5 Plan of a 10 storey Building

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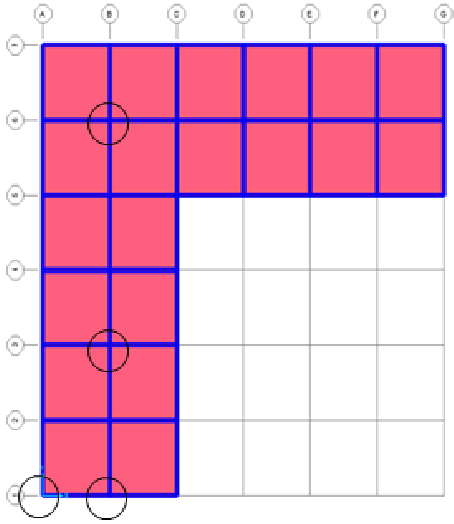

Fig.4.6 Location of the Column removal

V. RESULT AND DISCUSSION

a. Results of regular structure

Case 1: Corner Column removal

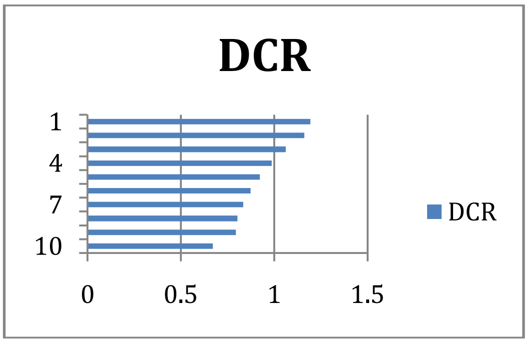

Fig.5.1 D-C Ratio v/s Storey

Case 2:Removal of Middle Column at longer span

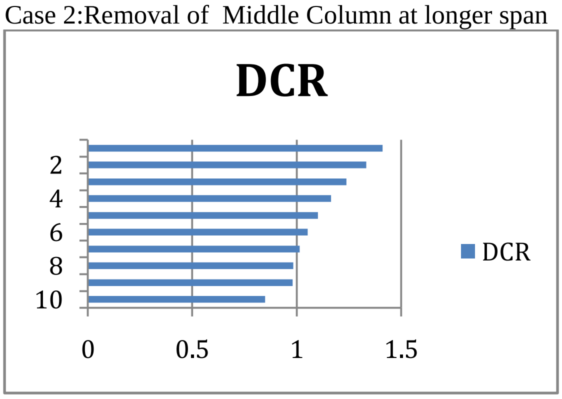

Fig. 5.2 D-C Ratio v/s Storey

Case 3: Removal of Middle Column at shorter span

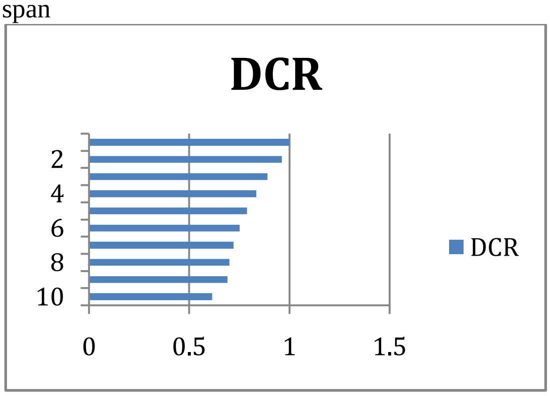

Fig. 5.3 D-C Ratio v/s Storey

Case 4: Removal of Interior column

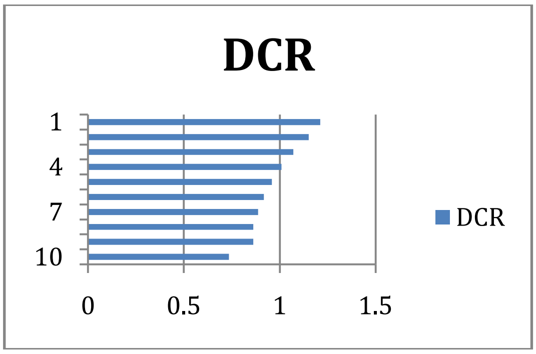

Fig. 5.4 D-C Ratio v/s Storey

In all the cases, the DCR value is less than the limting value, which shows that they are not going to fall under sudden column loss condition.

Results of irregular structure

Case 1: Removal of Centre base column

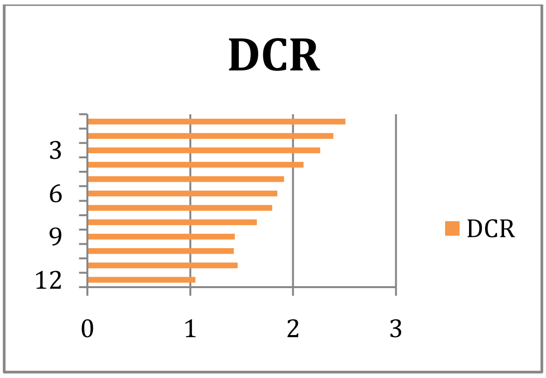

Fig. 5.5 D-C Ratio v/s Storey

In this case, the DCR value of beams are exceeding allowable limit of 1.5 and reaches 2.5 from 8th storey to 1st storey. The beams in the

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remaining storey are within the limit and safe from progressive collapse.

Case 2: Removal of corner base column

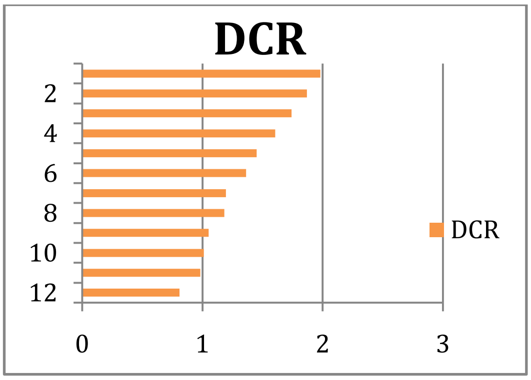

Fig. 5.6 D-C Ratio v/s Storey

In this case, the DCR value of beams are exceeding allowable limit of 1.5 and reaches 1.98 from 4th storey to 1st storey. The beams in the remaining storey are within the limit and safe from progressive collapse.

Case 3:Removal of middle exterior column

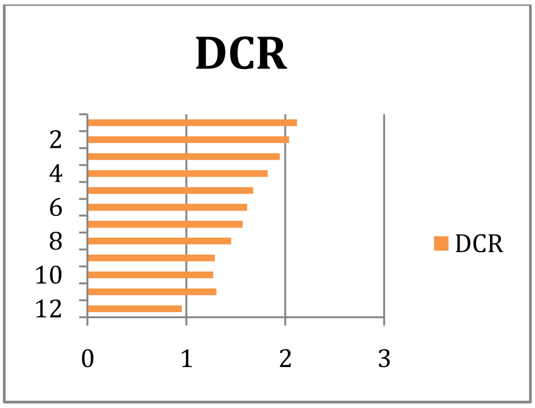

Fig. 5.7 D-C Ratio v/s Storey

In this case, the DCR value of beams are exceeding allowable limit of 1.5 and reaches 2.11 from 7th storey to 1st storey. The beams in the remaining storey are within the limit and safe from progressive collapse.

Case 4: Removal of interior base column

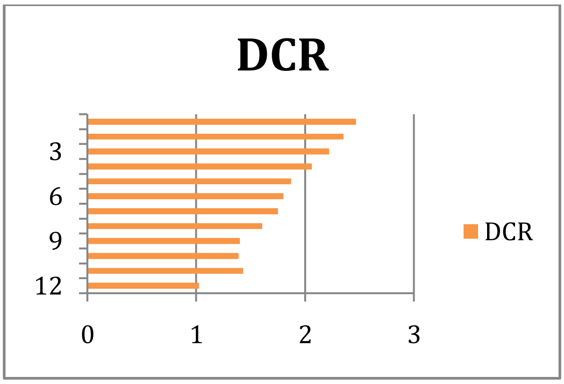

Fig. 5.8 D-C Ratio v/s Storey

In this case, the DCR value of beams are exceeding allowable limit of 1.5 and reaches 2.4 from 8th storey to 1st storey. The beams in the remaining storey are within the limit and safe from progressive collapse.

VI. CONCLUSON

[1] The regular structure analysedby linear static method indicates that the lower storey beams are more critical when compared to upper storey beams.

[2] For most of the beams in regular structure, the Demand Capacity Ratio will not exceed the limiting value. This indicates that they are not going to fail under sudden column loss condition.

[3] For L shape structure,the Demand Capacity Ratio will exceed the limiting value. This indicates that they are going to fail under sudden column loss condition.

[4] During progressive collapse, L shape mass irregularity structure is more susceptible to progressive collapse for both centre and interior column removal and less susceptible for corner column removal.

[5] In L shape plan it is observed that bottom storey beams are more critical than top storey beams.

[6] In plan irregularity structure, the Demand Capacity Ratiois linearly varying from top to bottom.

[7] Axial force at the base is higher in column removed case compared to normal case and the results of axial force with considering dynamic factor; we can conclude that it’s better to design the building considering dynamic factor as that case is more critical.

[8] In both type of structure, if DCR value exceeds the limit then such beams should be redesigned to avoid the progressive collapse. This can be

achieved by increasing the reinforcement or by increasing the size of the beam.

[9] The failure of vertical structural element is more hazardous than failure of horizontal structural elements.

[10] Finally it is observed that, the irregular structures are more critical than regular structure because the regular building is of uniform dimension and can receive equal load in both the direction.

[11] A Special moment resistance frame designed by IS 456 and detailed by IS 13920 does not provide resistance to progressive collapse this is because of that SMRF is designed for lateral loads and in progressive collapse the failure loads are gravity loads.

REFERENCES

[1] General Services Administration (GSA). (2003). Progressive collapse analysis anddesign guidelines for new federal office buildings and major modernization projects, GSA.

[2] IS 456:2000 (2005).Plain and reinfoRCed concrete code of practice, 4th Revision,7th Reprint, Bureau of Indian Standards, New Delhi.

[3] IS 1893 (Part 1):2002 (2006). Criteria for earthquake resistant design of structures,5th Revision, 3rd Reprint, Bureau of Indian Standards, New Delhi.

[4] S. M. Marjanishvili, P.E, "Progressive Analysis Procedure for Progressive Collapse", Journal of Performance of Constructed Facilities, ASCE, vol. 18, pp 79-85, 2004 [1]

[5] ShalvaMarjanishvili and Elizabeth Agnew, "Comparison of Various Procedures for Progressive Collapse Analysis", Journal of Performance of Constructed Facilities, ASCE, Vol. 20, pp 365-374, 2006

[6] Digesh D. Joshi, Paresh V. Patel and Saumil J. Tank, "Linear and Nonlinear Static Analysis for Assessment of Progressive Collapse Potential of Multistoried Building", ASCE, pp 3578-3589, 2010

[7] Ali Kazemi and MehrdadSasani, "Progressive Collapse Analysis of RC Structures including Beam Axial Deformation", ASCE, pp 3132-3140, 2011

[8] Huda Helmy, Hamed Salem and SherifMourad, "Progressive collapse assessment of framed reinfoRCed concrete structures according to UFC guidelines for alternative path method", Engineering Structures, Elsevier, Vol. 42, pp 127-141, 2012

[9] Paresh V. Patel and Digesh D. Joshi, "Various Approaches for Mitigating Progressive Collapse of Asymmetrical RC Building", ASCE, pp 2084-2094, 2012

[10] MassimilianoFerraioli, Alberto Maria Avossa and Alberto Mandara "Assessment of Progressive Collapse Capacity of Earthquake-Resistant Steel Moment Frames Using Pushdown Analysis", The Open Construction and Building Technology Journal, Vol. 8, pp 324-336, 2014 [10]

[11] H. Sezen1,"Collapse Performance of Existing Buildings after Loss of Load-Bearing Walls and Columns",ASCE

[12] ZHANG Peng , CHEN Baoxu, "Progressive Collapse Analysis of Reinforced Concrete Frame Structures in Linear Static Analysis Based on GSA", IEEE, 2012.