

**INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH
TECHNOLOGY****REVIEW PAPER- ANALYSIS OF RC BRACED FRAME FOR PROGRESSIVE
COLLAPSE USING ETABS****Monica S Swamy*, Ashwini B T, Chethan V R***Department of Civil Engineering, Adichunchanagiri Institute of Techology, India
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ABSTRACT

In day to day life there are many man made hazards or natural catastrophic events that are taking place. Because of these calamities, there is an effect on the building in one or the other way. One way of collapse of a structure is by progressive collapse. Progressive collapse is a way of collapse that happens which is not proportional to the reason of collapse.

KEYWORDS: Column Removal, Progressive collapse, Bracings.

INTRODUCTION

We have seen a lot of terrorism attacks, blasts, explosions lately and natural calamities like tsunami, earthquake etc. taking place in and around the world. There are many effects that take place on a structure. One way of effecting is by progressive collapse. Progressive collapse is defined as a process when the primary load bearing structure (column or wall) fails and consecutive members fail in the structure.

During failure, it is so observed that, when a primary member fails, the consecutive members look for an alternative path for the additional load to be carried by the structure. The members keep seeking the alternate path until the additional load encountered is balanced.

In the history of progressive collapse, the first collapse observed and studied was Ronan point apartment collapse in the year 1968. When the gas explosion took place on the 18th floor of the corner of the building. Followed by the events was the World Trade Centre (twin tower) that failed due to the terrorist attack in the year 2001. The failure was duly because of heat, that caused the steel structure to fail and the whole structure collapsed.

After the World Trade Centre event, U.S. Government laid down few guidelines noted as General Service Administration guidelines for progressive collapse. In this particular handbook, we can come across how to encounter the failure due to progressive collapse.

LITERATURE REVIEW

Raghavendra.C et al. (2014), in this paper, the authors describe about the progressive collapse analysis that is carried out on a twelve storey building. The progressive collapse is simulated by removal of columns. Several columns were removed according to U.S.General Service Administration. One column per trial is removed; analysis is carried out using ETABS software and linear static analysis method. The Demand Capacity Ratio (DCR) is calculated for each member. The summary for the behavior in each seismic zone is given as follows.

Columns when removed in zone 2

When all the columns were removed the DCR value was less than 2 and hence the adjacent columns had the capacity to resist progressive collapse. When single columns were removed and checked, the surrounding columns had DCR value greater than 1, less than 2. The column above the storey surrounding column had DCR value less than 1.

Columns when removed in zone 3

When all the columns were removed the DCR value was less than 2 and hence the adjacent columns had the capacity to resist progressive collapse. When one column was removed, the DCR value of that particular storey was less indicating that the load transfer occurred. But when the corner column was removed, the surrounding columns of that storey had DCR value greater than 1, the rest of the columns had DCR value less than 1.

Columns when removed in zone 4

When all the columns were removed the DCR value was less than 2 and hence the adjacent columns had the capacity to resist progressive collapse. When the corner column was removed, the surrounding columns had the DCR value less than 1, hence effective transfer of load occurred. When the middle column was removed, the surrounding columns in the first storey had DCR greater than 1 and for remaining columns in the structure less than 1.

Columns when removed in zone 5

When all the columns were removed the DCR value was less than 2 and hence the adjacent columns had the capacity to resist progressive collapse. Even in zone 5, the results were similar as the other zones. Load transfer mechanism was observed when all the columns were removed. The DCR value was found to be less than 1 in surrounding column when a column was removed, proving that load transfer was successful.

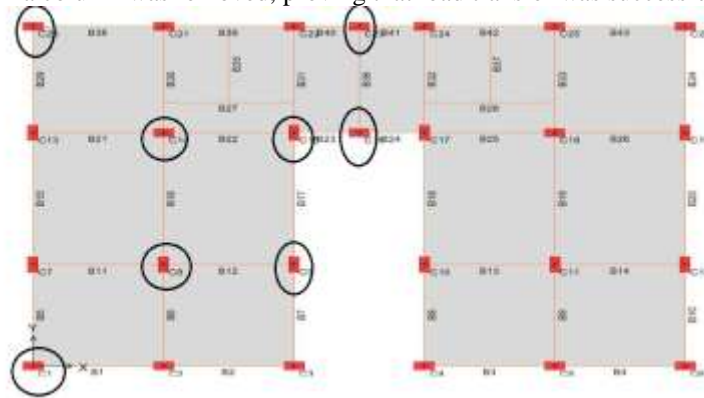


Fig 1: Position of column removal

Bhavik R Patel(2014), in this paper the author conducts progressive collapse analysis using SAP 2000 software for a G+15 storey building. The methods of analysis that are considered are linear static analysis and nonlinear dynamic analysis (time history method). The author considers earthquake loads in addition to gravity loads. The combinations of loads are followed as IS 1893-2002, part 1. Progressive analysis is done by removal of columns as shown below according to U.S.General Administration Service.

Both linear static analysis and nonlinear dynamic analysis are performed and the results are given in terms of Demand-Capacity Ratio (DCR) as follows.

DCR values calculated in flexure exceed the ratio 2 when they are subjected to column removal instantly. DCR values obtained by nonlinear dynamic analysis is higher compared to DCR values obtained by linear static analysis, because of the accuracy that is considered because of the non linearities that are considered like material non linearity and geometric non linearity. In the shorter side the progressive collapse is intended to happen when the column is removed. When the corner column is removed, the DCR values are higher when linear static analysis is used. Similar way, the DCR values are high when the central column is removed, using nonlinear dynamic analysis. So both the analysis is required to ascertain progressive collapse. As the height of the building increases the DCR value of the flexure, shear increases hence there is a higher possibility of taller building collapsing.

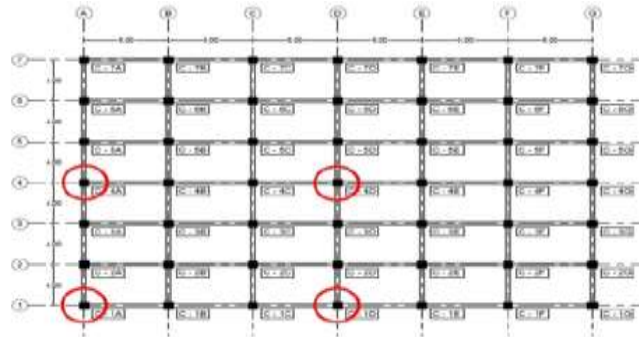


Fig 2: Position of column removal

Syed Asaad Mohiuddin Bukhari et al. (2015), in this paper the author describes about the response to the progressive collapse that acts on the structure. The author considers two different kinds of models i.e. 5 storeys and 8 storeys with 4X6 bays at a distance of 5m in both directions. The building is analyzed in two zones, zone (II) and zone (V) to know the response. The building is analyzed for static loading (dead load and live load) using linear static analysis.

Later the simulation for the progressive collapse is done by removing the column as per GSA standards. Three cases are considered, case 1: removal of the corner column, case 2: Internal column removal and case 3: middle column removal in the shorter direction. The analysis is done for the each case and the results are reviewed. Further the results are checked for DCR (Demand-Capacity Ratio) for the member at the ends and along the member. If the DCR value is less than 2, then the structure is a typical structure. If the ratio is less than 1.5 then the structure is atypical structure.

When the columns were removed for the simulation of the progressive collapse, the structure failed. When the depth of the beams were increased from the initial depth to the size of the column the collapse was prevented. If the DCR value obtained is more than 2 then the structure is bound to fail.

Briefing the results for the 5 storey building, in case 1, for zone 2, the progressive collapse for all the cases lead to failure of the structure until the beam dimension were modified to the dimensions of the column. In zone 5, the DCR value for the top 2storeys is more compared to the bottom 3 storeys, but less than 2, i.e. because of the amount and size of the reinforcement used. In case 2, for zone 2, the DCR value is in the bottom 3 storeys exceeded by 20% as there is no seismic reinforcements are provided. In zone 5, since the building is seismically designed, DCR value is less than 2. In case 3, for zone 2 and zone 5 the DCR value is less than 2, hence there is no collapse.

Similarly, briefing the results for 8 storey building, in case 1, zone 2 the progressive collapse happened until the beam properties were changed to size of the column. In case of zone 5, because of the seismic design of the building, the DCR value was less than 2 and hence the collapse was resisted. In case 2, zone 2, the collapse progressed up to 73% in X direction beams for bottom 5 storeys and for the rest 3 storeys the DCR value was well within limits. For Zone 5, the collapse was resisted as the building was seismically designed. In case 3, for zone 2 the top 3 storeys had the DCR value well within limits. For the bottom 5 storeys the shear exceeded by 33% and flexure by 142%. For zone 5 the DCR value was found to be well within limits.

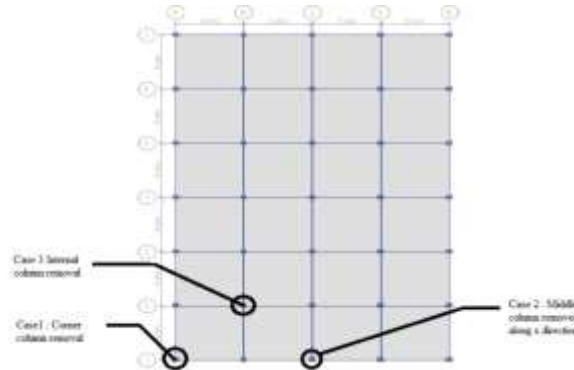


Fig 3: Position of column removal

Shilpa Shree G C et al.(2015), in this paper the author has analyzed a building that is G+19 storeys on a sloping ground and an irregular structure. As already we know that in progressive collapse the building or the element supports always look forward for alternate path to be stable. According to the author there are two phases of progressive collapse mechanism that takes place

- a) Crush down: where the initial collapse takes place and due to gravity.
- b) Successive collapse takes place due to lack of strength to take upon the additional load coming on the elements in the structure downwards.

ETABS version 9.7 is used. The conclusions of the analysis were as follows.

The result obtained evidently shows that by nonlinear static analysis are more than linear dynamic analysis that has been done, as nonlinear analysis takes up the nonlinear properties like the geometric non linearity and material non linearity. Storey drift values increases initially according to storey height upto certain height and then reduces. Bending moments obtained after the analysis show that the moments are greater in places where columns are removed, rather than other places. Pushover curves were plotted.

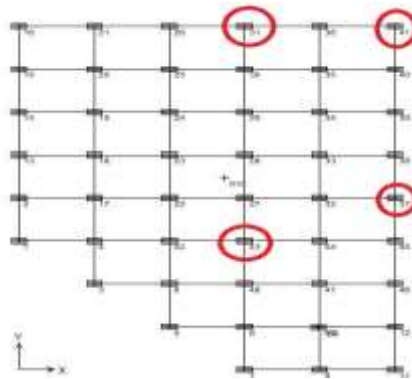


Fig 4: Position of column removal

Ram Shankar Singh et al.(2015), the authors have analyzed for symmetrical and unsymmetrical frame structure. The author has considered 5 storey concrete frames as shown in the fig 2.5. according to GSA guidelines the columns are removed as indicated in the fig 2.5. ETABS version 9.7 is used for the analysis.

From the analysis carried out, it was observed that the DCR values of the members with respect to loads, beam forces and design beam forces were less than the acceptable value, indicating that the structure is capable of withstanding the progressive collapse taking place.

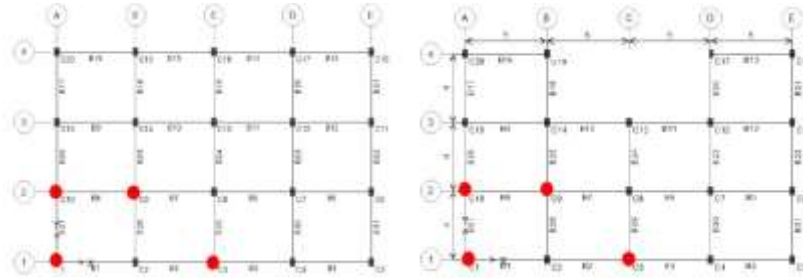


Fig 5: Position of column removal

CONCLUSION

- With the results that are obtained, it can be seen that when an interior column fails there is chances that the whole structure fails but when an exterior column fails, the other structural member can take the additional load coming on the structure.
- When the corner bracings are provided the structure was able to control the collapse due to corner column failure. When the bracings are provided in the mid-section, the structure was able to control the failure due to columns on the exterior longer and shorter direction. Collapse can be controlled when the structure is braced in all the direction.
- In linear static procedure, only the linear properties of material, geometry, stress and strain are considered according to Hooke's law and within elastic limits.
- In a structure without bracings, the failure of all consecutive members is observed and with bracings that are placed in the corners and in the midsection the failure to consecutive members is seen but due to alternate path the structural members above the consecutive members is safe as the DCR value is less than 2.

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