# INTERNATIONAL JOURNAL
# FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

www.ijraset.com

Call:  ◎08813907089    |    E-mail ID: ijraset@gmail.com

# Progressive Collapse Analysis of Irregular Reinforced Concrete Framed Structure

Gagan B M[1], Shivaraj G Nayak[2]

[1]M.Tech Student, Computer Aided Design of Structures, Department of Civil Engineering, PES College of Engineering, Mandya, Karnataka
[2]Assistant Professor, Department of Civil Engineering, PES College of Engineering, Mandya, Karnataka,

Abstract: The ability of buildings is affected by the activities of man and nature. The activities like gas burst, earthquake, bomb explosion by terrorist attack causes the failure of building. The continuous action of failure of building components causing failure of adjacent members and finally leads to failure of whole building or partial building. This action of failure is the progressive collapse. In this study, progressive collapse analysis is carried out on a Y shaped 12 storey building. Then the building is assessed using linear static analysis by removing column at different locations. The columns are removed at different locations each one at a time and analysis is carried out using Etabs 2016. Then Demand Capacity Ratio (DCR) value is evaluated. The analysis is done as per the guidelines of General Service Administration (GSA). From the analysis it can be concluded that the building is safe against progressive collapse when center column and corner column is removed.
Keywords: Progressive Collapse Analysis, DCR Value, GSA Guidelines, Linear Static Analysis, Etabs 2016

## I. INTRODUCTION

Nowadays the building are exposing to extreme conditions i.e. the impulsive force or stress. To bear this extreme load conditions, the structures are analysed for the severe condition. Then the design and detailing is done based on the analysis done on the stricture. When progressive collapse occurs the building will collapse fully or partially. This is due to the failure of any one of the building components like column, beam and slabs due to abnormal loads. In most of the cases column failure is the main reason for the progressive collapse. The column failure results in the failure of beams connecting it. The failure of beams leads to failure of surrounding or adjacent building components and finally building collapses. So that the building components should be potent such that it can take unexpected load without failure. The buildings are designed such that it can take all the loads coming on it without collapse. The components in the building should take the load and it distributes the load uniformly to the adjacent members. The building components are designed using some dynamic scale factor so that the adjacent members will not fail when any members fails. When the load carrying component like column fails the adjacent beams connecting the failed column by abnormal loads will be able to transfer the load without failing. The beams should distribute the load the load to the adjacent beams and column. This phenomenon should takes continuously to resist progressive collapse.

A. Objective
1) To understand the behaviour of irregular or asymmetrical building under progressive collapse
2) To understand the action or sequence of failure of plan irregular building.
3) To know that at which column removal, the building is more critical to progressive collapse
4) To evaluate the DCR value and stability of building against progressive collapse at different seismic zones.
5) To compare performance of irregular building at different seismic zones

## II. GENERAL SERVICE ADMINISTRATION GUIDELINES

According to guidelines of GSA, the failure occurs in the structural member at first in the building refers the local failure. This local failure leads to global failure i.e. collapse of whole structure. So it has to be ensuring to avoid failure of local failure.
GSA suggests different locations to remove 2 or more columns for analysis,

A. Column at exterior side in longer direction.
B. Column at exterior side in shorter direction.
C. Columns located in the corner.
D. Columns located at interior of the building.

*1) Linear Static Methods:* The loading is taken as per G.S.A guidelines and design is done using IS 456 i.e.

Before column removal:   [D.L. + 0.25L.L.]

And after column removal:       2*[D.L. + 0.25L.L.]

D.L.: Self weight and L.L.: Live load

Analysis will be carried out using available software like Etabs, SAP2000 etc...

In the present study, Etabs software is used to perform analysis.

*2) Demand Capacity Ratio Value:* As per GSA guidelines, based on the DCR value of the member obtained from the analysis, the structural components are considered as the safe and sound. Otherwise the structural member is said to be damaged and leads to collapse of structure. The member is safe when DCR value is within the limit.

The ratio of force acted upon the structural component to ultimate load that withstand by the structural component.

DCR = load acting on the member / load withstand by the member

$= L_{acting} / L_{capacity}$

$L_{acting}$ = Load or stress on the element. BM, SF and AL of beams and columns are considered.

$L_{capacity}$ = Load or stress withstand by the element in terms of BM, SF, AL.

As per G.S.A, the limiting acceptable value of DCR is limited to 2 for symmetrical structure and 1.5 for asymmetrical structures.

## III. METHODOLOGY

For the analysis, a 12 storied Y structure having storey height of 3m each is considered. It consists of 12 storeys with bay size as 5 meters in both the direction.

The building details are as follows,

Table. 1

| Material: | | |
|---|---|---|
| Concrete | $f_{ck}$ 30 | |
| Steel Reinforcement | Fe500 | |
| Dimensions | | |
| Slab | 150mm | |
| Wall | 300mm | |
| Beam | 300mm*500mm | |
| Column | 9 – 12 storey | 300mm*800mm |
| | 4 -8 storey | 300mm*600mm |
| | 1 – 4 storey | 300mm*450mm |
| Loads | | |
| Live Load | $3kn/m^2$ | |
| Floor load | $1.5kn/m^2$ | |
| Wall load | 13.75kn/m | |
| Parapet load | 3.7kn/m | |
| Seismic consideration | | |
| Zones factors | 0.10, 0.16, 0.24 and 0.36 | |
| Soil type | III | |
| Response Reduction factor | 3 | |
| Importance factor | 1 | |

The analysis is done using linear static method for all seismic for the following cases.

A. Shorter side middle exterior column removal at ground floor.
B. Middle interior column removal at ground floor.
C. Corner column removed at ground floor.
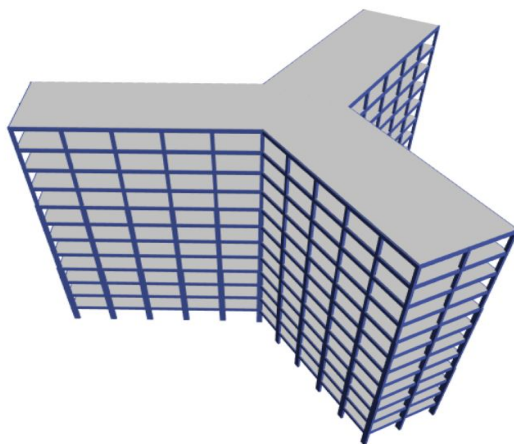D. Column removed at centre in ground floor.
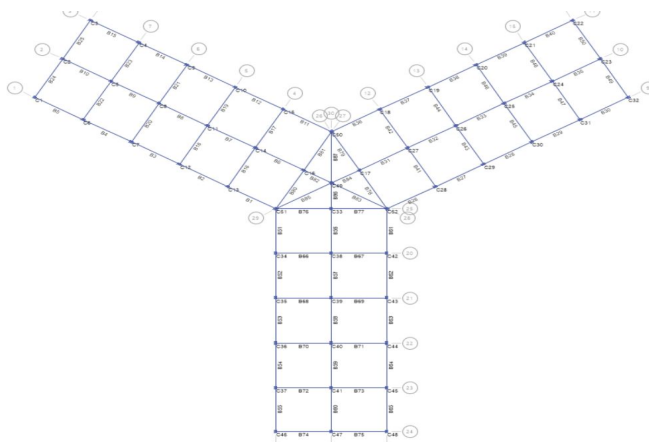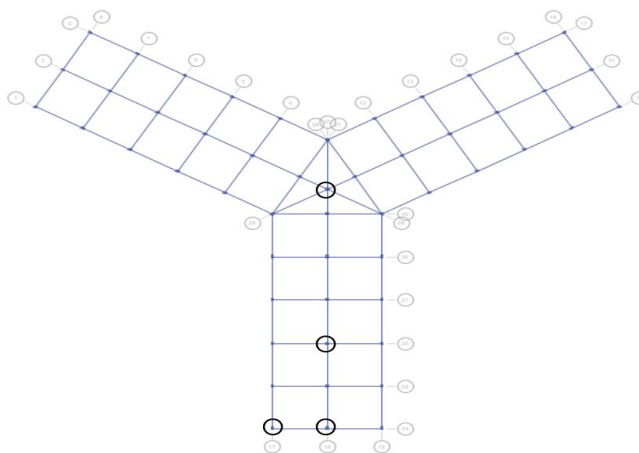


Fig. 1: 3D Model of Y Shaped Building



Fig. 2: Plan



Fig. 3: Column Removing Locations

## IV. RESULTS AND DISCUSSION

In the present study, the columns are removed at different locations and analysis is carried out for all seismic zones. Then DCR value of beam adjacent to column removed is calculated. A graph of DCR value along x axis and storeys are plotted for all cases.

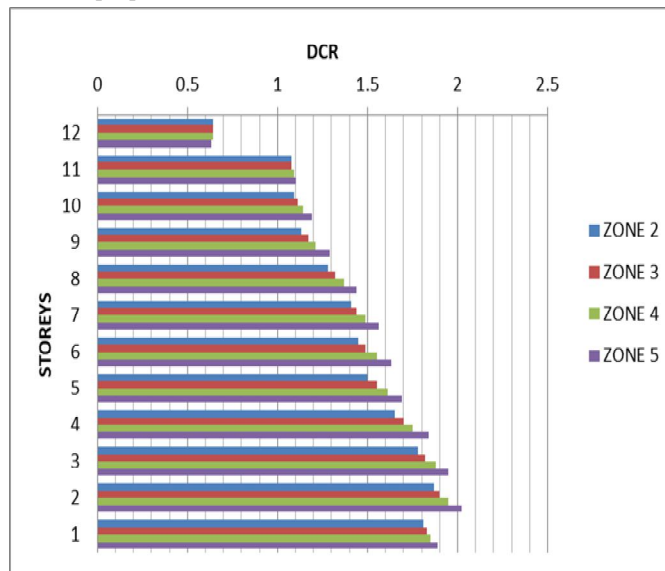*A.* Shorter Side Middle Exterior Column [47] Removal at Ground Floor.



Fig. 4: DCR vs Storeys for Middle Column Removal for all zones of beam [B75]

In this case, the DCR value of the beam upto $7^{th}$ storey will exceeds the 1.5 and the remaining storeys beams exceeds 1.5 reaching the value of 2.02. Hence progressive collapse occurs.

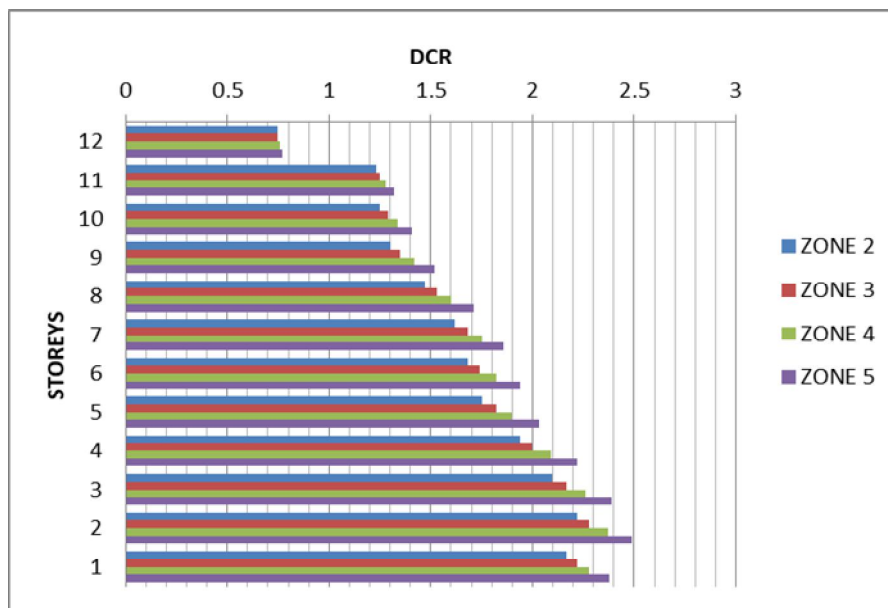*B.* Middle Interior Column [C40] Removal at Ground Floor.



Fig. 5: DCR vs Storeys for Interior Column Removal for all zones of beam [B71]

In this case, the beams upto $9^{th}$ storeys are exceeding the DCR value of 1.5 and reaching the value of 2.5. The beams of $10^{th}$, $11^{th}$ and $12^{th}$ are with in the limit. Progressive collapse occurs in this case.

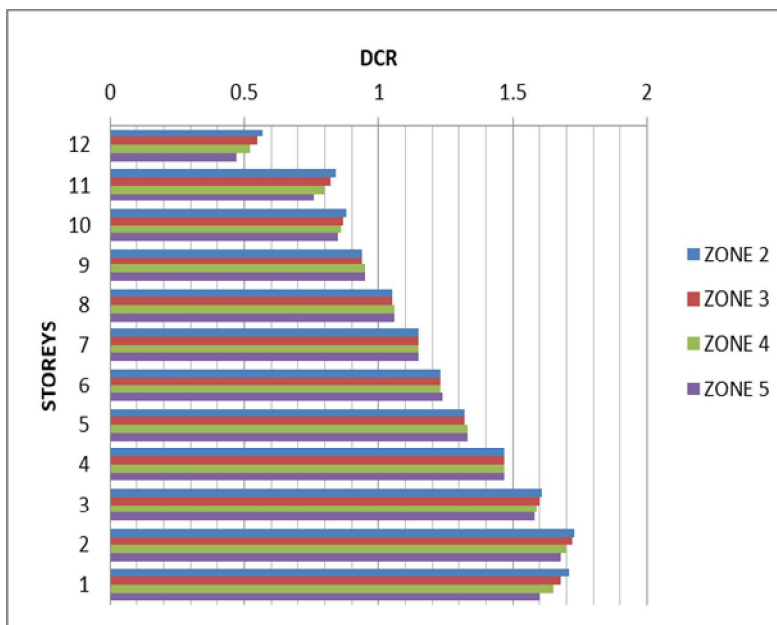*C.* Corner Column [C46] Removed at Ground Floor.



Fig. 6: DCR vs Storeys for Corner Column Removal for all zones of beam [B74]

In this case, bottom 3 storeys DCR value is by exceeding the limiting value is negligible. Hence the beams in this case are safe and no progressive collapse takes place.

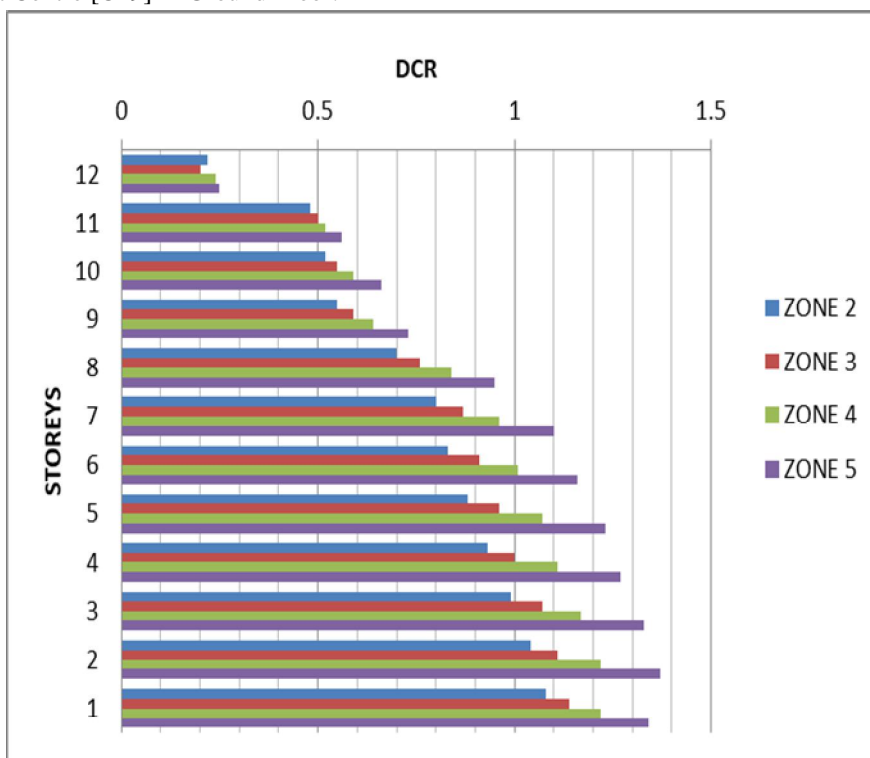*D.* Column Removed at Centre [C49] in Ground Floor.



Fig. 7: DCR vs Storeys for Middle Column Removal for all zones of beam [B86]

In this case, the DCR value of all the beams for all the cases at all seismic zones are within the limit. There is no progressive collapse occurs.

## V. CONCLUSIONS

From the analysis results, the study on the Y shaped RC building it can be conclude that,

A. The members surrounding the column removal fails by exceeding the demand capacity value of 1.5 for middle and interior column removal case for all the zones.
B. The DCR values for centre and corner column removal case are within the limit. Hence no progressive collapse occurs.
C. Zone 5 is the most critical zone for progressive collapse when compared to other seismic zones.
D. The structures should be seismically designed so that it sustains the progressive collapse when any of the columns fails.
E. From top to bottom storeys, the DCR value is varying linearly.
F. By increase in the beam dimension, it can be made safe against progressive collapse.
G. At final it can be concluded that regular buildings are safer than irregular buildings as irregular buildings are unsafe against progressive collapse.

## REFERENCES

[1] Anu Thampy, Hanna Paulose, "Assessment of Progressive Collapse Potential in Regular and Irregular RC Structures Using Linear Static Analysis", International Journal of Advance Engineering and Research Development Volume 4, Issue 6, June 2017.

[2] Balasaraswathi.K.M, Ramakrishna.G, "Progressive Collapse Analysis of Asymmetric Reinforced Concrete Building", International Journal for Trends in Engineering & Technology, ISSN: 2349 – 9303, Volume 23, Issue 1, May 2017.

[3] Ram Shankar Singh, Yusuf Jamal, Meraj A. Khan, "Progressive Collapse Analysis of Reinforced Concrete Symmetrical And Unsymmetrical Framed Structures By Etabs", International Journal of Innovative Research in Advanced Engineering (IJIRAE), ISSN: 2349-2763, Issue 12, Volume 2 December 2015.

[4] Rameezulla, Naveen Kumar, "Progressive Collapse Analysis of RC Structures", International Research Journal of Engineering and Technology (IRJET), ISSN: 2395-0056, Volume 4, issue 9, September 2017.

[5] Anju C. B, Mathew C. George, "Assessment of Progressive Collapse Resistance of a Symmetrical Reinforced Concrete Framed Structure", ISSN: 2321-9653, Volume 5 Issue V, May 2017.

[6] Mrs. Mir Sana Fatema, Prof. A.A. Hamane, "Progressive Collapse of Reinforced Concrete Building", ISSN: 2278-1684, Volume 13, Issue 6, Dec. 2016.

[7] Shefna L Sunamy, Binu P, Dr. Girija K, "Progressive Collapse Analysis of a Reinforced Concrete Frame Building", ISSN 0976 – 6316, Volume 5, Issue 12, December 2014.

[8] Raghavendra C, Mr. Pradeep A R, "Progressive Collapse Analysis of Reinforced Concrete Framed Structure", International Journal of Civil and Structural Engineering Research, ISSN 2348-7607, Vol. 2, Issue 1, 2014.

[9] Samrat Prakash Khokale, Prof. Mrs. U. R. Kawade, "Progressive Collapse of High Rise R.C.C. Structure under Accidental Load", ISSN: 2278-621X, Volume 3, Issue 4, March 2014.

[10] Bhavik R. Patel, "Progressive Collapse Analysis of RC Buildings Using Non-Linear Static and Non-Linear Dynamic Method", ISSN 2250-2459, Volume 4, Issue 9, September 2014.

# INTERNATIONAL JOURNAL
# FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089    (24*7 Support on Whatsapp)