Pogressive Collapse Analysis of Multi Storey (G+10) Building by Staad Pro. using Column Removal

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Abstract: This project presents an attempt to do progressive collapse analysis of multistory (G+10) residential building by STAAD Pro (Structural Analysis and Design Software Application). STAAD Pro is software that helps to analysis and design of low and high-rise buildings and portal frame structures. In this project G+10 RC frame building is analysis statically (linear method) along with Progressive Collapse analysis. In progressive collapse the weight of the building transfers to the neighbour columns in the structure causes to the failure of adjoining members and finally to the failure of partial or whole structure. All the members of the project are analyzed as per Indian codes IS 456:2000, IS 800:2007, and IS 1893:2002 (part1) code using this software. Here the result for is compared between the shear force, bending moment variations value of corner column, Zone1, Zone2, Zone 3 by STAAD Pro. With medium soil type and for Progressive Collapse analysis GSA guidelines are followed. As per GSA guidelines three column removal cases for each case1, case2, case3 one at a time has studied, namely Corner column removal, Exterior column removal and interior column removal all at ground floor.

Key Words: Progressive collapse analysis, GSA Guidelines, Column removal cases.

I. INTRODUCTION

Generally, we consider Self weight, dead loads, Live Loads, wind loads and Earthquake loads for Static and dynamic Analysis. However, after doing static and dynamic analysis also we not sure the structure is safe against local failure due to sudden loss of Column in the structure or abnormal loading like blast of cylinder or due to terrorist attack. So, we have move one step further and check our building against failure of Column at different location in ground floor as per General Service Administration (GSA) guidelines.

Now a day in advance countries, the building is built considering the progressive collapse. Progressive collapse results help to know the behavior of the building generally Progressive Collapse occurs when one of the major load carrying element failed due to some reason such as blast of cylinder or terrorist attack, due to failure of major load element carried by major element is distributed to adjacent elements which increases load on adjacent member more than its capacity and due to which adjacent member also get failed and transfers loads to its adjacent member. The process is continuing until all the structure gets failed.

1.1 GUIDELINES OF GSA

1.1.1 Facility security levels (FSL):

The facility security level resolve to define the norms and process for determining the FSL of a federal facility, which categorizes facilities, depend on the analysis of several security-related facility factors, including its target attractiveness, as well as its value or criticality.

1.1.2 FSL I & II:

Specified the low occupancy and risk level correlated with these types of facilities, progressive collapse design is not preferred for FSL I and II, irrespective of the number of floors.

1.1.3 FSL III &IV:

These Guidelines are relevant to FSL III and IV buildings with four stories or more sustained from the lowest point of exterior grade to the highest point of elevation. Uninhabited floors such as mechanical penthouses or parking shall not be considered a story. It shall implement both the Alternate Path and Redundancy design procedures.

1.1.4 FSL V:

These Guidelines are used for all FSL V buildings regardless of number of floors. FSL V facilities shall implement the Alternate Path method for identification of vertical load resisting element removal area. Redundancy design procedures not required for FSL V facilities.

II. LITRATURE REVIEW

• S. Mahesh et al (2014)\(^{11}\) has published a journal on “Comparison of analysis and design of regular and irregular configuration of multi-Story building in various seismic zones and various types of soils using ETABS and STAAD” to know the behavior of G+11 multi story building of regular and irregular configuration under earth quake is complex and it varies of wind loads are assumed to act simultaneously with earth quake loads. In that paper a residential of G+11 multi story building was studied for earth quake and wind load using ETABS and STAAD PRO V8i. Assuming that material property is linear static and dynamic analysis ware performed. These analyses were...
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carried out by considering different seismic zones and for each zone the behavior was assessed by taking three different types of soils namely Hard, Medium and Soft. Different response like story drift, displacements base shear was plotted for different zones and different types of soils.

- S.S. Patil et al (2013) has published a journal “Seismic Analysis of High-Rise Building by Response Spectrum Method” to analyzed high rise buildings by response spectrum method using STAADPRO with various conditions of lateral stiffness system. Analysis was done with response spectrum method. Analysis produced the effect of higher modes of vibration & actual distribution of forces in elastic range in a better way. Test results including base shear, story drift and story deflections were presented and got effective lateral load resisting system.

III. METHODOLOGY

To meets the basic requirements such as safety, durability, economy, aesthetic appearance, feasibility, practicability and acceptability following methodology is followed.

3.1. Modeling and Loading:

In STAAD PRO. First Modeling of multistory building which is to be analysis is done. In modeling material to be used to build the structure is defined. The input data used for modeling are as follows:

- Building type: G+10 Residential Building
- Plan area: 25(m)*25(m)
- Beam size: 300(mm)*300 (mm)
- Column size: 350(mm)*350 (mm)
- Slab thickness: 150mm
- Typical story height: 3m
- Bottom story height: 3m
- Live load, LL: 3kN/m² External Wall load: 10.4 KN/m
- Partition and floor finishing load, FL: 1.5kN/m²

- Soil type: Type II (Medium Soil)
- Materials: M25 and Fe415 Grade
- Soil Bearing Capacity 200 KN/m²
- Earthquake Direction: X and Y Seismic is defined
  - Zone: III -Zone factor 0.16,
- For Progressive Collapse Analysis: In Each Cases further there are 3 Cases they are:
  - i) Corner Column Removal.
  - ii) Exterior Column Removal.
  - iii) Interior Column Removal.
- First a Response Spectrum function is defined for above 4 different Zones with Function Damping Ratio as 0.05.

Fig 1.1 G+10 modeling using STAAD PRO.

IV. RESULT AND DISCUSSIONS

The result obtained for the Shear force, bending moment, for different column removal cases are shown in respective Table and Graph and with discussions.

4.1. CORNER COLUMN

SHEAR FORCE VARIATIONS:

From the above graphical representation, it was observed that the axial load $F_y$ was increased to maximum by 38.27%, 2.73% and 38.27% in zone-1, zone-2 and zone-3 columns respectively when compared with the base segment was removed.

Due to removal of ground floor column mostly effected zones are zone1 and zone3.
From the above graphical representation, it was observed that the axial load $F_y$ was increased to maximum by 48.37%, 13.26% and 48.37% in zone-1, zone-2 and zone-3 columns respectively when compared with the 1st segment was removed.

Due to removal of 1st floor column mostly effected zones are zone1 and zone3.

From the above graphical representation, it was observed that the axial load $F_y$ was increased to maximum by 60.34%, 25.94% and 60.34% in zone-1, zone-2 and zone-3 columns respectively when compared with the 2nd segment was removed.

Due to removal of 2nd floor column mostly effected zones are zone1 and zone3.

From the above graphical representation, it was observed that the axial load $F_y$ was increased to maximum by 75.15%, 41.64% and 75.15% in zone-1, zone-2 and zone-3 columns respectively when compared with the 3rd segment was removed.

Due to removal of 3rd floor column mostly effected zones are zone1 and zone3.

From the above graphical representation, it was observed that the axial load $F_y$ was increased to maximum by 94.19%, 61.72% and 94.19% in zone-1, zone-2 and zone-3 columns respectively when compared with the 4th segment was removed.

Due to removal of 4th floor column mostly effected zones are zone1 and zone3.

From the above graphical representation, it was observed that the axial load $F_y$ was increased to maximum by 7.46%, 9.14% and 7.42% in zone-1, zone-2 and zone-3 columns respectively when compared with the 5th segment was removed.

Due to removal of 5th floor column mostly effected zones are zone2.

From the above graphical representation, it was observed that the axial load $F_y$ was increased to maximum by 7.72%, 9.16% and 7.72% in zone-1, zone-2 and zone-3 columns respectively when compared with the 6th segment was removed.

Due to removal of 6th floor column mostly effected zones are zone2.

From the above graphical representation, it was observed that the axial load $F_y$ was increased to maximum by 8.02%, 9.19% and 8.02% in zone-1, zone-2 and zone-3 columns respectively when compared with the 7th segment was removed.

Due to removal of 7th floor column mostly effected zones are zone2.
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From the above graphical representation, it was observed that the axial load $F_y$ was increased to maximum by 8.30%, 9.21% and 8.30% in zone-1, zone-2 and zone-3 columns respectively when compared with the 8th segment was removed.

Due to removal of 8th floor column mostly effected zones are zone2.

From the above graphical representation, it was observed that the axial load $F_y$ was increased to maximum by 481.56%, 9.14% and 481.5% in zone-1, zone-2 and zone-3 columns respectively when compared with the 9th segment was removed.

Due to removal of 9th floor column mostly effected zones are zone1 and zone3.

From the above graphical representation, it was observed that the axial load $F_y$ was increased to maximum by 1026.35%, 990.34% and 1026.35% in zone-1, zone-2 and zone-3 columns respectively when compared with the 10th segment was removed.

Due to removal of 10th floor column mostly effected zones are zone1 and zone3.

BENDING MOMENT VARIATIONS:

From the above graphical representation, it was observed that the bending moment $M_y$ was increased to maximum by 46.36%, 1.97% and 0% in zone-1, zone-2 and zone-3 columns respectively when compared with the base segment was removed.

Due to removal of base floor column mostly effected zones are zone1.

From the above graphical representation, it was observed that the bending moment $M_y$ was increased to maximum by 27.42%, 24.20% and 186.37% in zone-1, zone-2 and zone-3 columns respectively when compared with the 1st segment was removed.

Due to removal of 1st floor column mostly effected zones are zone3.

From the above graphical representation, it was observed that the bending moment $M_y$ was increased to maximum by 46.02%, 36.53% and 265.72% in zone-1, zone-2 and zone-3 columns respectively when compared with the 2nd segment was removed.

Due to removal of 2nd floor column mostly effected zones are zone3.

From the above graphical representation, it was observed that the bending moment $M_y$ was increased to maximum by 43.64%, 39.29% and 300% in zone-1, zone-2 and zone-3 columns respectively when compared with the 3rd segment was removed.

Due to removal of 3rd floor column mostly effected zones are zone3.
From the above graphical representation, it was observed that the bending moment $M_y$ was increased to maximum by 44.86%, 43.12% and 30.68% in zone-1, zone-2 and zone-3 columns respectively when compared with the 4th segment was removed.

Due to removal of 4th floor column mostly effected zones are zone3.

From the above graphical representation, it was observed that the bending moment $M_y$ was increased to maximum by 51.49%, 49.04% and 334.49% in zone-1, zone-2 and zone-3 columns respectively when compared with the 5th segment was removed.

Due to removal of 5th floor column mostly effected zones are zone3.

From the above graphical representation, it was observed that the bending moment $M_y$ was increased to maximum by 55.11%, 58.77% and 400% in zone-1, zone-2 and zone-3 columns respectively when compared with the 6th segment was removed.

Due to removal of 6th floor column mostly effected zones are zone3.

From the above graphical representation, it was observed that the bending moment $M_y$ was increased to maximum by 81.93%, 75.87% and 495.24% in zone-1, zone-2 and zone-3 columns respectively when compared with the 7th segment was removed.

Due to removal of 7th floor column mostly effected zones are zone3.

From the above graphical representation, it was observed that the bending moment $M_y$ was increased to maximum by 55.11%, 58.77% and 400% in zone-1, zone-2 and zone-3 columns respectively when compared with the 8th segment was removed.

Due to removal of 8th floor column mostly effected zones are zone3.

From the above graphical representation, it was observed that the bending moment $M_y$ was increased to maximum by 55.11%, 58.77% and 400% in zone-1, zone-2 and zone-3 columns respectively when compared with the 9th segment was removed.

Due to removal of 9th floor column mostly effected zones are zone3.

From the above graphical representation, it was observed that the bending moment $M_y$ was increased to maximum by 55.11%, 58.77% and 400% in zone-1, zone-2 and zone-3 columns respectively when compared with the 10th segment was removed.

Due to removal of 10th floor column mostly effected zones are zone1.

4.2. EXTERIOR COLUMN SHEAR FORCE VARIATIONS:-

From the above graphical representation, it was observed that the bending moment $M_y$ was increased to maximum by 371.88%, 325% and 254.29% in zone-1, zone-2 and zone-3 columns respectively when compared with the 7th segment was removed.

Due to removal of 7th floor column mostly effected zones are zone3.
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From the above graphical representation, it was observed that the axial load $F_y$ was increased to maximum by 35.31%, 2.42%, 23.24%, 2.43% and 34.74% in zone-1, zone-2, zone-3, zone-4 and zone-5 columns respectively when compared with the base segment was removed.

Due to removal of base floor column mostly effected zones are zone 1.

From the above graphical representation, it was observed that the axial load $F_y$ was increased to maximum by 30.38%, 12.76%, 33.12%, 12.92% and 44.39% in zone-1, zone-2, zone-3, zone-4 and zone-5 columns respectively when compared with the 1st segment was removed.

Due to removal of 1st floor column mostly affected zones are zone 5.

From the above graphical representation, it was observed that the axial load $F_y$ was increased to maximum by 55.12%, 25.26%, 44.82%, 25.54% and 55.95% in zone-1, zone-2, zone-3, zone-4 and zone-5 columns respectively when compared with the 2nd segment was removed.

Due to removal of 2nd floor column mostly effected zones are zone 5.

From the above graphical representation, it was observed that the axial load $F_y$ was increased to maximum by 69.36%, 40.82%, 37.35%, 41.16% and 70.39% in zone-1, zone-2, zone-3, zone-4 and zone-5 columns respectively when compared with the 3rd segment was removed.

Due to removal of 3rd floor column mostly effected zones are zone 5.

From the above graphical representation, it was observed that the axial load $F_y$ was increased to maximum by 87.89%, 60.64%, 78.59%, 61.20% and 89.09% in zone-1, zone-2, zone-3, zone-4 and zone-5 columns respectively when compared with the 4th segment was removed.

Due to removal of 4th floor column mostly effected zones are zone 5.

From the above graphical representation, it was observed that the axial load $F_y$ was increased to maximum by 112.86%, 87.01%, 104.12%, 87.73% and 114.23% in zone-1, zone-2, zone-3, zone-4 and zone-5 columns respectively when compared with the 5th segment was removed.

Due to removal of 5th floor column mostly effected zones are zone 5.

From the above graphical representation, it was observed that the axial load $F_y$ was increased to maximum by 148.03%, 123.82%, 140.01%, 124.78% and 149.74% in zone-1, zone-2, zone-3, zone-4 and zone-5 columns respectively when compared with the 6th segment was removed.

Due to removal of 6th floor column mostly effected zones are zone 5.

From the above graphical representation, it was observed that the axial load $F_y$ was increased to maximum by 201.56%, 179.97%, 194.24%, 180.03% and 203.45% in zone-1, zone-2, zone-3, zone-4 and zone-5 columns respectively when compared with the 7th segment was removed.

Due to removal of 7th floor column mostly effected zones are zone 5.
From the above graphical representation, it was observed that the axial load \( F_y \) was increased to maximum by 292.53%, 269.25%, 284.80%, 272.03% and 293.81% in zone-1, zone-2, zone-3, zone-4 and zone-5 columns respectively when compared with the 8th segment was removed.

Due to removal of 8th floor column mostly affected zones are zone 5.

From the above graphical representation, it was observed that the axial load \( F_y \) was increased to maximum by 472.79%, 452.97%, 465.88%, 455.03% and 475.72% in zone-1, zone-2, zone-3, zone-4 and zone-5 columns respectively when compared with the 9th segment was removed.

Due to removal of 9th floor column mostly affected zones are zone 5.

From the above graphical representation, it was observed that the axial load \( F_y \) was increased to maximum by 1026.20%, 995.06%, 988.24%, 990.81% and 1024.06% in zone-1, zone-2, zone-3, zone-4 and zone-5 columns respectively when compared with the 10th segment was removed.

Due to removal of 10th floor column mostly affected zones are zone 1.

**BENDING MOMENT VARIATIONS:**

From the above graphical representation, it was observed that the bending moment \( M_y \) was increased to maximum by 16.56%, 0.66%, 1.98%, 1.97% and 40.14% in zone-1, zone-2, zone-3, zone-4 and zone-5 columns respectively when compared with the base segment was removed.

Due to removal of base floor column mostly affected zones are zone 5.

From the above graphical representation, it was observed that the bending moment \( M_y \) was increased to maximum by 20.67%, 24.40%, 26.23%, 25.21% and 5.70% in zone-1, zone-2, zone-3, zone-4 and zone-5 columns respectively when compared with the 1st segment was removed.

Due to removal of 1st floor column mostly affected zones are zone 3.

From the above graphical representation, it was observed that the bending moment \( M_y \) was increased to maximum by 20.67%, 24.40%, 26.23%, 25.21% and 5.70% in zone-1, zone-2, zone-3, zone-4 and zone-5 columns respectively when compared with the 2nd segment was removed.

Due to removal of 2nd floor column mostly affected zones are zone 3.

From the above graphical representation, it was observed that the bending moment \( M_y \) was increased to maximum by 33.93%, 33.63%, 34.52%, 33.05% and 29.83% in zone-1, zone-2, zone-3, zone-4 and zone-5 columns respectively when compared with the 3rd segment was removed.

Due to removal of 3rd floor column mostly affected zones are zone 3.
From the above graphical representation, it was observed that the bending moment $M_y$ was increased to maximum by 38.54%, 36.04%, 36.94%, 35.40% and 33.93% in zone-1, zone-2, zone-3, zone-4 and zone-5 columns respectively when compared with the 4th segment was removed.

Due to removal of 4th floor column mostly effected zones are zone 1.

From the above graphical representation, it was observed that the bending moment $M_y$ was increased to maximum by 43.81%, 41.13%, 42.06%, 41.67% and 39.89% in zone-1, zone-2, zone-3, zone-4 and zone-5 columns respectively when compared with the 5th segment was removed.

Due to removal of 5th floor column mostly effected zones are zone 1.

From the above graphical representation, it was observed that the bending moment $M_y$ was increased to maximum by 54.09%, 52%, 52%, 50% and 49.51% in zone-1, zone-2, zone-3, zone-4 and zone-5 columns respectively when compared with the 6th segment was removed.

Due to removal of 6th floor column mostly effected zones are zone 1.

From the above graphical representation, it was observed that the bending moment $M_y$ was increased to maximum by 71.60%, 67.04%, 65.94%, 64.52% and 64.14% in zone-1, zone-2, zone-3, zone-4 and zone-5 columns respectively when compared with the 7th segment was removed.

Due to removal of 7th floor column mostly effected zones are zone 1.

From the above graphical representation, it was observed that the bending moment $M_y$ was increased to maximum by 96.16%, 94.88%, 94.88%, 93.68% and 93.59% in zone-1, zone-2, zone-3, zone-4 and zone-5 columns respectively when compared with the 8th segment was removed.

Due to removal of 8th floor column mostly effected zones are zone 1.

From the above graphical representation, it was observed that the bending moment $M_y$ was increased to maximum by 160.35%, 149.19%, 147.55%, 139.07% and 143.55% in zone-1, zone-2, zone-3, zone-4 and zone-5 columns respectively when compared with the 9th segment was removed.

Due to removal of 9th floor column mostly effected zones are zone 1.

From the above graphical representation, it was observed that the axial load $F_y$ was increased to maximum by 23.02%, 2.34%, 2.34%, 2.33%, 22.92%, 2.32%, 22.92% and 2.33% in zone-1, zone-2, zone-3, zone-4, zone-5, zone-6, zone-7 and zone-8 columns respectively when compared with the base segment was removed.

4.3. INTERIOR COLUMN

SHEAR FORCE VARIATIONS:-

From the above graphical representation, it was observed that the axial load $F_y$ was increased to maximum by 23.02%, 2.34%, 2.34%, 2.33%, 22.92%, 2.32%, 22.92% and 2.33% in zone-1, zone-2, zone-3, zone-4, zone-5, zone-6, zone-7 and zone-8 columns respectively when compared with the base segment was removed.
Due to removal of base floor column mostly effected zones are zone 1.

From the above graphical representation, it was observed that the axial load \( F_y \) was increased to maximum by 32.66%, 12.80%, 32.66%, 12.51%, 32.36% and 12.67% in zone-1, zone-2, zone-3, zone-4, zone-5, zone-6, zone-7 and zone-8 columns respectively when compared with the 1st segment was removed.

Due to removal of 1st floor column mostly effected zones are zone 1.

From the above graphical representation, it was observed that the axial load \( F_y \) was increased to maximum by 44.01%, 25.41%, 44.01%, 25.13%, 43.63% and 24.92% in zone-1, zone-2, zone-3, zone-4, zone-5, zone-6, zone-7 and zone-8 columns respectively when compared with the 2nd segment was removed.

Due to removal of 2nd floor column mostly effected zones are zone 1 and zone 3.

From the above graphical representation, it was observed that the axial load \( F_y \) was increased to maximum by 58.95%, 41.04%, 58.98%, 40.67%, 58.41% and 40.75% in zone-1, zone-2, zone-3, zone-4, zone-5, zone-6, zone-7 and zone-8 columns respectively when compared with the 3rd segment was removed.

Due to removal of 3rd floor column mostly effected zones are zone 1.

From the above graphical representation, it was observed that the axial load \( F_y \) was increased to maximum by 77.85%, 61.03%, 77.85%, 60.51%, 77.17% and 59.98% in zone-1, zone-2, zone-3, zone-4, zone-5, zone-6, zone-7 and zone-8 columns respectively when compared with the 4th segment was removed.

Due to removal of 4th floor column mostly effected zones are zone 1 and zone 3.

From the above graphical representation, it was observed that the axial load \( F_y \) was increased to maximum by 104.28%, 87.57%, 104.28%, 86.86%, 102.48% and 86.19% in zone-1, zone-2, zone-3, zone-4, zone-5, zone-6, zone-7 and zone-8 columns respectively when compared with the 5th segment was removed.

Due to removal of 5th floor column mostly effected zones are zone 1 and zone 3.

From the above graphical representation, it was observed that the axial load \( F_y \) was increased to maximum by 139.12%, 124.58%, 139.12%, 123.63%, 138.09% and 122.79% in zone-1, zone-2, zone-3, zone-4, zone-5, zone-6, zone-7 and zone-8 columns respectively when compared with the 6th segment was removed.

Due to removal of 6th floor column mostly effected zones are zone 1 and zone 3.
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From the above graphical representation, it was observed that the axial load $F_y$ was increased to maximum by 193.35%, 179.85%, 193.35%, 178.79%, 192.12%, 192.12%, 192.12% and 178.79% in zone-1, zone-2, zone-3, zone-4, zone-5, zone-6, zone-7 and zone-8 columns respectively when compared with the 7th segment was removed.

Due to removal of 7th floor column mostly effected zones are zone 1 and zone 3.

From the above graphical representation, it was observed that the axial load $F_y$ was increased to maximum by 284.09%, 271.87%, 284.09%, 270.47%, 282.51%, 270.47%, 282.51% and 270.47% in zone-1, zone-2, zone-3, zone-4, zone-5, zone-6, zone-7 and zone-8 columns respectively when compared with the 8th segment was removed.

Due to removal of 8th floor column mostly effected zones are zone 1 and zone 3.

From the above graphical representation, it was observed that the axial load $F_y$ was increased to maximum by 465.41%, 454.91%, 465.41%, 452.85%, 464.59%, 452%, 464.59% and 452.85% in zone-1, zone-2, zone-3, zone-4, zone-5, zone-6, zone-7 and zone-8 columns respectively when compared with the 9th segment was removed.

Due to removal of 9th floor column mostly effected zones are zone 1.

From the above graphical representation, it was observed that the axial load $F_y$ was increased to maximum by 1006.83%, 991.28%, 1006.83%, 995.06%, 1010.33%, 998.60%, 1010.33% and 995.06% in zone-1, zone-2, zone-3, zone-4, zone-5, zone-6, zone-7 and zone-8 columns respectively when compared with the 10th segment was removed.

Due to removal of 10th floor column mostly effected zones are zone 5 and zone 7.

BENDING MOMENT VARIATIONS:

From the above graphical representation, it was observed that the bending moment $M_y$ was increased to maximum by 13.08%, 0.66%, 1.98%, 2.64%, 34.65%, 2.62%, 1.97% and 1.31% in zone-1, zone-2, zone-3, zone-4, zone-5, zone-6, zone-7 and zone-8 columns respectively when compared with the base segment was removed.

Due to removal of base floor column mostly effected zones are zone 1.

From the above graphical representation, it was observed that the bending moment $M_y$ was increased to maximum by 16.67%, 23.21%, 25.22%, 26.23%, 8.14%, 25.21%, 26.02% and 22.23% in zone-1, zone-2, zone-3, zone-4, zone-5, zone-6, zone-7 and zone-8 columns respectively when compared with the 1st segment was removed.

Due to removal of 1st floor column mostly effected zones are zone 7.

Retrieval Number: B11301292S319/2019©BEIESP
DOI: 10.35940/ijitee.B1130.1292S319

Published By:
Blue Eyes Intelligence Engineering & Sciences Publication

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From the above graphical representation, it was observed that the bending moment \( M_y \) was increased to maximum by 3.46%, 32.18%, 32.18%, 33.05%, 29.57%, 33.92%, 33.05% and 31.9% in zone-1, zone-2, zone-3, zone-4, zone-5, zone-6, zone-7 and zone-8 columns respectively when compared with the 2nd segment was removed.

Due to removal of 2nd floor column mostly effected zones are zone6.

From the above graphical representation, it was observed that the bending moment \( M_y \) was increased to maximum by 35.4%, 35.72%, 34.52%, 34.52%, 32.46%, 34.22%, 34.22% and 35.4% in zone-1, zone-2, zone-3, zone-4, zone-5, zone-6, zone-7 and zone-8 columns respectively when compared with the 3rd segment was removed.

Due to removal of 3rd floor column mostly effected zones are zone2.

From the above graphical representation, it was observed that the bending moment \( M_y \) was increased to maximum by 40%, 39.45%, 36.94%, 36.94%, 35.75%, 36.60%, 36.60% and 39.1% in zone-1, zone-2, zone-3, zone-4, zone-5, zone-6, zone-7 and zone-8 columns respectively when compared with the 4th segment was removed.

Due to removal of 4th floor column mostly effected zones are zone1.

From the above graphical representation, it was observed that the bending moment \( M_y \) was increased to maximum by 102.63%, 105.22%, 94.88%, 94.88%, 93.68%, 93.68%, 91.26%, and 101.32% in zone-1, zone-2, zone-3, zone-4, zone-5, zone-6, zone-7 and zone-8 columns respectively when compared with the 8th segment was removed.

Due to removal of 8th floor column mostly effected zones are zone2.
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From the above graphical representation, it was observed that the bending moment $M_y$ was increased to maximum by 175%, 186.54%, 149.18%, 146.78%, 146.78%, 146.76% and 173.22% in zone-1, zone-2, zone-3, zone-4, zone-5, zone-6, zone-7 and zone-8 columns respectively when compared with the 9th segment was removed.

Due to removal of 9th floor column mostly effected zones are zone2.

From the above graphical representation, it was observed that the bending moment $M_y$ was increased to maximum by 264.29%, 313.52%, 322.23%, 265.29%, 270.73%, 273.17%, 264.29% and 97.23% in zone-1, zone-2, zone-3, zone-4, zone-5, zone-6, zone-7 and zone-8 columns respectively when compared with the 10th segment was removed.

Due to removal of 10th floor column mostly effected zones are zone3.

V. CONCLUSION

After doing progressive Analysis following conclusion were made:

- It was observed that there is continuous decrease in the value from bottom Story to top Story, which concludes that the failure is more at bottom Story than top Story.
- It was also found that by removing of corner columns individually, the values are decreasing according to the bottom to top story that concludes for Corner Column Removal Case, beam in the base ,1st, 2nd, 3rd, 4th, 5th, 6th story face progressive collapse but from 7th to 10th Story is safe against Progressive Collapse.
- It was also observed that during removal of Exterior Column Removal case, beams in 1st and 5th story of building more affected by progressive collapse rather than the top stories.
- It was also observed that in Case of Interior Column Removal Case, beam in 3rd, 4th, 5th, 8th, 9th and 10th Story were safe against Progressive Collapse.
- The Special Moment Resistance Frame (SMRF) by IS 456:2000 does not provide resistance to progressive Collapse. This is because of that SMRF is designed for Lateral loads and in Progressive Collapse the Failure is due to gravity Loads.

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