Journal of Civil Engineering and Environmental Technology
p-ISSN: 2349-8404; e-ISSN: 2349-879X; Volume 3, Issue 3; January-March, 2016, pp. 257-261

http://www.krishisanskriti.org/Publication.html

A Study on Progressive Collapse of 15 Storey Building

Patel B N.[1], Patel D Y.[2] and Thomas[3]

[1,2,3]Dept. of Civil Engineering, CSPIT, CHARUSAT, Anand, Gujarat, India
E-mail: [1]bhavyapatel1709@gmail.com, [2]dipalipatel.cv@charusat.ac.in

Abstract—*This paper includes the study of behavior of building undergone a column loss. An attempt has been made to find the alternate load path for "Progressive Collapse" – outlined as the "whole or partial failure of the structure triggered by damage of a relatively small part of it". Progressive collapse takes place when any structure undergoes a loss of major vertical load carrying element due to any natural or man-made hazards resulting in increase in stresses in rest of the structural elements leading to partial or total collapse of the structure. In this paper, an attempt has been made to study the behavior of a 15 storey building undergone a column loss. General Service Administration (GSA) guidelines were used for removing the columns. Analysis is carried out in a commercial software ETABS. Various parameters are compared for before and after column removal cases.*

1. INTRODUCTION

Progressive collapse is defined as "the spread of associate initial local failure from component to component, eventually leading to the collapse of a whole structure or a disproportionately massive a part of it". Major causes of failures of structures include man-made and natural hazards such as earthquake, hurricane, explosion, etc. Such events imposes abnormal loading on structure which may cause the failure of any major structural element. On failure of a single element a chain reaction is started causing failure of other components in domino effect. When one or more vertical load carrying member fails, load transfers to neighboring elements. Rest of the elements keeps on seeking alternate load path for load redistribution. This causes further failure of other elements leading to global failure.

This paper includes a case of column removal using the GSA guidelines. A symmetric building is considered which is analyzed before and after column removal and various parameters are compared to study the alternate load path for load redistribution.

2. MODEL DEVELOPMENT

A 15 storey building is analyzed in ETABS for this study. Plan dimension is 25m*25m. Various details of model are given in table below.

Table 1: Building Data

No. of bays in X-direction	5
No. of bays in Y-direction	5
Bay length in X-direction	5m
Bay length in Y-direction	5m
Height of storey	3m
Column size Plinth-4th storey 5th-9th storey 10th-terrace	 900mm*900mm 600mm*600mm 450mm*450mm
Beam size	230mm*450mm
Slab thickness	150mm
Damping	5 percent

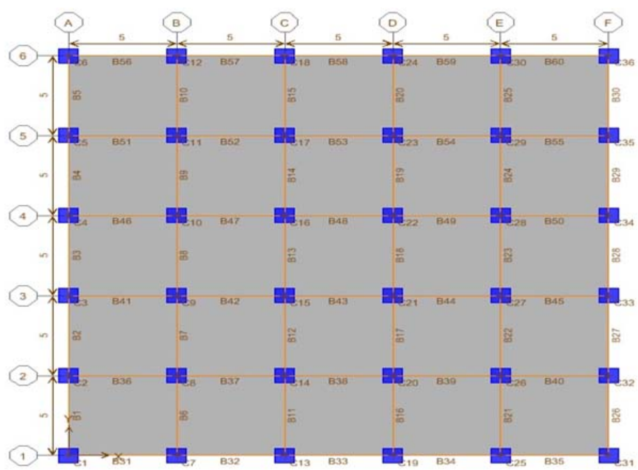

Fig. 1: Plan view of a model

3. LOADS CONSIDERED

1) Dead Load
Self weight of building elements

Floor finish = 1kN/m^2 on typical floors

2) Live Load
On typical floors = 2.5kN/m^2

On roof = 1.5kN/m^2

3) Seismic Load (as per IS 1893:2000)
   Zone V, Response Reduction Factor = 5, Importance Factor = 1

4. MODEL ANALYSIS

Models were developed in ETABS software. First the regular building model without any column removal was analyzed for above mentioned loads and various results for the same model were obtained from ETABS. Secondly an internal corner column C8 from the same model was removed following the GSA guidelines. Similar to first model, various results of model were obtained from ETABS. Results of both the models were compared with each other and an attempt was made to study the behavior of a structure underwent an internal corner column loss.

5. RESULTS AND DISCUSSIONS

Comparative graphs of various parameters such as deflection, bending moment, and axial force of adjacent structural elements are shown below.

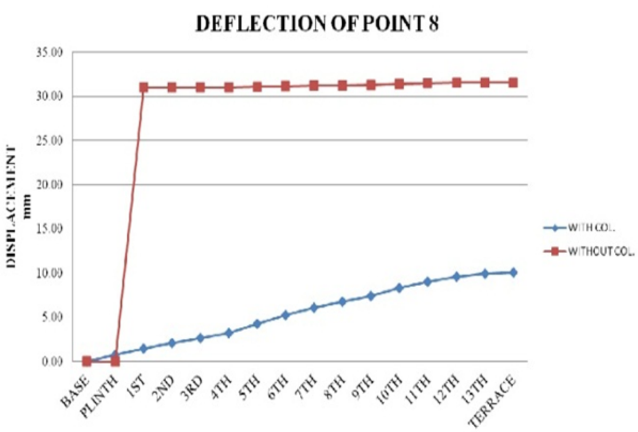

Fig. 2: Deflection Comparison of Point 8

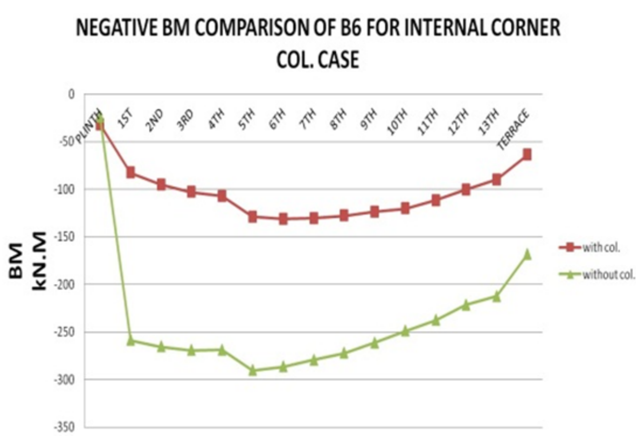

Fig. 3: Negative Bending Moment Comparison of Adjacent Beam B6

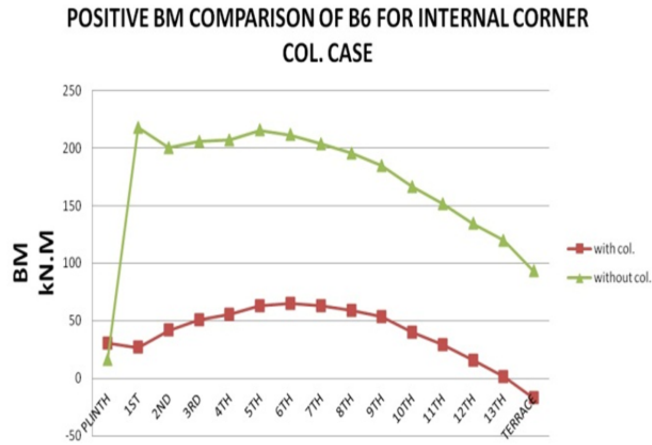

Fig. 4: Positive Bending Moment Comparison of Adjacent Beam B6

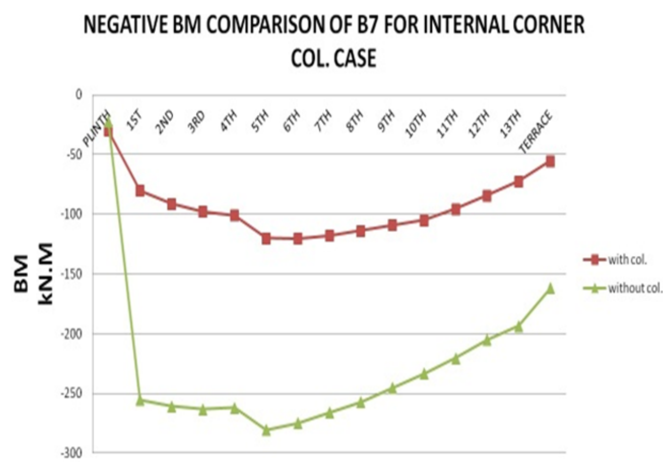

Fig. 5 Negative Bending Moment Comparison of Adjacent Beam B7

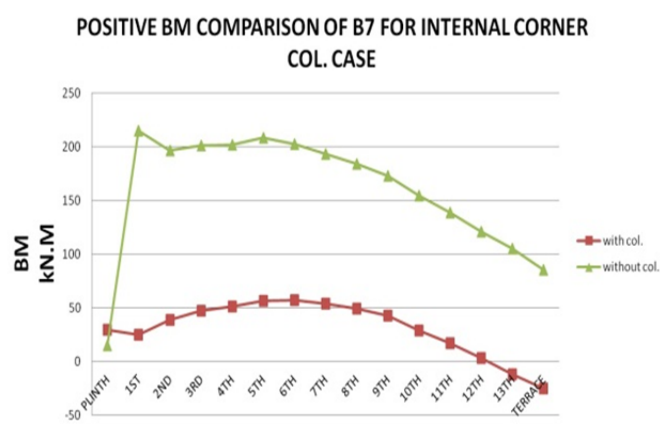

Fig. 6: Positive Bending Moment Comparison of Adjacent Beam B7

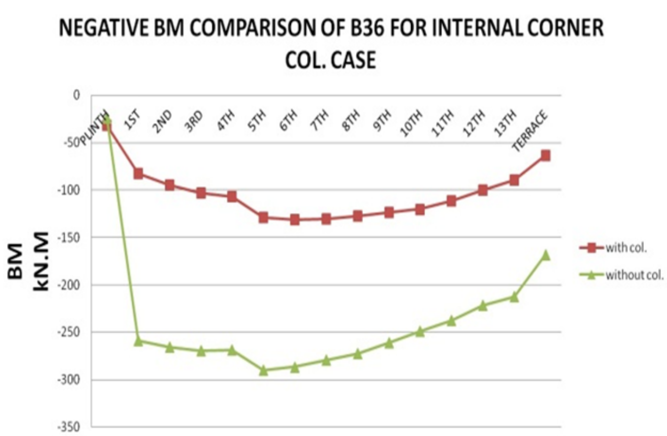

Fig. 7 Negative Bending Moment Comparison of Adjacent Beam B36

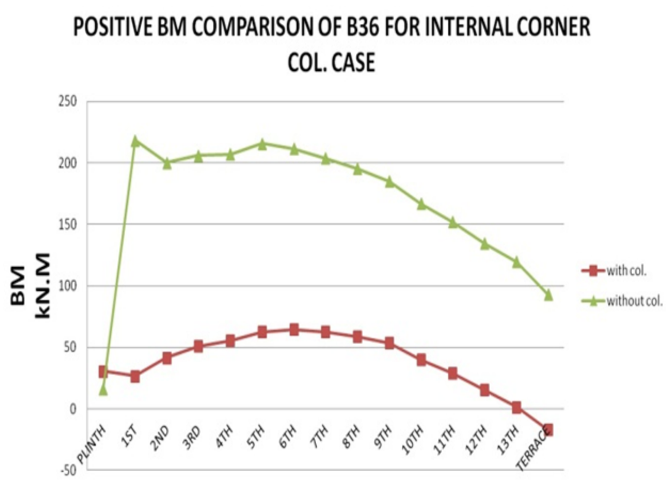

Fig. 8 Positive Bending Moment Comparison of Adjacent Beam B36

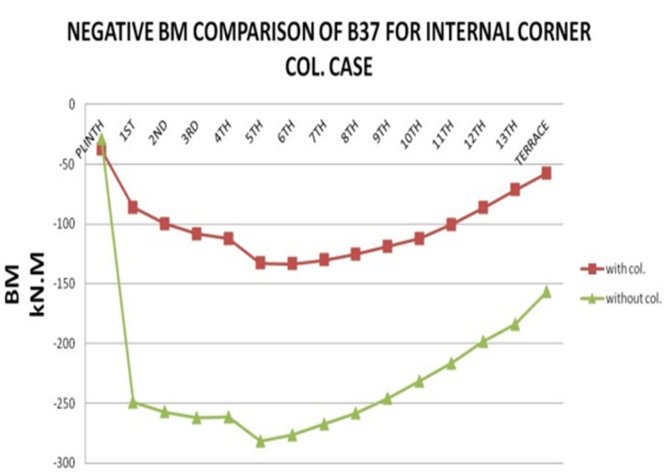

Fig. 9 Negative Bending Moment Comparison of Adjacent Beam B37

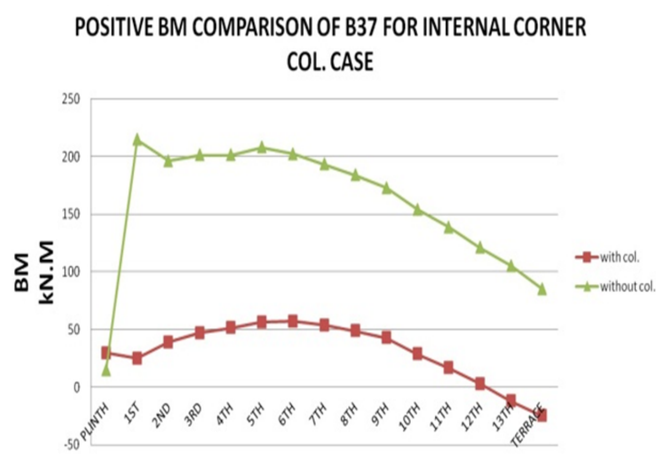

Fig. 10: Positive Bending Moment Comparison of Adjacent Beam B37

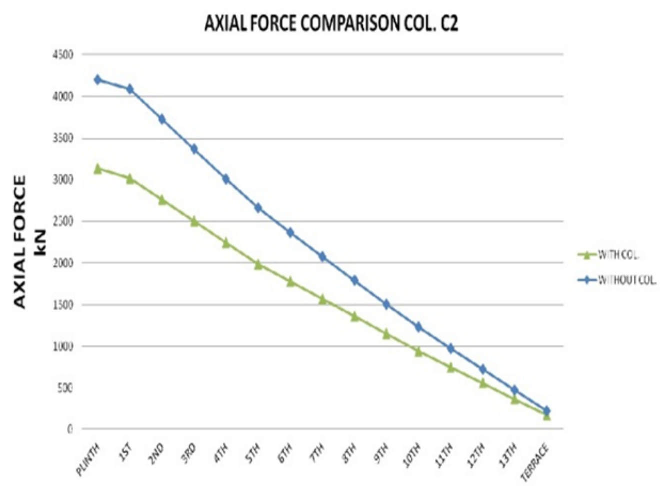

Fig. 11 Axial Force Comparison of Adjacent Column C2 & C7

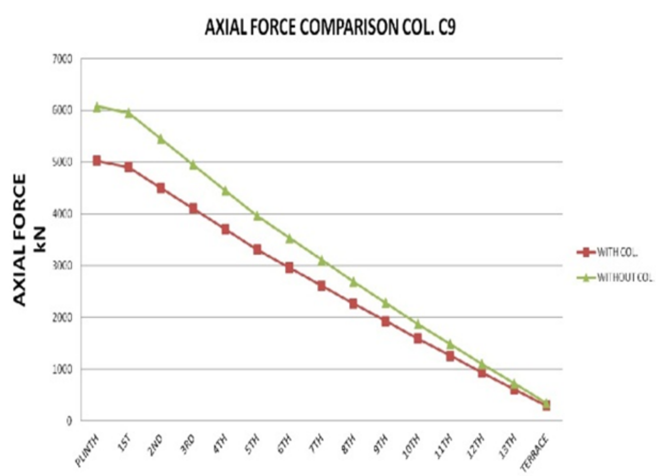

Fig. 12 Axial Force Comparison of Adjacent Column C9 & C14

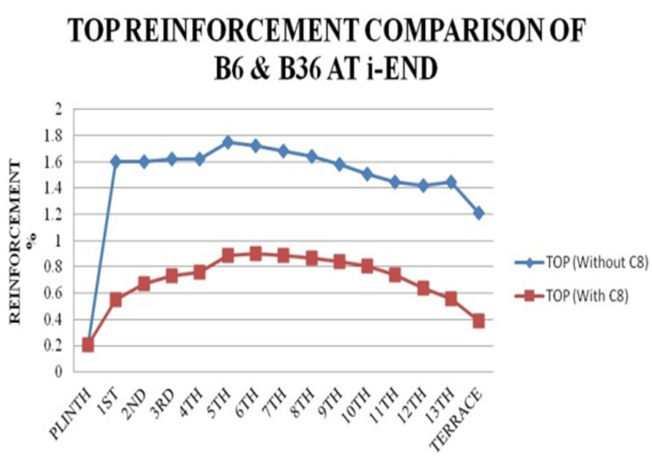

Fig. 13 Top Reinforcement Comparison of Beam B6 & B36 at i-End

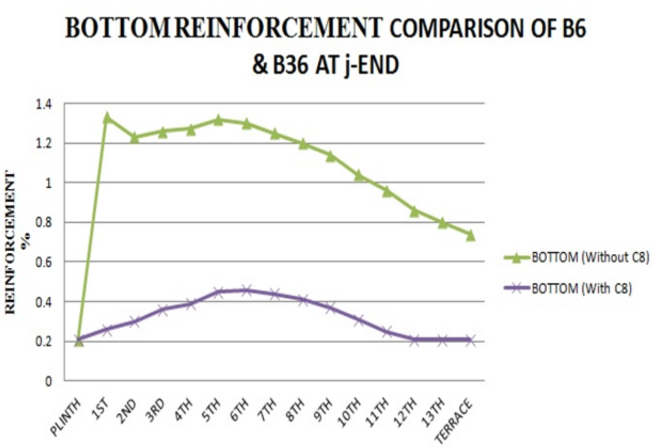

Fig. 14 Bottom Reinforcement Comparison of Beam B6 & B36 at i-End

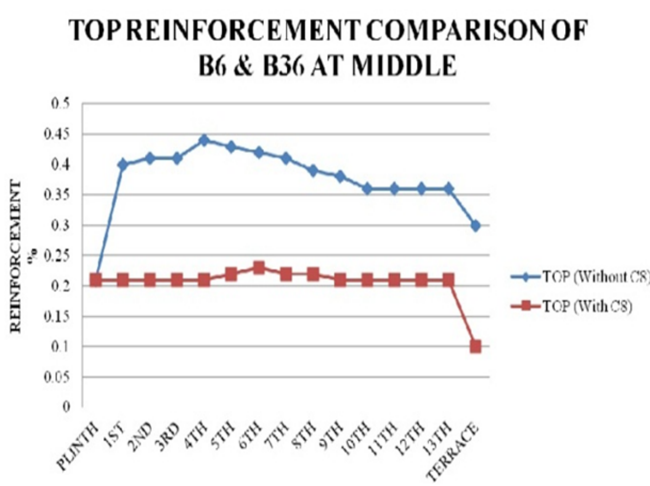

Fig. 15 Top Reinforcement Comparison of Beam B6 & B36 at Middle

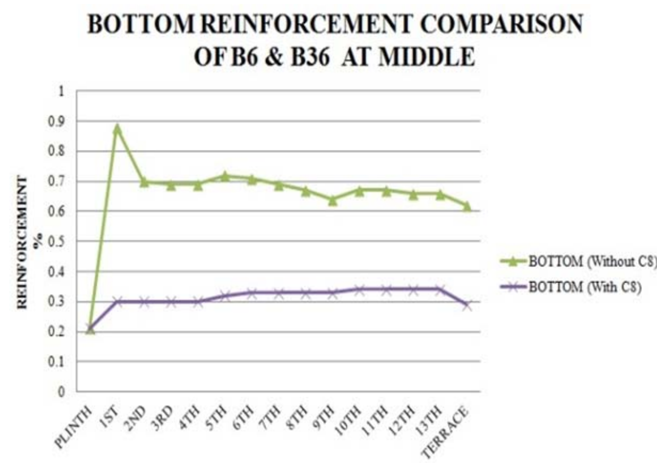

Fig. 16 Bottom Reinforcement Comparison of Beam B6 & B36 at Middle

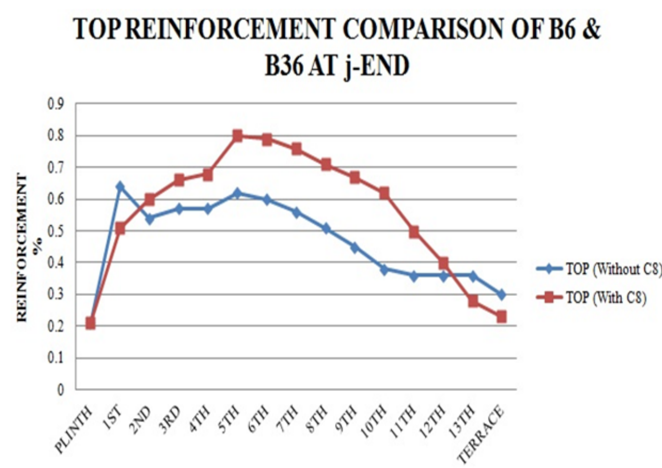

Fig. 17 Top Reinforcement Comparison of Beam B6 & B36 at j-End

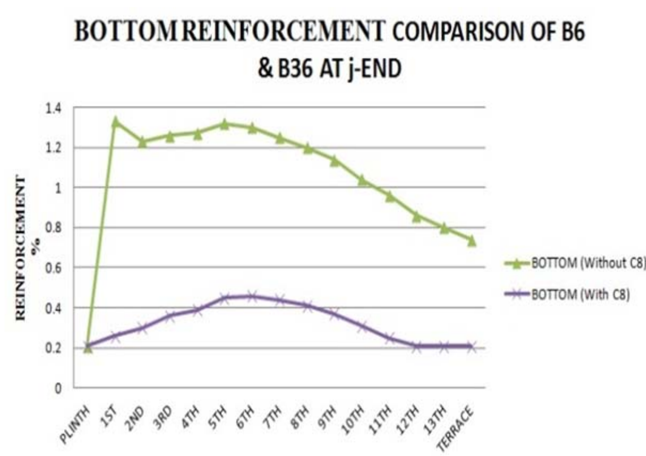

Fig. 18 Bottom Reinforcement Comparison of Beam B6 & B36 at j-End

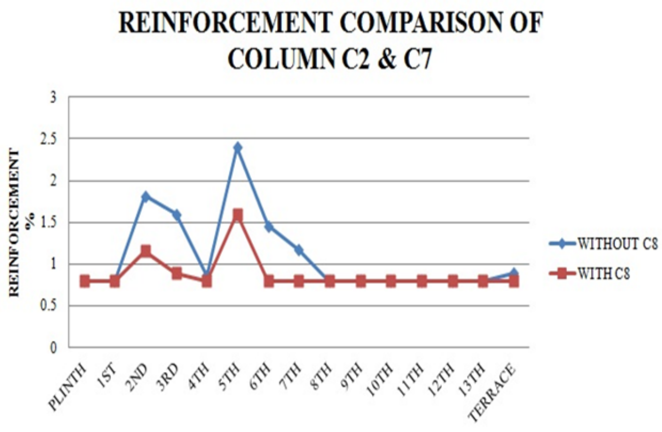

Fig. 19 Reinforcement Comparison of Column C2 & C7

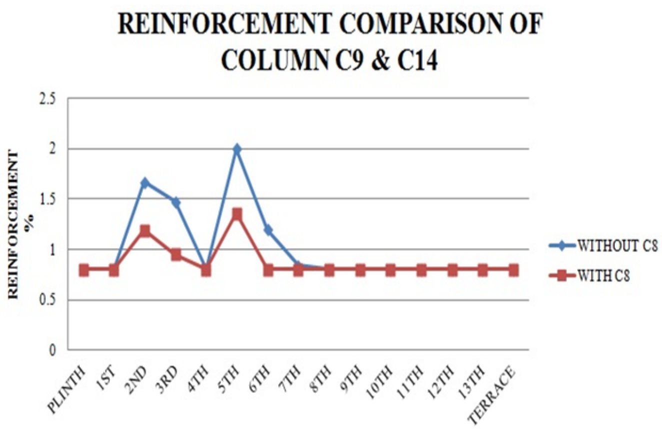

Fig. 20 Reinforcement Comparison of Column C2 & C7 at j-End

Fig. 2 shows that after the removal of column C8, the vertical deflection of the above floors at that point increases. At 1st level vertical deflection is 1.43mm before column removal which increases to 30.99mm after column is removed.

Fig. 3 to Fig. 10 shows that both the bending moments i.e. negative as well as positive bending moment increases in all the four adjacent beams B6, B7, B36 and B37after the removal of internal corner column C8. This shows that the after the removal of column C8, adjacent elements has acquired an alternate load path for load redistribution. Load carried by C8 is now supported by its adjacent columns. This load is transferred to adjacent columns through those above mentioned four adjacent beams. Maximum difference in bending moment is observed at 1st floor level because column is removed at that level, so beams had no column below to transfer load.

Fig. 11 to Fig. 12 shows the axial force comparison of adjacent columns before and after the removal of column C8. The above graphs clearly shows that the axial force in adjacent columns C2, C7, C9 and C14 has drastically increased after removal of column C8.

It is clear from Fig. 13 to 18 of reinforcement comparison that except top reinforcement of i-end, reinforcement is increasing at all other section of beams B6 & B36 after removal of C8. As i-end behaves as partially free support there is decrease in reinforcement after removal of C8. Beams B7 & B37 have similar pattern of reinforcement.

Fig. 22 and 23 shows the reinforcement comparison of adjacent columns.

6. CONCLUSION

An average increase in deflection of 80% is observed of all floors.

Bending moment in beams has mean increase up to 2 times after removing the external and internal corner column.

There is mean increase of 20% in axial force of adjacent columns after removal of C8. It also indicates that the structure has acquired an alternate load path for load redistribution.

Reinforcement graphs show the alternate load path acquired by rest of the elements for load redistribution.

7. ACKNOWLEDGEMENTS

The authors would like to express most gratitude to the department of civil engineering, CSPIT, CHARUSAT for providing a platform to accomplish our work.

REFERENCES

[1] GSA Progressive Collapse Analysis and Design Guidelines for New Federal Office Buildings and Major Modernization Projects. General Services Administration (GSA) Washington D.C. 2003.

[2] Rakshith K G and Radhakrishna "Progressive Collapse Analysis of Reinforced Concrete Framed Structure" *International Journal of Research in Engineering and Technology*.

[3] Khokale S P "Progressive Collapse of High Rise R.C.C. Structure under Accidental Load" *International Journal of Latest Trends in Engineering and Technology (IJLTET).*