Progressive Collapse Analysis for ‘C’ Shape RC Building

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ABSTRACT

In a construction progressive collapse occur when an essential underlying part like Column fails because of unforeseen effect, blast or seismic Earthquake has happened. The failure of a part in the essential load opposing framework prompts reallocation of powers to the abutting individuals and whenever rearranged load surpasses part limit it comes up short. In the current investigation progressive collapse of 'C' shape G+8 Story School building is consider. The Non Linear static examination is completed utilizing programming, STAAD PRO CONNECT EDITION as per Indian Standard codes for four unique cases after corner section evacuation conditions. To contemplate collapse, normal sections are taken out each in turn, and preceded with examination and plan. It is seen that Demand Capacity Ratio(DCR) in radiates and are surpassing as far as possible for four cases according to U.S. General Services Administration (GSA) rules. This demonstrates the structure considered for study is having high capability of reformist collapse.

Keyword: - *Progressive Collapse, G+8 Story, ‘c’ shape Building, GSA 2003,DCR Value*.

1. INTRODUCTION

Progressive collapse is a circumstance where neighborhood disappointment of an essential underlying segment prompts the breakdown of connecting individuals, which thusly prompts extra breakdown. Progressive collapse happens when a construction has its stacking example or limit conditions changed to such an extent that underlying components are stacked past their ability and fizzle. The single component disappointment can prompt a bigger harm in determinate construction, for that this underlying framework isn't powerful. Rather than uncertain design, the collapse of one component won't cause building disappointment as other component can remunerate the nearby harm and extension out the heap of harmed component to whole approach. The structures are first designed and afterward made arrangements for extreme powers or stresses opposition. However, in the event that the heap following up all in all construction or an underlying component surpasses the restricting worth of this functional load or stress, the design comes up short or any disappointment of primary component happens. What's more, Progressive breakdown suggests a marvel of successive disappointment of part of the design or the total construction started by abrupt loss of vertical load conveying part (for the most part section). The disappointment of a part in the essential load opposing framework prompts reallocation of powers to the bordering individuals and whenever rearranged load surpasses part limit it falls flat.

Progressive collapse the spread of neighborhood harm, from a starting occasion, from one component to another subsequent, in the end, in the breakdown of a whole construction or a lopsidedly enormous piece of it; otherwise called disproportionate collapse.

This disappointment happens when a structure loses at least one of its upward load conveying segments. The single component disappointment can prompt a bigger harm in determinate design, for that this primary framework isn't strong. Rather than vague design, the collapse of one component won't cause building disappointment as other component can repay the nearby harm and scaffold out the heap of harmed component to intact close to components. Underlying vigor is an element of primary level of repetition, which addresses the construction capacity to rearrange loads after collapse to unblemished individuals.

1.1 Objective

Keeping the past part referenced focuses in see, the primary destinations of present investigation are formed as under: -

• To Analyse, plan G+8 'C' shape RC structure by utilizing various cases to support Progressive collapse .
• To perform investigation for the proposed structure with expulsion of basic sections completely to know potential for Progressive collapse.
• To propose successful strategy for plan of new structure to keep away from Progressive collapse.

1.2 Scope

1. G+8 'C' Shape RC Building is examinations and plan by traditional strategy for dead Load, live Load, and Earthquake load in STAAD PRO CONNECT EDITION programming.
2. The above structure is further examinations for expulsion section considering load combination according to GSA rules.
3. Results of All Four cases are contrasted with Case without incidental load with see the collapse by utilizing STAAD.
4. Remedial measures are given to stay away from Progressive collapse like – Bracing System gave Bracing at Bottom and Top Story of framework,
5. Results of different kinds of charts and thought about in the middle of propping and Without Bracing cases in Progressive collapse examination condition and additionally plot the near diagrams like – part, case, floor, independent, generally investigation.

2. BUILDING CONFIGURATION

To examine the impact of column removal condition on the design, theoretical instance of G+8 story 'c' shape RC building is thought of. Reformist breakdown examination depends on the GSA rules. Construction considered in this examination is thought to be a School building, which is intended for a significance factor 1 (IS code 1893-2016). Building size in arrangement is 30m x 45m. Stature of base to plinth is taken as 2m, Plinth to ground floor as 3 m, which is considered as empty plinth and tallness of average floor as 3.5m. 230mm thick dividers are thought to be on all beams

2.1 Load Considered Are As Follows:

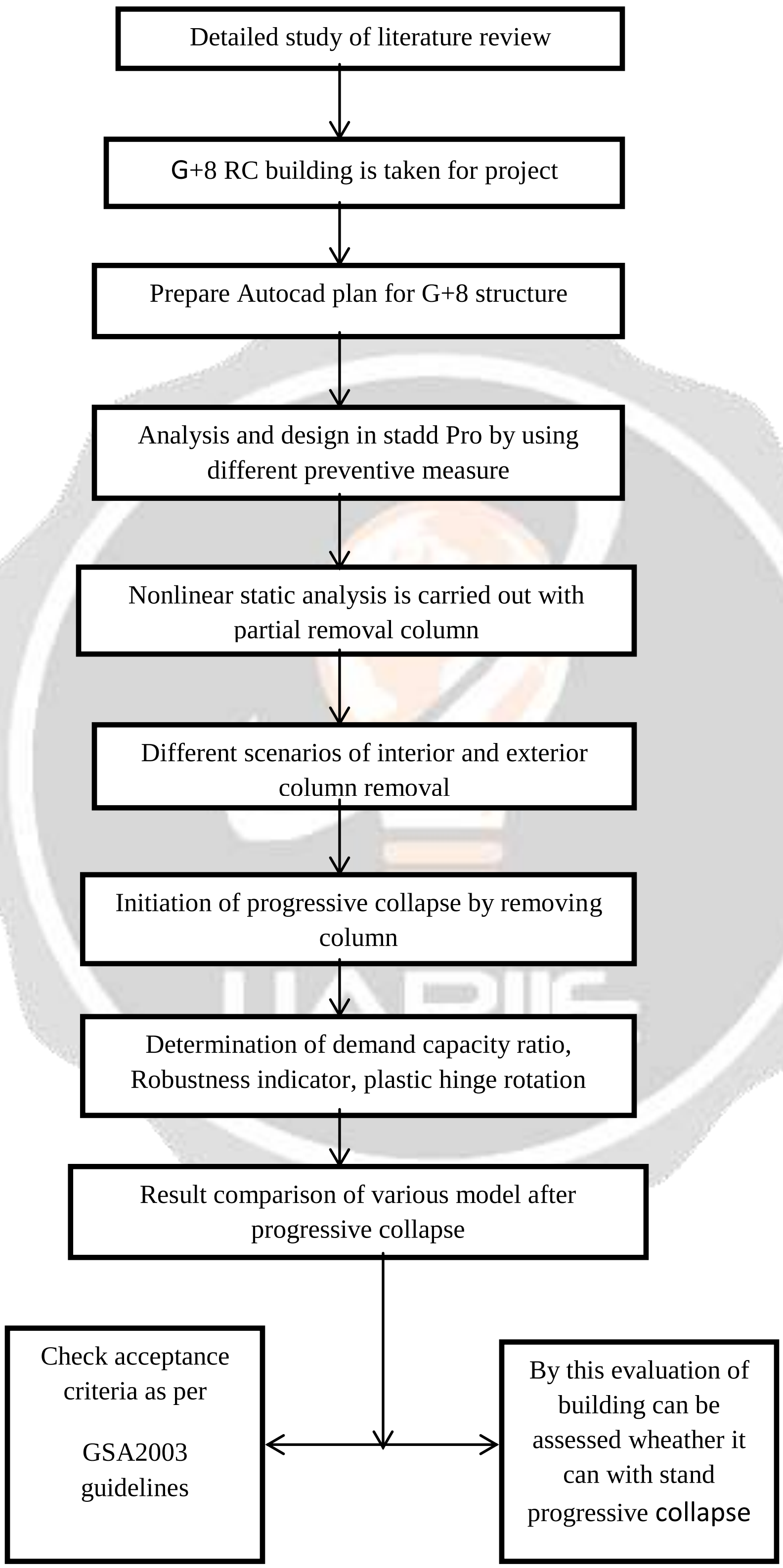
1. Dead Load as per IS 875 (Part I).
2. Live Load IS 875 (Part II) - on Roof 1.5 KN/m2 and on Floors 4.0 KN/m2
3. Self-weight of the Structural elements, Floor Finish =1.5 KN/m2.
4. Seismic loading as per IS: 1893 (Part I): 2016 Zone – IV
   Zone factor = 0.24,
   Soil Type = Type –I, Rock or hard soil, Importance Factor = 1.5 and
   Response Reduction Factor = 5.0

Material:-
Concrete Grade: M25
Grade of Steel: Fe 500
No. of stories: G + 8
Storey Height: 3m

2.2 Basic Load Combination

1) 1.5(DL + LL)
2) 1.2(DL + LL ± EQ)
3) 1.5(DL ± EQ)
4) 0.9DL ± 1.5EQ

3. RESEARCH METHODOLOGY



3.1 Modeling

The 8 storied reinforced concrete framed structures is modeled using Staad pro Connect software.

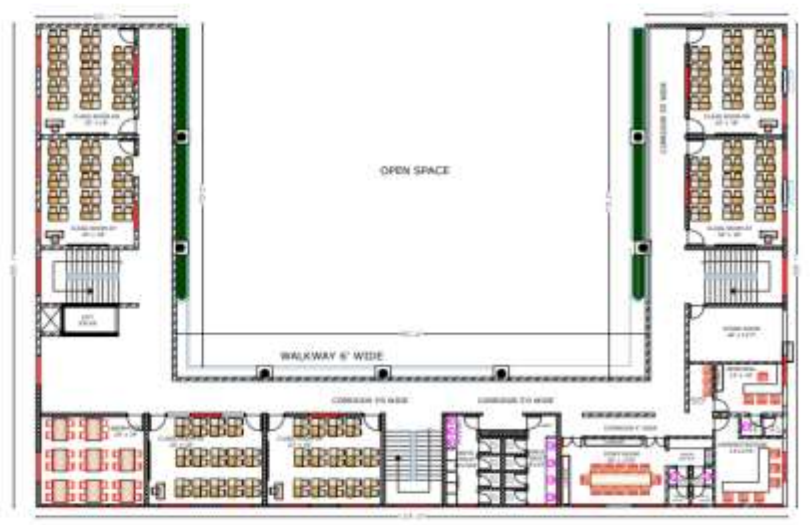


Fig -1 Typical floor plan of school structure / building

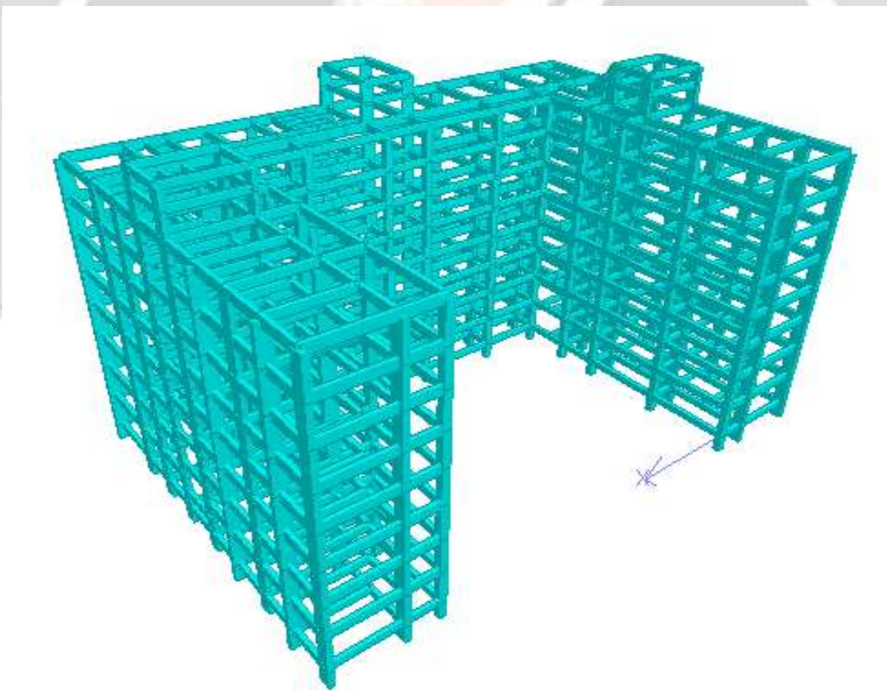


Fig:-2 Render view of 8 storied School Building

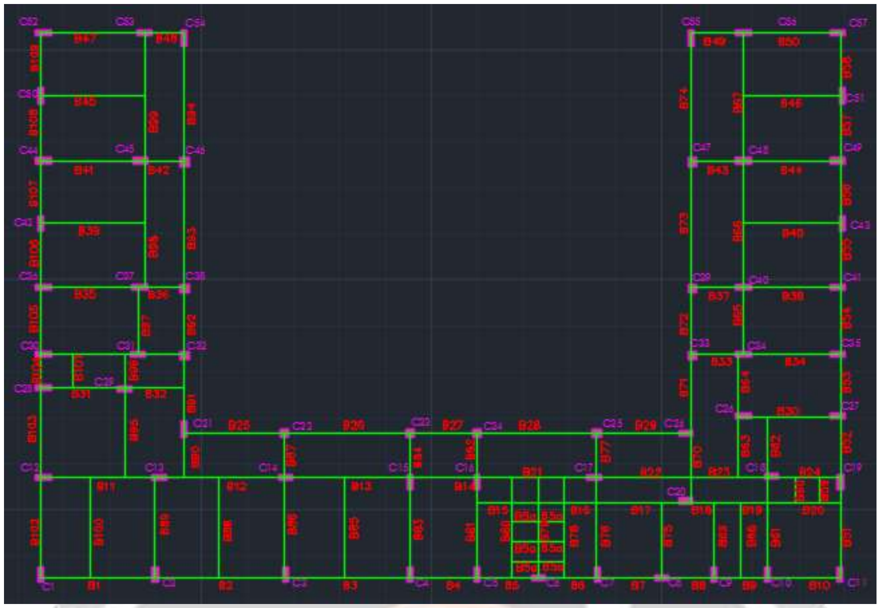


Fig:-3 Typical Floor Plan (Showing Beam & Column Numbering)

For a significant structure having high potential for Progressive collapse, it is important to decrease the capability of Progressive collapse. In the event that DCR for shaft and segment individuals surpass the admissible worth determined by rules, then, at that point it is said that building is having high potential for Progressive collapse. To limit the potential for Progressive collapse fundamental primary changes are required models will be prepared. Each separate model will be prepared by considering various preventive measures such as,

• Model 1 – With corner removal column.
• Model 2 – By considering load combination as recommended by GSA
• Model 3 - By considering beam above column removal to be designed as cantilever beam.
• Model 4 -. By Increasing Beam and Column sizes by 20 % at column removal area.
• Model 5 - Providing inverted 'A' type bracing at ground and roof floor level

After investigation and plan of the structure by utilizing previously mentioned alternatives nonlinear examination will be done to check viability of choices against Progressive collapse. Subsequent to contemplating different writing study it appears to be that corner section expulsion is very basic case, so chipped away at just corner column removal case.

Step-l. In the first step, the structure is designed in Staad pro for the IS 1893 load combination and the yield results are acquired for second and shear without eliminating column.

Step-2. A vertical support (column) is eliminated from the situation viable and direct static investigation is completed to the modified design with previously mentioned preventive measures.

Step-3. The load combinations are entered into the staad pro program. Each case of different Column removal location on the model and the results are reviewed.

Step-4. Further, from the analysis results are obtained and if the DCR for any member exceeds the allowable limit based upon moment and shear force, the member is expected as a failed member.

Step-5. If DCR value If DCR values surpass its criteria then it will lead to progressive collapse

4. RESULT AND DISCUSSION

4.1 General

- Five Models of G+8 School Building are generated using software staad pro.
- Each models of G+ 8 storey are analyzed for Different column removal case. The progressive collapse analysis is done according to the G.S.A. guidelines. Linear static analysis has been carried out.
- Comparison of all cases is done on the basis of Demand Capacity Ratio.

- Obtained results have been presented in form of graphs/charts, indicating the trends and pattern of Demand Capacity Ratio.
- Four different mitigation approaches like providing bracing at bottom and top floors, by considering beam above column removal to be designed as cantilever beam, by considering load combination as suggested by GSA and by increasing column and beam sizes by 20 % at column removal location.

4.2 Render View of All Model

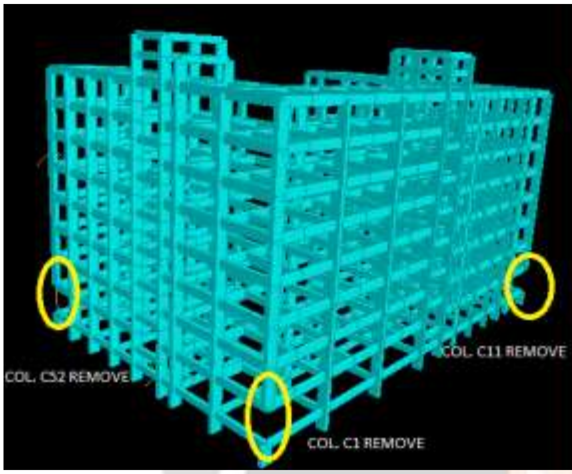


Fig. 4- CASE-I With Corner Column are Remove.

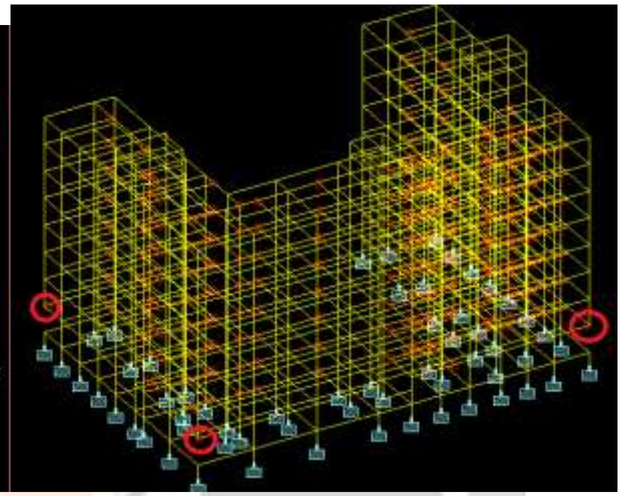


Fig.5- CASE-III By considering Beam above Column Removal to be designed as cantilever beam.

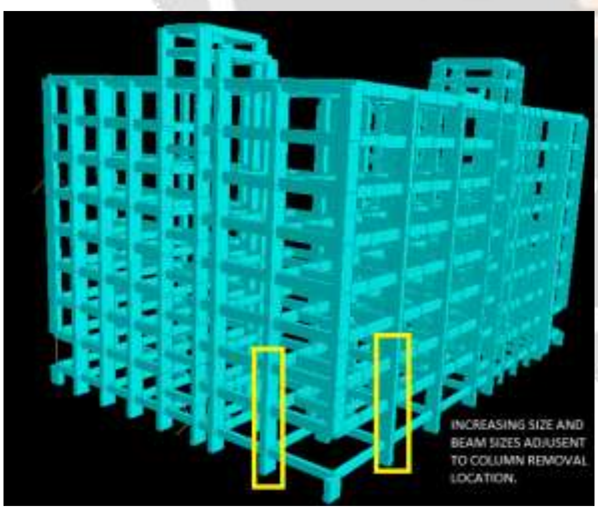


Fig.6. CASE-IV Showing Increasing Column Sizes adjacent.

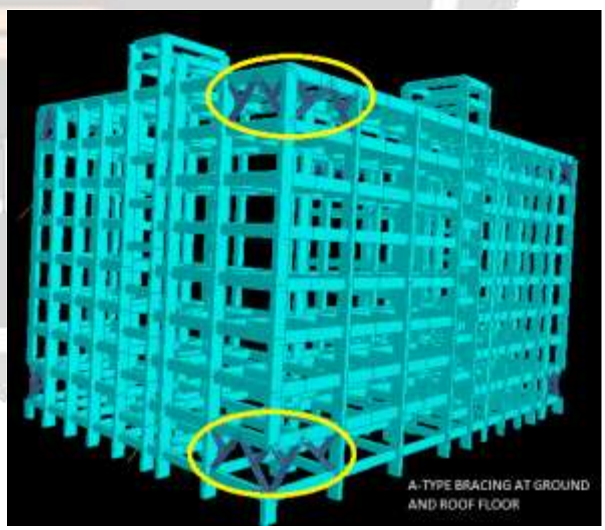


Fig.7- CASE-V Providing Inverted 'A' type bracing at ground and roof floor level.

4.3 Flexural Demand for Various Cases

1. Flexural Demand for Base Model

STOREY NO	BEAM B1	BEAM B102	BEAM B10	BEAM B51	BEAM B50	BEAM B58	BEAM B47	BEAM B109
1	324.9	136.79	318.59	256.92	232.23	402.15	437.89	136.02
2	346.75	134.26	304.68	260.76	238.15	443.21	485.37	158.35
3	339.57	128.80	275.36	259.76	230.26	438.98	487.89	145.92
4	320.94	120.90	236.83	256.11	226.65	409.37	462.78	149.08
5	294.93	111.53	189.63	150.8	200.23	363.85	418.97	139.85
6	263.05	136.79	318.59	141.33	210.65	307.98	362.49	148.09
7	244.3	134.26	304.68	241.48	227.36	249.84	302.82	133.20
8	164.5	128.80	275.21	240.23	215.45	178.58	223.54	140.92

2. Flexural Demand for Cases-I

STOREY NO	BEAM B1	BEAM B102	BEAM B10	BEAM B51	BEAM B50	BEAM B58	BEAM B47	BEAM B109
1	656.78	577.37	538.52	520.63	401.37	373.83	379.77	429.01
2	648.80	602.37	562.51	540.64	410.07	377.16	372.89	411.17
3	636.37	584.59	523.14	506.32	389.78	363.40	359.98	409.29
4	605.98	553.16	473.53	440.23	363.37	336.82	342.64	356.18
5	568.68	522.47	416.80	396.36	341.82	312.32	320.79	319.86
6	578.72	498.18	363.56	348.23	361.07	302.41	295.77	306.67
7	539.32	486.81	347.85	324.12	306.06	305.23	302.23	304.15
8	425.04	361.70	272.59	365.21	408.23	299.31	305.32	250.63

3. Flexural Demand for Cases-II

STOREY NO	BEAM B1	BEAM B102	BEAM B10	BEAM B51	BEAM B50	BEAM B58	BEAM B47	BEAM B109
1	664.13	592.01	551.03	340.26	406.91	385.08	274.32	426.20
2	655.02	618.30	573.51	347.02	415.92	383.16	271.64	406.20
3	643.02	600.98	534.02	324.65	395.62	370.91	257.61	387.05
4	614.23	565.30	549.33	284.15	368.92	343.01	24093	346.25
5	578.02	530.98	377.02	240.91	348.16	307.65	218.10	321.65
6	549.23	576.30	425.91	292.97	335.01	364.07	293.06	307.85
7	540.32	489.24	462.08	248.64	319.61	322.96	268.02	311.09
8	427.08	486.30	462.08	225.08	240.36	255.91	219.32	354.07

4. Flexural Demand for Cases-III

STOREY NO	BEAM B1	BEAM B102	BEAM B10	BEAM B51	BEAM B50	BEAM B58	BEAM B47	BEAM B109
1	513.65	583.08	413.09	408.91	436.83	378.45	280.30	430.98
2	672.95	609.21	587.37	414.23	406.34	375.09	276.06	434.97
3	650.94	590.14	552.37	394.28	384.24	362.34	263.02	410.38
4	621.83	558.01	502.43	360.81	301.95	336.57	244.82	356.08
5	586.64	527.56	446.12	331.26	346.29	301.61	222.87	319.7
6	558.13	509.37	386.32	283.41	326.80	260.48	239.86	314.83
7	560.02	498.65	368.08	247.28	338.63	220.44	172.34	313.82
8	433.81	498.03	371.16	228.03	332.51	257.04	126.02	235.07

5. Flexural Demand for Cases-IV

STOREY NO	BEAM B1	BEAM B102	BEAM B10	BEAM B51	BEAM B50	BEAM B58	BEAM B47	BEAM B109
1	654.42	562.89	520.56	275.09	411.05	395.36	269.34	398.81
2	649.31	586.32	541.23	232.30	366.25	395.81	279.54	383.94
3	641.31	570.61	504.84	263.30	401.95	354.97	266.84	369.84
4	611.34	542.91	457.69	232.96	376.34	315.32	248.51	345.61
5	545.28	417.32	404.28	200.36	360.84	270.67	226.12	327.91
6	552.0	503.30	349.34	170.95	348.08	223.59	200.54	313.20
7	421.60	491.02	327.21	140.36	338.41	255.84	273.81	273.91
8	419.05	365.30	360.32	123.51	356.02	250.36	221.91	240.98

6. Flexural Demand for Cases-V

STOREY NO	BEAM B1	BEAM B102	BEAM B10	BEAM B51	BEAM B50	BEAM B58	BEAM B47	BEAM B109
1	165.84	134.13	325.18	150.28	180.32	100.63	137.56	160.56
2	171.56	188.07	336.28	123.55	178.98	233.89	136.24	153.65
3	163.41	295.16	285.55	110.98	136.54	234.68	130.91	142.94
4	158.22	128.98	238.11	95.85	119.15	206.87	113.32	118.45
5	157.44	116.27	186.06	85.39	108.62	161.81	97.26	104.76
6	156.05	119.76	138.08	18.63	115.27	101.05	82.64	99.84
7	148.23	168.86	151.23	70.98	60.38	96.45	72.38	99.02
8	146.19	150.56	100.98	60.91	68.54	70.64	68.45	70.65

4.3 DCR for Various Cases

Check for Demand Capacity Ratio (DCR) in each structural member is carried out. The DCR of each member is calculated from the following equation.

$$DCR = \frac{QUD}{Q_{CE}}$$

Where

QUD = Acting force (demand) determined in component orconnection/joint (moment, shear force,).

QCE = Expected ultimate, un-factored capacity of thecomponent and/or connection/joint (moment, shear forces

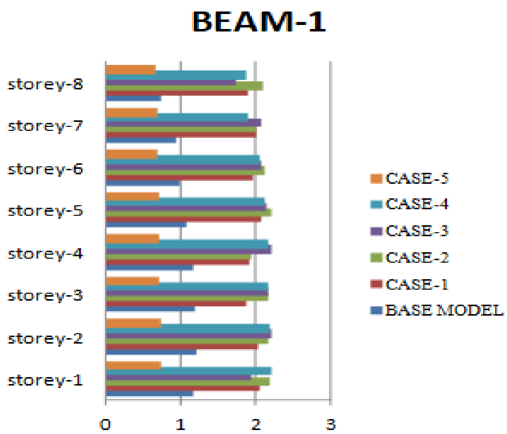


Fig.8- DCR for Beam-1

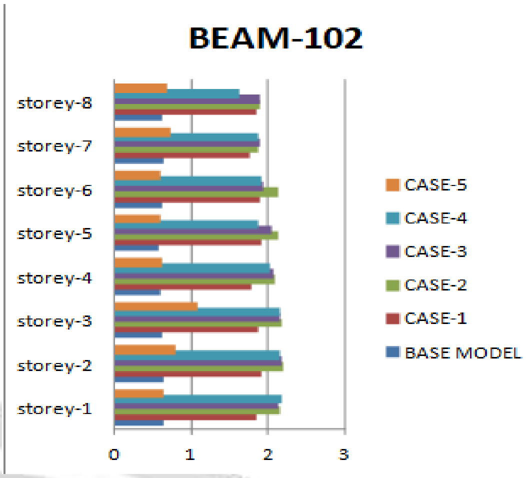


Fig.9- DCR for Beam-102

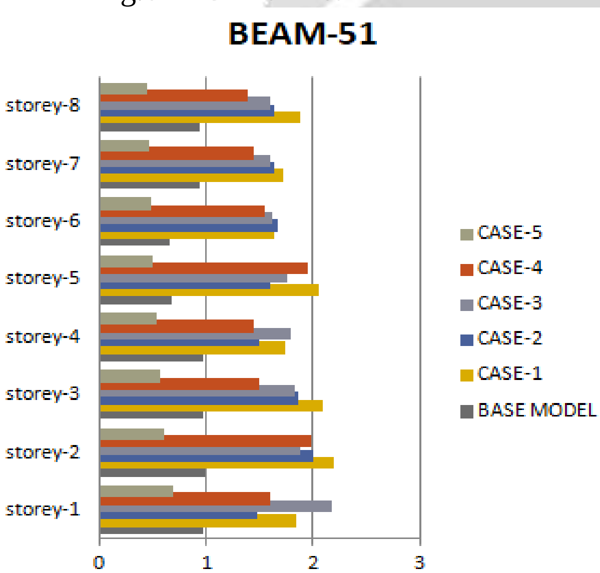


Fig.10- DCR For Beam-51

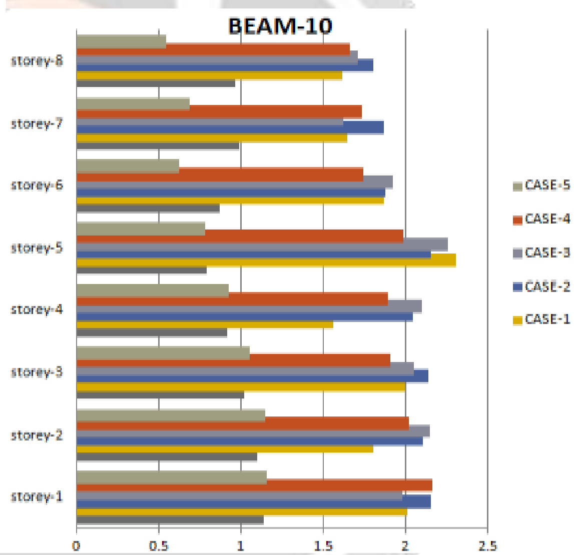


Fig.11- DCR For Beam-10

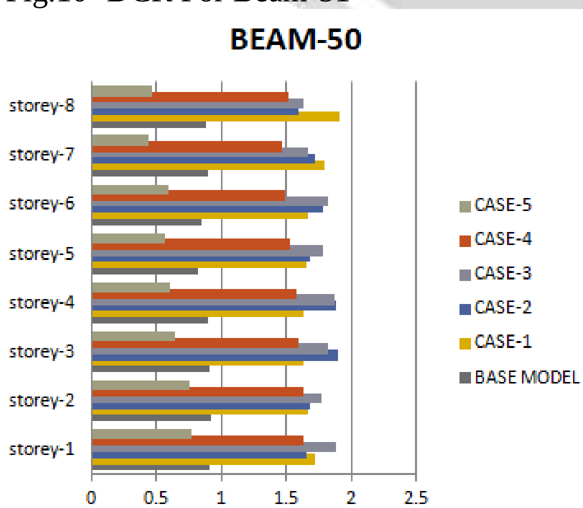


Fig.12- DCR For Beam-50

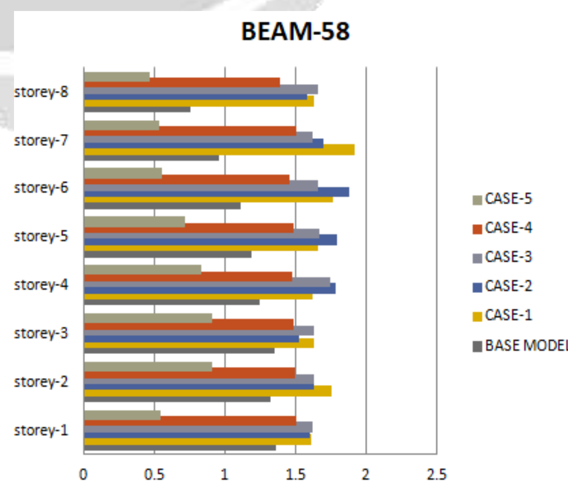


Fig.13- DCR For Beam-58

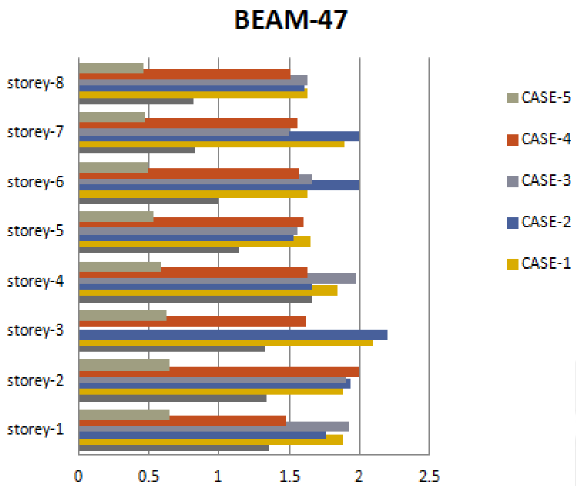


Fig.14- DCR For Beam-47

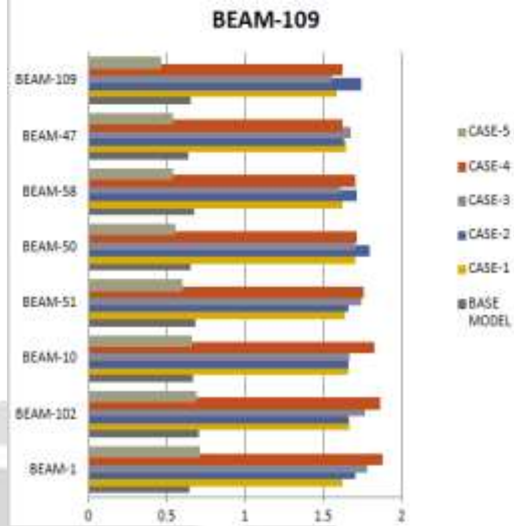


Fig.13- DCR For Beam-109

5. CONCLUSION

5.1 Progressive Collapse Analysis of Building

The analytical study on both 8-storey building is done by creating the 3D model and the analysis is done for all corner column removal cases by following GSA guidelines. Progressive collapse potential of building is found out by considering column removal cases. Demand Capacity Ratio in flexure is calculated for all the cases. From the study, the following conclusions can be drawn out:

1. DCR in flexure of beam exceeds permissible limit of 2.0 in all storey of for case 3, 4 & 5. The DCR values in beams in case 2 i.e. by providing inverted 'V' type bracing at ground and roof floor level are within limit indicate that building considered for the study is having very low potential to resist the progressive collapse when column is considered as fully damage/removed.

2. The adjacent beam to the damaged/removed column joint experienced more damage as compared to the beams which are away from the removed column joint.

3. Corner column case is found critical in the event of progressive collapse.

4. Four different alternatives are used to mitigate the progressive collapse. When mitigation alternatives are adopted, DCR value is reduced within permissible limit. From four mitigation alternatives presented, provision of bracing in the building is economical solution to reduce the potential of progressive collapse

5.2 Scope of Future Work

There is a scope of extending this work to include the following for future:-
1. The present work has been carried out to calculate the DCR for a symmetric building. The work can be extended to asymmetric buildings

2. In this study STAAD Pro has been used other software like SAP, and ANSYS etc. can be used.

3. Here linear static and linear dynamic (response spectrum method) analysis have been performed; Push over Non-linear analysis can be done for same building.

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