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Progressive Collapse Assessment of RCC Structure under Instantaneous Removal of Columns and its Modeling Using Etabs Software

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Abstract: The structures generally get collapse because of the disappointment of one or a couple of basic parts which at that point advances over the progressive of different segments. This procedure is alluded as Progressive Collapse of the structure. Nearby harm that starts dynamic breakdown is called starting harm. So as to contemplate the breakdown in diagnostic manner, stacking example or limit conditions are required to be changed so other auxiliary components inside the structure are stacked past their ability. This prompts improvement of elective burden ways to start the redistribution of burdens. A typical model of a 12 storey structure is made on ETABS Software and investigation of fortified cement encircled structure under basic section evacuation has been conveyed utilizing the direct and non-straight static examination techniques according to the rules gave in GSA (2003) and FEMA: 356 rules separately contemplating the arrangements of IS1893:2002 codes to recreate dynamic breakdown issues. The outcomes are then looked at for the parameters, for example, Demand limit proportion and Robustness marker were checked for the acknowledgment criteria gave in GSA 2003.

Keywords: Progressive Collapse, GSA, Demand capacity ratio, Robustness indicator, ETABS.

I. INTRODUCTION

The R.C.C. building is consists of elements such as column, beams, Slab, Foundation etc these elements are also referred as load bearing elements of the structure. Though there are mainly two types of load that acts on structure and are dead (DL) and live (LL) loads. The dead load consists of the weight of permanent structure elements such as column; beam whereas the live load consists of weight of moving people, furniture etc and the wind load and seismic load also act on the structure. When the interior load-bearing structural element fails due to any number of means such as blast activity or vehicular accident which results in the failure of a structure or component to maintain its structural integrity this phenomenon is called collapse phenomena. This situation may be initiated by an earthquake, interior or exterior explosions and construction activities. The classification of the causes of the building collapse is specified under general headings given below:

1. Faulty Construction
2. Unexpected Failure Modes
3. Extraordinary Loads
4. Foundation Failure
5. Column and beam failure

The worldwide problem of ensuring the stability of structures of high-rise buildings against progressive collapse as a result of fire and blasts is becoming more urgent because, leads to very serious consequences. Wear and tear of fixed assets of the country, increasing the rate and density of construction in urban areas, an increase in recent years, the number of terrorist acts (bombings, arson, etc.)

1.1 Progressive Collapse

The expression “Progressive Collapse" can be just characterized as a definitive disappointment or proportionately enormous disappointment of a bit of a structure because of the spread of a neighborhood disappointment from component to component all through the structure. Dynamic breakdown happens when moderately neighborhood basic harm, causes a chain response of structure components disappointments, unbalanced to the underlying harm, causing in halfway or full breakdown of the structure. Nearby harm that starts dynamic breakdown of structure is called starting harm. When all is said in done, dynamic breakdown happens in a brief timeframe right away. It is additionally conceivable that it very well may be described by the loss of burden conveying limit of a moderately little segment of a structure because of a normal burden which, thusly, starts a fall of disappointments influencing a primary segment of the structure. A dynamic breakdown is commanding occasion as it involves the vibrations of auxiliary segments and results in powerful interior powers. These inside powers could be, for example, inactivity powers and so on, whose force isn't consumed by the structure. Dynamic breakdown is a characteristic non-direct occasion, in which auxiliary segments are worried past their versatile point of confinement to happen the failure. Progressive breakdown is a reliable annihilation of the bearing structures of the (structure) because of the underlying nearby harm to the individual transporters of basic segments and prompting the breakdown of the whole building or significant part .The potential irregular loads that can cause the dynamic breakdown are arranged that way

a. Pressure Loads

- Internal gas explosions
- Blast
- Wind over pressure
- Extreme values of environmental loads

b. Impact Loads

- Aircraft impact
- Vehicular collision
- Earthquake Overload due to occupant overuse Storage of hazardous materials

II. METHODOLOGY

In this work, the analysis based on linear static method is used to investigate **Progressive Collapse Assessment of RCC Structure under Instantaneous Removal of Columns and its Modeling Using ETABS Software** as per IS-standards. In order to study the effect seismic force on Progressive Collapse Assessment zone II of India is considered.

BUILDING MODEL

Cases of a Building Models which has been considering the study are given below-

Table 1: ***Cases under consideration***

Software used	Configuration of Building	Model Dimensions	Storey	Remarks
ETABS	Rectangular	31.5m x 22.5m	12	Seismic forces of Zone II as per IS: 1893:2002.

Table 2: ***Specifications of Conventional Slab Structure***

Specifications	Data
Typical Storey Height	3 m
Base Storey Height	3.0 m
No. of Bays along X-Direction	7
No. of Bays along Y-Direction	5
Bay Length along X-Direction	4.5 m
Bay Length along Y-Direction	4.5 m
Concrete Grade	M-30
Density of R.C.C.	25 KN/m^3
Density of Masonry	20 KN/m^3
Columns (perimeter)	500 mm x 500 mm
Columns (interior)	600 mm x 600 mm
Beams	250 mm x 550 mm
Slab Thickness	150 mm
Bottom Support Conditions	Fixed
Live Load- **Roof** **Rest of the structure**	 1 KN/m^2 2 KN/m^2
Soil Conditions	Type 2 Soil (medium)
Damping Ratio	5%, asper IS-1893: 2002 (Part-1)
Poisson Ratio	0.2

Response Reduction Factor	3
Importance Factor	1
Zone Factor	As per IS1893- 2002 (Part 1) for different_Seismic_Zones

For the study, **G+**11 storey building is considered. The building has 7 bays in X-direction and 5 bays in Y- direction with the plan dimension of 31.5 m x22.5 m and story height of 3 m in typical story and 3 m in base storey. To minimize torsion response under lateral force, building is kept symmetric in plan. The shape of the column in plan is kept square and size of the column is kept constant through the height of structure.

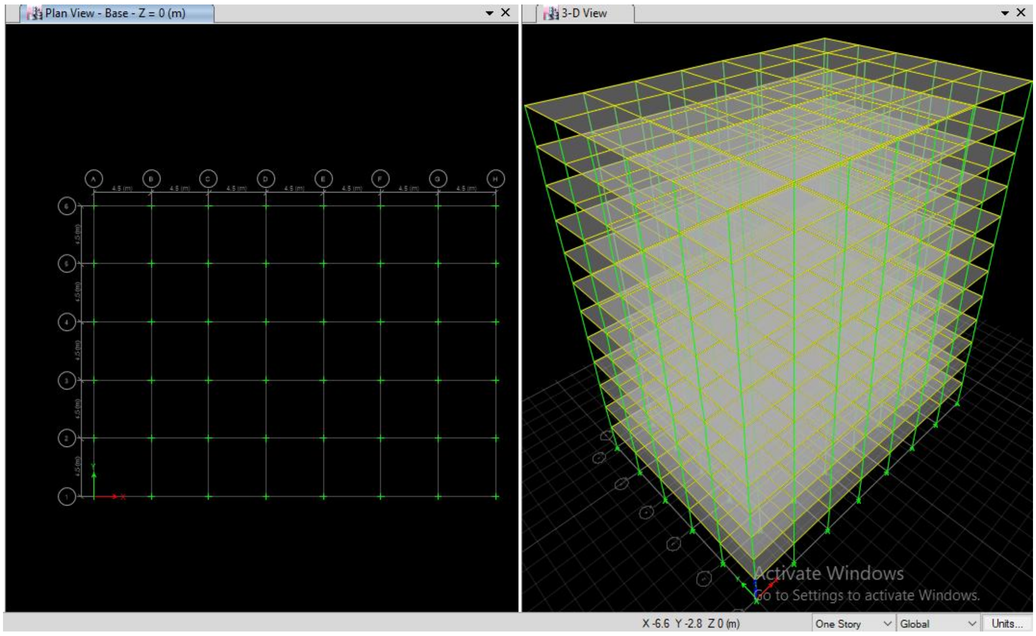


Figure 1: ***General view of building on ETABS***

The building consider in the study is to be located in seismic Zone II, and intended for Commercial use (Hotel). Building is founded medium strength soil. The columns at base are assumed to be provided with isolated footing. Response reduction factor for the special moment resting frame without shear wall and frame with shear wall has taken as 4 (Ductile detailing is assumed). The finish load on the floor is taken as 1.5 KN/m^2. Live load on the floor is taken as 3.0 KN/m^2. In seismic weight calculation, 25% of the floor live loads are considered in the analysis.

III. RESULTS AND DISCUSSIONS

A multistory hotel building of G +11 configurations is taken in zone II and progressive collapse assessment is performed using following two cases of sudden column removal –

(i) Column removal due to accident by any high speed vehicle- in this case outer column of ground floor is destroyed and suddenly removed.

(ii) Column removal due to LPG cylinder explosion – in this case the interior column of intermediate or ground floor is destroyed and suddenly removed.

3.1 Identification of critical columns for removal:

The removal of critical columns is governed by GSA (general service administration) shown as following

3.1.1 The GSA (2003) Guidelines Recommended Missing Column Scenario:

The potential for progressive collapse is evaluating using linear static analysis and nonlinear static analysis in four damage analysis cases. These four damaged column cases are shown in the fig. below:

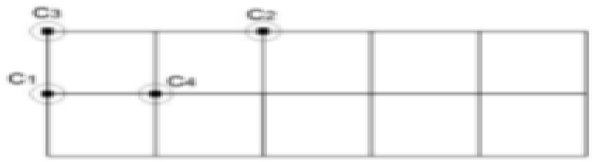
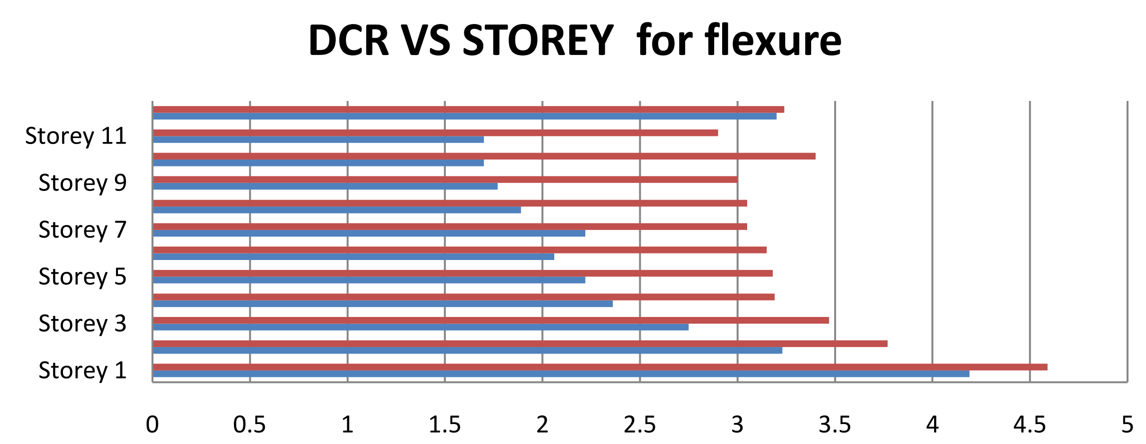


Figure 2: ***A plan showing GSA column removal criteria***

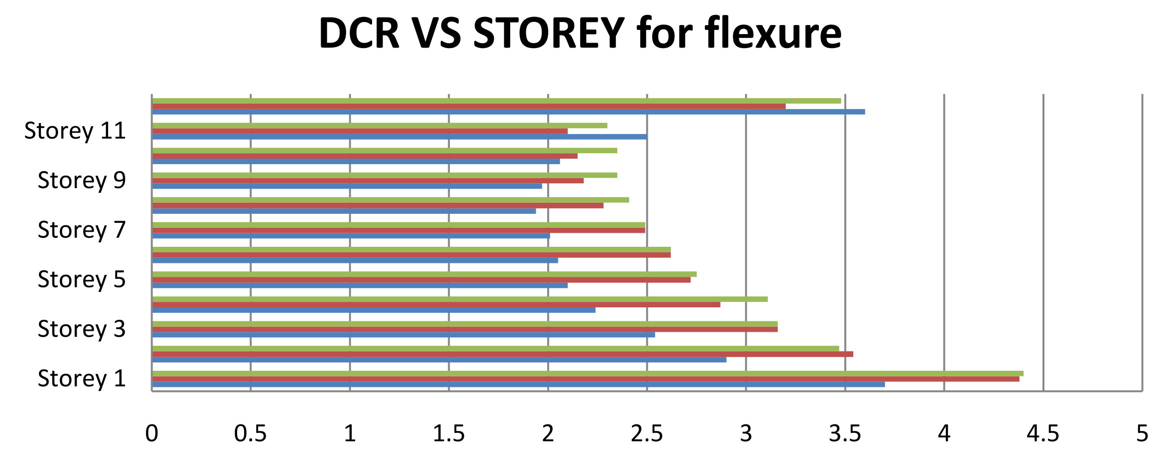
The loss of an outside segment situated close to the center of the short side (C1).
The loss of an outside section situated close to the center of the long side (C2).
The passing of a corner section (C3).

3.2 Determination of DCR (demand capacity ratio) values for the beams neighboring to removed columns:



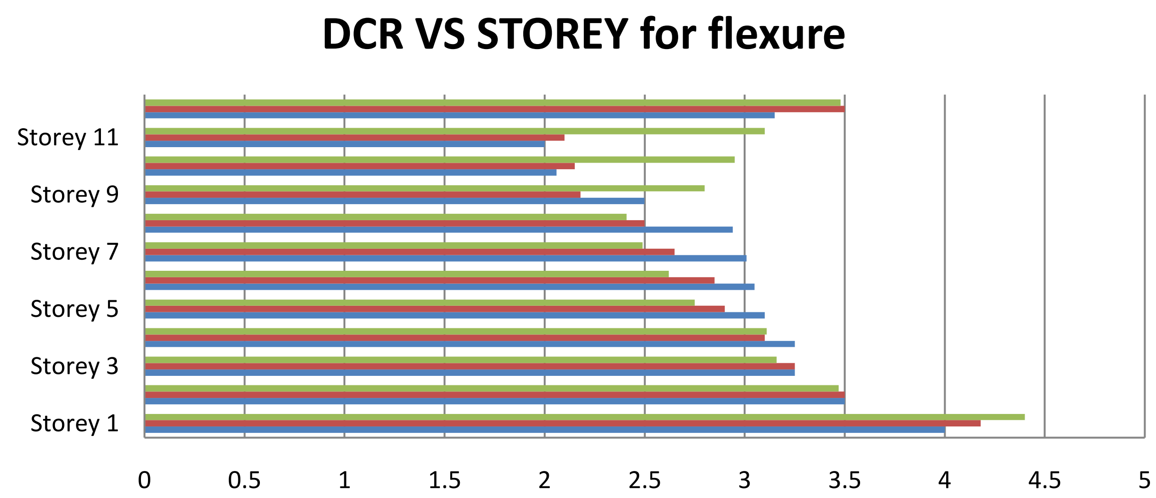
	Storey 1	Storey 2	Storey 3	Storey 4	Storey 5	Storey 6	Storey 7	Storey 8	Storey 9	Storey 10	Storey 11	Storey 12
DCR B 76	4.59	3.77	3.47	3.19	3.18	3.15	3.05	3.05	3	3.4	2.9	3.24
DCR B 5	4.19	3.23	2.75	2.36	2.22	2.06	2.22	1.89	1.77	1.7	1.7	3.2

Figure 3: ***DCR values for Beams in flexure near to critical column C 41 of GF***



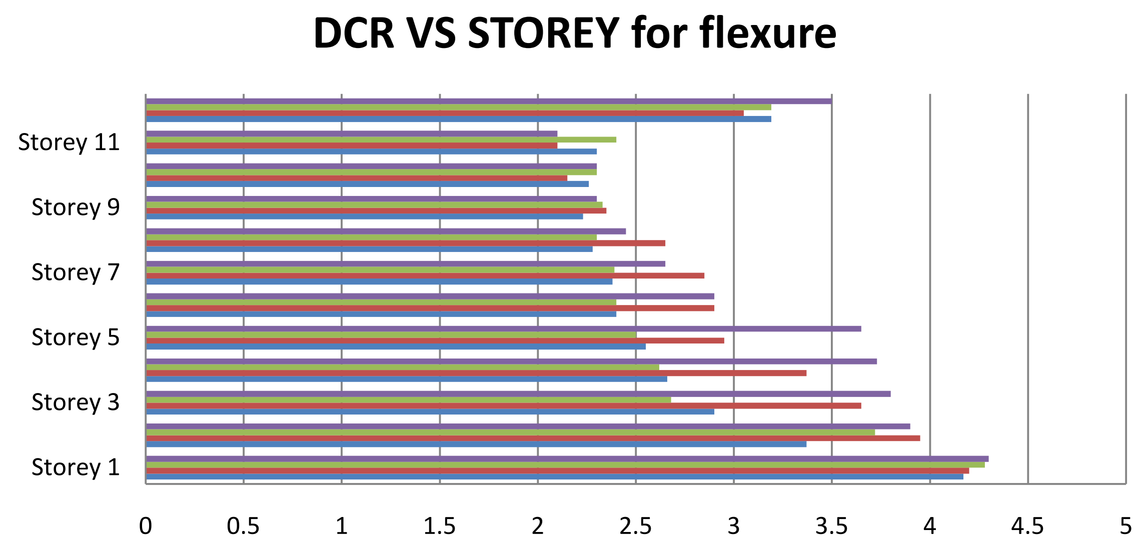
	Storey 1	Storey 2	Storey 3	Storey 4	Storey 5	Storey 6	Storey 7	Storey 8	Storey 9	Storey 10	Storey 11	Storey 12
DCR-B 79	4.4	3.47	3.16	3.11	2.75	2.62	2.49	2.41	2.35	2.35	2.3	3.48
DCR-B 78	4.38	3.54	3.16	2.87	2.72	2.62	2.49	2.28	2.18	2.15	2.1	3.2
DCR - B 20	3.7	2.9	2.54	2.24	2.1	2.05	2.01	1.94	1.97	2.06	2.5	3.6

Figure 4: ***DCR values for Beams in flexure near to critical column C 31 of GF***



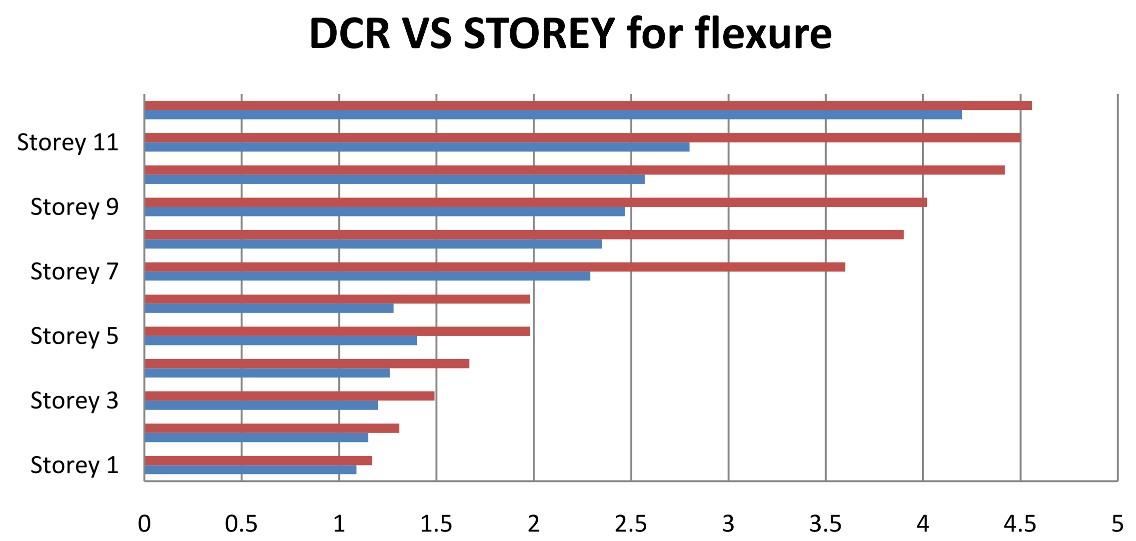
	Storey 1	Storey 2	Storey 3	Storey 4	Storey 5	Storey 6	Storey 7	Storey 8	Storey 9	Storey 10	Storey 11	Storey 12
DCR-B 62	4.4	3.47	3.16	3.11	2.75	2.62	2.49	2.41	2.8	2.95	3.1	3.48
DCR-B 4	4.18	3.5	3.25	3.1	2.9	2.85	2.65	2.5	2.18	2.15	2.1	3.5
DCR-B 3	4	3.5	3.25	3.25	3.1	3.05	3.01	2.94	2.5	2.06	2	3.15

Figure 5: ***DCR values for Beams in flexure near to critical column C 39 of GF***



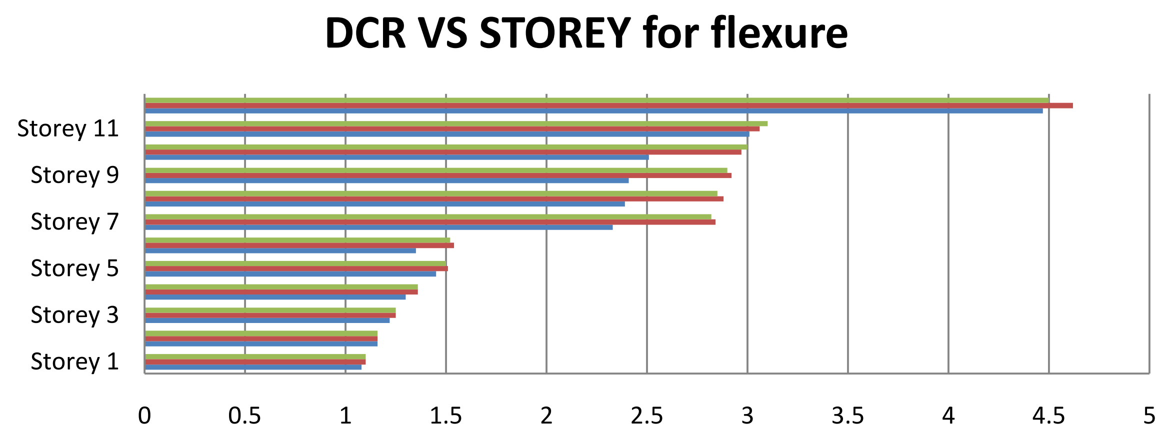
	Storey 1	Storey 2	Storey 3	Storey 4	Storey 5	Storey 6	Storey 7	Storey 8	Storey 9	Storey 10	Storey 11	Storey 12
DCR-B 65	4.3	3.9	3.8	3.73	3.65	2.9	2.65	2.45	2.3	2.3	2.1	3.5
DCR-B 64	4.28	3.72	2.68	2.62	2.5	2.4	2.39	2.3	2.33	2.3	2.4	3.19
DCR-B 19	4.2	3.95	3.65	3.37	2.95	2.9	2.85	2.65	2.35	2.15	2.1	3.05
DCR-B 18	4.17	3.37	2.9	2.66	2.55	2.4	2.38	2.28	2.23	2.26	2.3	3.19

Figure 6: ***DCR values for Beams in flexure near to critical column C 12 of GF***



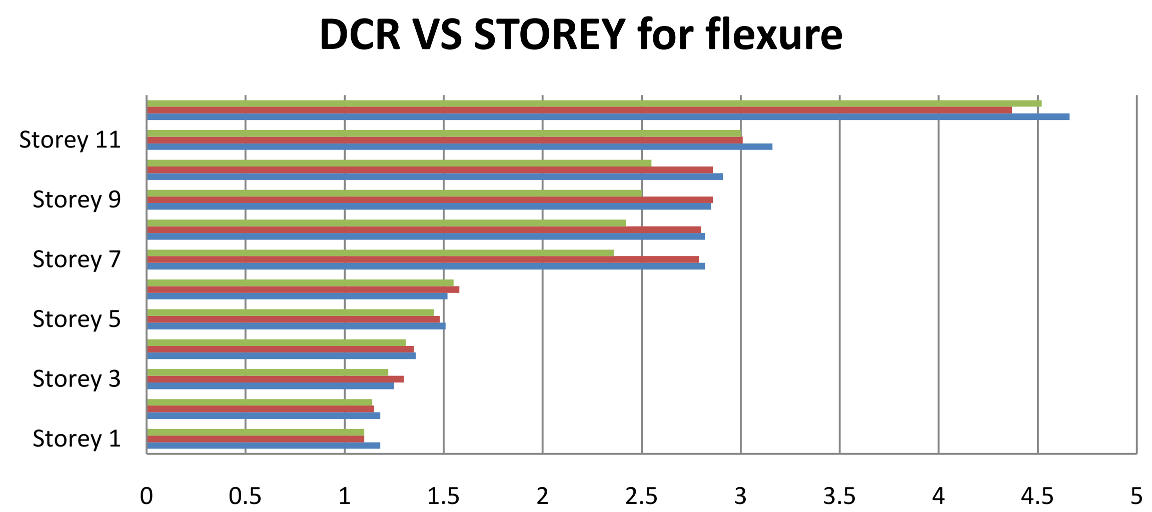
	Storey 1	Storey 2	Storey 3	Storey 4	Storey 5	Storey 6	Storey 7	Storey 8	Storey 9	Storey 10	Storey 11	Storey 12
DCR-B 76	1.17	1.31	1.49	1.67	1.98	1.98	3.6	3.9	4.02	4.42	4.5	4.56
DCR-B 5	1.09	1.15	1.2	1.26	1.4	1.28	2.29	2.35	2.47	2.57	2.8	4.2

Figure 7: ***DCR values for Beams in flexure near to critical column C 41 of 7th floor***



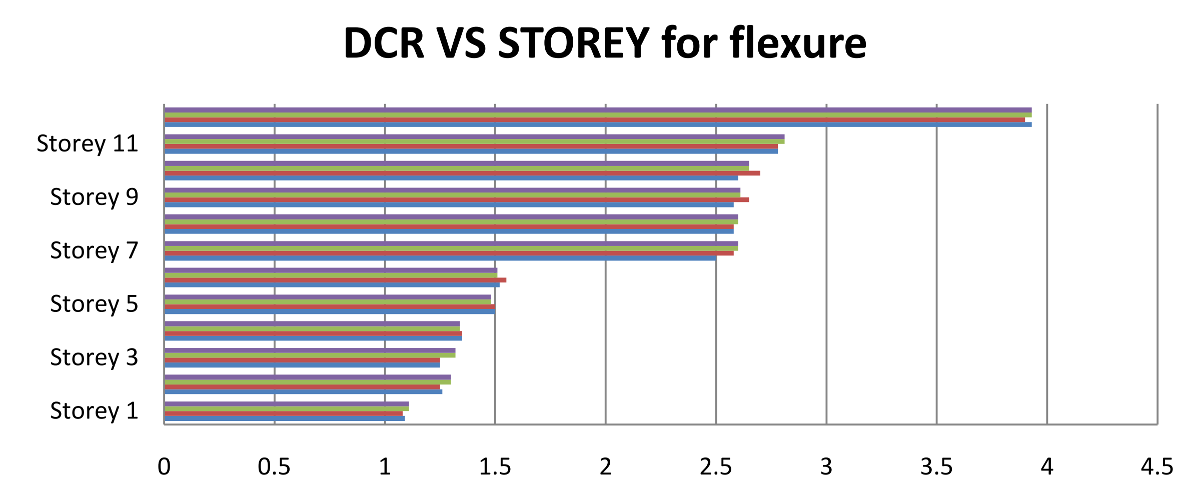
	Storey 1	Storey 2	Storey 3	Storey 4	Storey 5	Storey 6	Storey 7	Storey 8	Storey 9	Storey 10	Storey 11	Storey 12
DCR-B 79	1.1	1.16	1.25	1.36	1.5	1.52	2.82	2.85	2.9	3	3.1	4.5
DCR-B 78	1.1	1.16	1.25	1.36	1.51	1.54	2.84	2.88	2.92	2.97	3.06	4.62
DCR-B 20	1.08	1.16	1.22	1.3	1.45	1.35	2.33	2.39	2.41	2.51	3.01	4.47

Figure 8: ***DCR values for Beams in flexure near to critical column C 31 of 7th floor***



	Storey 1	Storey 2	Storey 3	Storey 4	Storey 5	Storey 6	Storey 7	Storey 8	Storey 9	Storey 10	Storey 11	Storey 12
DCR-B 62	1.1	1.14	1.22	1.31	1.45	1.55	2.36	2.42	2.5	2.55	3	4.52
DCR-B 4	1.1	1.15	1.3	1.35	1.48	1.58	2.79	2.8	2.86	2.86	3.01	4.37
DCR-B 3	1.18	1.18	1.25	1.36	1.51	1.52	2.82	2.82	2.85	2.91	3.16	4.66

Figure 9: ***DCR values for Beams in flexure near to critical column C 39 of 7th floor***



	Storey 1	Storey 2	Storey 3	Storey 4	Storey 5	Storey 6	Storey 7	Storey 8	Storey 9	Storey 10	Storey 11	Storey 12
DCR-B 65	1.11	1.3	1.32	1.34	1.48	1.51	2.6	2.6	2.61	2.65	2.81	3.93
DCR-B 64	1.11	1.3	1.32	1.34	1.48	1.51	2.6	2.6	2.61	2.65	2.81	3.93
DCR-B 19	1.08	1.25	1.25	1.35	1.5	1.55	2.58	2.58	2.65	2.7	2.78	3.9
DCR-B 18	1.09	1.26	1.25	1.35	1.5	1.52	2.5	2.58	2.58	2.6	2.78	3.93

Figure 10: ***DCR values for Beams in flexure near to critical column C 12 of 7th floor***

3.3 Determination of PMM (column forces) values for the columns neighboring to removed columns:

Table 3: ***Column forces for the case of removal of critical column C-41***

Building parameters related to C-40	Value in Damaged condition	Value in Intact condition	Increment in Percentage
Axial load (kN)	4279.35	3201.26	33.60%
Bending moment (kN-m)	101.10	89.02	13.56%
Shear force (kN)	67.97	48.65	39.57%

Table 4: ***Column forces for the case of removal of critical column C-31***

Building parameters related to C-30	Value in Damaged condition	Value in Intact condition	Increment in Percentage
Axial load (kN)	4259.94	3295.50	31.66%
Bending moment (kN-m)	192.84	114.95	67.75%
Shear force (kN)	46.19	40.15	15.04%

Table 5: ***Column forces for the case of removal of critical column C-39.***

Building parameters related to C-38	Value in Damaged condition	Value in Intact condition	Increment in Percentage
Axial load (kN)	4277.61	3295.50	29.80%
Bending moment (kN-m)	197.83	98.48	100.08%
Shear force (kN)	91.53	38.72	136.38%

Table 6: ***Column forces for the case of removal of critical column C-12***

Building parameters related to C-13	Value in Damaged condition	Value in Intact condition	Increment in Percentage
Axial load (kN)	6220.20	4120.77	50.94%
Bending moment (kN-m)	288.98	185.54	55.75%
Shear force (kN)	112.47	54.22	107.43%

IV. CONCLUSION

Direct static investigation for dynamic breakdown opposition assessment of a 12 storey RC building has been done for four column removal case namely corner, short edge, long edge and interior as per GSA 2013. Column has been removed at ground floor and at 7th storey each in turn and DCR proportions for shafts in flexure just as shear and PMM values sections are assessed and introduced as bar diagrams.

Beams only up to the topmost storey are going to fail for any Column evacuation instance of ground floor and flexure in pillar is the basic criteria in dynamic breakdown procedure of structure.

For the basic cases seventh story inside evacuation case upper 4 story Beams are a larger number of worries than lower story beams. Since PMM estimations of the greater part of the section (with the exception of C38 and C13) is under 2, segments are not basic in dynamic breakdown procedure of structure. Interior column removal case is the most critical (since values of PMM are nearer to limiting value i.e. 2.0) and corner column removal case is least critical for ground floor column removal.

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