Progressive Collapse Analysis of a High Rise Building with RCC Column in a Zone of Severe Seismic Intensity

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Abstract: *The progressive collapse of building structure is initiated when one or more vertical load carrying members are removed. Once a column is removed or made weak, due to man-made or natural hazards, load carried by column removed is transferred to neighbouring columns in the structure, if the neighbouring column is incapable of withstanding the extra load, leads to the progressive failure of adjoining members and finally to the failure of partial or whole structure. The collapsing system continually seeks alternative load paths in order to survive. Hence this study is made to examine the potential ability of seismically designed building against progressive collapse. A high rise building of RCC column of a symmetrical building was considered in the study to evaluate the Demand Capacity Ratio, the ratio of the member force and the member strength as per U.S. General Services Administration (GSA) guidelines. The Linear static analysis is carried out using software, ETABS 2015 according to Indian Standard codes. The behaviour of the building is studied and Demand Capacity Ratio is calculated for story.*

INTRODUCTION

Progressive Collapse

Such term as one of a kind breakdown was showed up not too quite a while back. Since makers looked with this marvel in 1968 when the Ronan Point town house building was squashed. The structure was a 22-story with precast solid, bearing dividers. A gas sway in a corner on the eighteenth floor smothered the outside divider board and frustration of the corner waterway of the structure spread upward to the rooftop structure and down till the ground level, anyway the entire structure didn't suffer (More about this model will be showed up in another bit of the segment). So this event looked like a push for further examination of that sort of breakdown in Europe, USA and Russia. After that the term dynamic breakdown has been used to depict the incite of a basic neighborhood dissatisfaction in a manner like a chain reaction that causes to fragmentary or full scale breakdown of the structure. The fundamental typical for the dynamic breakdown that the end state of the destructions is excessively more vital than the failure that made the breakdown. However, what does the term dynamic breakdown mean?

As showed by the Russian benchmarks it suggests: Progressive breakdown is a consistent obliteration of the bearing structures of the due to the hidden neighborhood mischief to the individual transporters of fundamental fragments & provoking the breakdown of the entire structure/ liberal part

Concerning the European codes: Progressive breakdown is the spread of neighborhood hurt, from a beginning event, from segment to segment coming to fruition, at last, in the breakdown of an entire structure or a too much huge bit of it; generally called unbalanced breakdown

As can be seen the various benchmarks approach the dynamic breakdown in various propensities, yet they share for all intents and purposes a couple of cutoff focuses for the level of the mischief. Usually pulverization in such a breakdown would widen one assistant segment, a100 m22 of floor an area, or two stories. That kind of mishap can be begun by various causes, including structure and improvement slip-ups and burden events that are over arrangement estimations or are not considered. Such events would join surprising weights not ordinarily considered in an endeavor. The potential sporadic burdens that can cause the dynamic breakdown are organized that way

Objectives

Here the models are dissected for the examination where the sections are utilized for the (G+12) story building and the static investigation is done. The Demand limit Ratio is determined for the corner segment evacuation of a structure. The material properties and parameters are considered as required for the investigation and coming up next are the goals

- The conduct of the structure is examined by considering the SFD and BMD

- The Demand Capacity Ratio is determined for the close by sections and checking, according to the GSA rules.

REVIEW OF LITERATURE

Yash Jain , Dr.V.D. Patil Done tackle 'Examination of Progressive Collapse for a Multi Story RC Framed Structure using Linear Static Analysis Technique' in which he inspected the straight static examination approach has been grasped here for choosing healthiness against the close by frustration and accidental occasions for a RC circled structure to survey as far as possible extent and the security of the structure.

The given end is that the direct static investigation, it is discovered that the segment number C31, C12 and C 76 are seen as basic as they flop in plan criteria and therefore prompting the four instances of section evacuation for examination. As the DCR esteem for every one of the bars in the examination is under 1.5 (as indicated in GSA rules), there is no bar that has experienced the disappointment for all the segment evacuation cases viable. In Case 1, the segment C-48 contiguous the basic segment C-31 has been bombed in shear and has the DCR esteem as 1.78, which is more prominent than the worthy furthest reaches of 1.5 as gave in GSA rules. In Case 2, the segment C-23 contiguous the basic segment C-12 has been flopped in pivotal, bowing and shear and has the DCR esteem as 1.56, 1.56 and 1.78 individually, which is more prominent than the satisfactory furthest reaches of 1.5 as gave in GSA rules. In Case 3, the segment C-74 adjoining the basic segment C-76 has been flopped in pivotal and bowing and has the DCR esteem as 1.56 and 1.55 separately, which is more noteworthy than the adequate furthest reaches of 1.5 as gave in GSA rules. In Case 4, the segment C-48, C-23 and C-74 nearby the basic segment C-31, C-12 and C-76 separately has been flopped in hub and bowing and has the DCR esteem as 1.78, 1.78 and 1.60 individually, which is more prominent than the worthy furthest reaches of 1.5 as gave in GSA rules. It is seen in the investigation that there is roughly 78 % addition of the underlying incentive in the prompt adjoining individuals (with the exception of C-74), of the expelled component because of huge redistribution of powers in both longer and shorter bearing while there is move of around 24 % to 30 % augmentation of the underlying incentive in the contiguous section in inside area. The heap moving impact on the closest individual from the expelled segment is more and is irrelevant when moved away from the evacuated segment. Since DCR proportion for the majority of the segment (aside from ground floor sections C-48, C-23, C-74) is under 1.5, these segments are not basic in dynamic breakdown procedure of the structure.

Ruchika Mishra, Sima Padamwar and Manish Saklech completed work on 'Dynamic Collapse Analysis on Reinforced Concrete Structures' in which they considered The interest limit proportion is evaluated in the basic district of the RC bit related with the section evacuated, according to the arrangements of GSA rules.

The given end is that the Progressive breakdown is the consequence of a confined disappointment of a couple of auxiliary components that lead to a relentless movement of burden move that surpasses the limit of other encompassing components, in this way starting the movement that prompts an aggregate or fractional breakdown of the structure.

Sonu Mangla, Dr. aShailendra Kumar Tiwary, Rishabh Sharma , Mohd. Tauseef Husain done arrangement with 'Dynamic Collapse Behavior of Reinforced Concrete Building Based on Non Linear Static Analysis' in which they proposed to consider dynamic breakdown examination of G+12 story sustained strong packaging working by Non-Linear Static assessment.

The given end is that By Observing turn advancement plan in all the three cases of area removal of nonlinear static assessment obviously inside section clearing is most dangerous and corner fragment ejection is least unsafe. observing all the three case it has found that Nonlinear turn in lower story shafts has gone past E-state (frustration) which infers that lower story columns are more fundamental than upper story bars. A Special moment restriction packaging organized by IS 456 and point by point by IS 13920 doesn't give security from dynamic breakdown this is an immediate aftereffect of that SMRF is planned for parallel weights and in unique breakdown the mistake weights are gravity loads.

METHODOLOGY

For the investigation of dynamic breakdown examination of a tall structure with RC segments on a high seismic power zone, I have broke down the two models. The conduct of the structure is broke down when the corner segment are expelled in a tall structure.

The bar and segment sizes are planned in the ETABS and afterward taken for the investigation of the models. The material and different properties are taken is clarified in the technique for the demonstrating. The static investigation is completed for the examination of the models.

Modelling Cases and Procedure for Preparing the Models

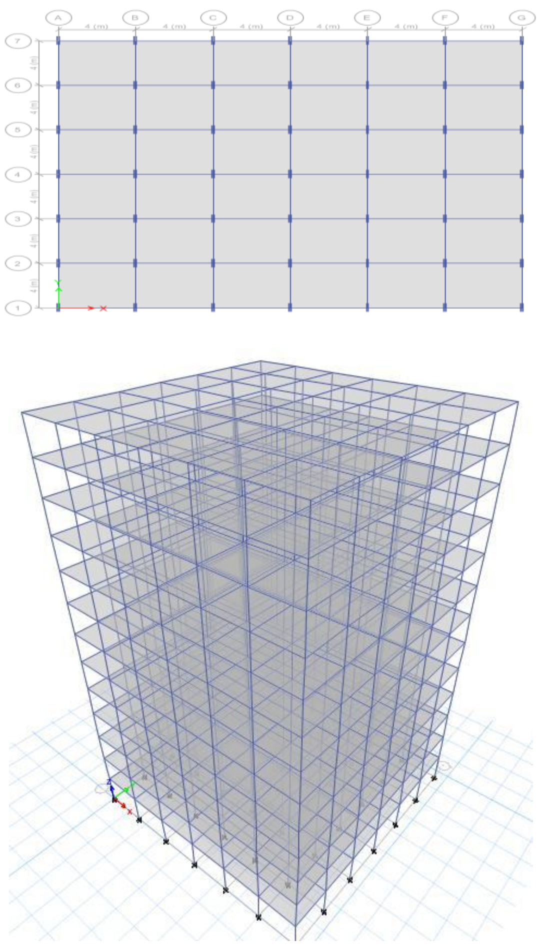
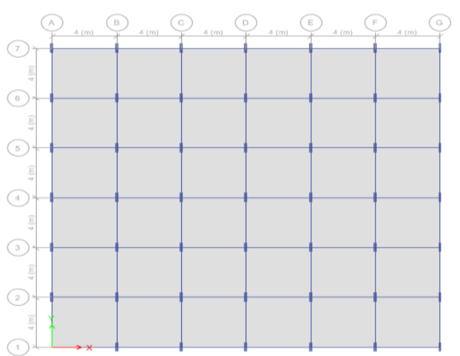


Fig 1 Plan and 3D Model of RCC Column Building



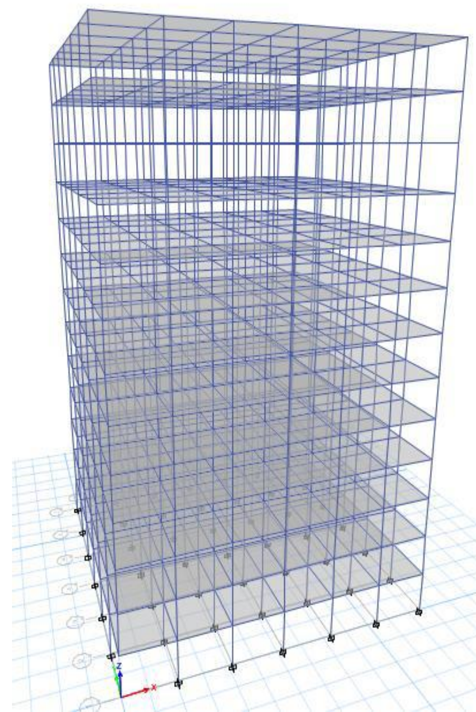


Fig 2 Plan and 3D Model of RCC Column Building with Corner Column Removed

Table 1 Material Properties

Density of RCC	25 KN/m^3
Density of Masonry	19.2 KN/m^3
Compressive Strength, f_{ck}	25 N/mm^2
Steel, f_y	500 N/mm^2&415 N/mm^2
Modulus of Elasticity, E_c	$5000*(f_{ck})^{0.5}$

Table 2 Data / Parameters for the analysis of Problem.

Each Storey Height	3m
Grid Spacing	4m
Wall Thickness	200 mm
Thickness of Slabs	150 mm
Size of Beams	200 x 600 mm

Size of Columns	200 x 750 mm
Building Frame System	Ordinary RC Moment Resisting Frame
Parapet Height	600 mm
Supports	Fixed

Table 3 Loading Conditions

SLAB	SDL Assuming, Floor Finish = 1.5KN/m LIVE Considered as per IS 875 (part 2)-1987 i.e., Live Load = 3 KN/m^3
WALL	For 200 mm thick Wall load = (3-0.6) * 0.2 * 16 = 7.68 KN/m Parapet wall load = 0.6 * 0.1 * 16 = 0.96 KN/m
EARTHQUAKE LOADS	All the structure edges are investigated for one seismic Zone-4,the seismic parameters for structure edges are Reaction Reduction Factor =3, Importance Factor = 1. Damping = 5 %, Soil Type is Medium and the basic common time frame is 0.075*h 0.75. Where 'h' is tallness.

RESULTS AND DISCUSSIONS

Here the two model are created utilizing the ETABS 2015 with and without the shear sections and contrasted and the Demand Capacity Ratio of the close by segments. The main corner segment is taken in to thought in view of the site conditions and neighborhood the site.

Shear Force and Bending Moment Diagrams

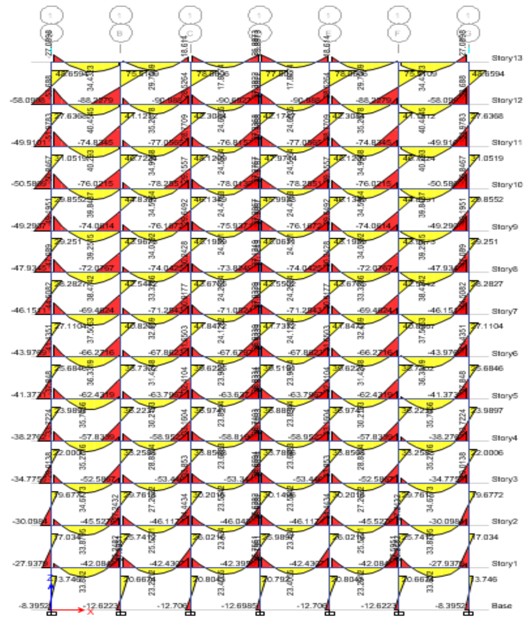


Fig 3 Bending Moment Diagram for DCON 2 Load

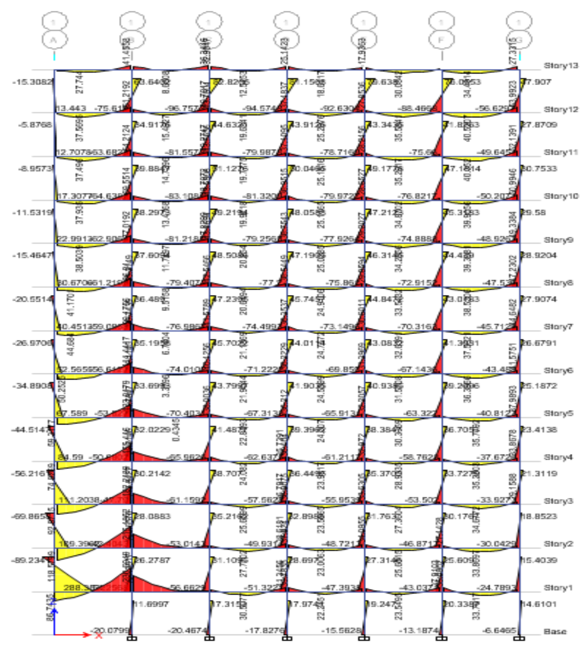


Fig 4 Bending Moment Diagram for DCON 2 Load when Corner Column is removed

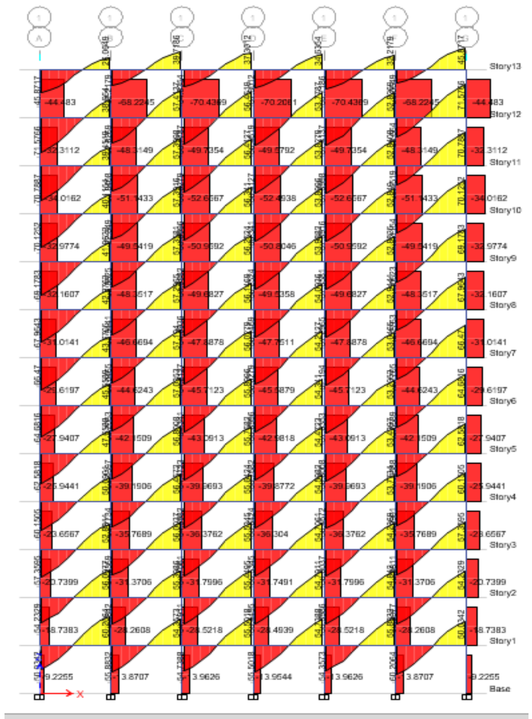


Fig 5 Shear Force Diagram for DCON 2 Load

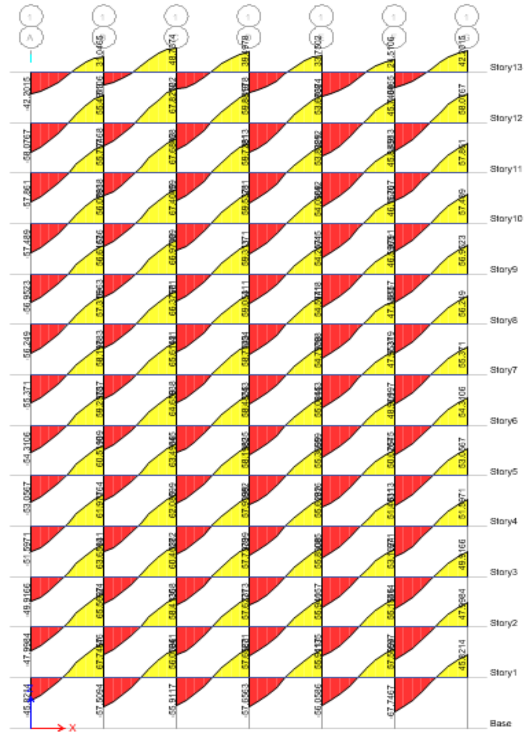


Fig 6 Shear Force Diagram for DCON 2 Load when Corner Column is removed

From the above figures of bending moment and shear force diagrams it is seen that the when the corner column is removed the neighbouring columns will take the loads.

Demand Capacity Ratios

Table 4 Comparisons of Values for the Corner Column Removed on Story 1

Removed Column	Parameters Related to	Building Parameters	Value in Intact Condition	Value in Damaged Condition	Increment in Percentage
C1	C2	SF (kN)	1.7550	64.0344	35.48
		BM(kN-m)	2.6150	105.3300	39.27
	C8	SF (kN)	13.8707	13.2415	-0.045
		BM(kN-m)	20.6674	20.0799	-0.028
	C9	SF (kN)	2.7081	4.4530	0.644
		BM(kN-m)	4.0351	12.0824	1.99

Table 5 Comparisons of Values for the Corner Column Removed on Story 2

Removed Column	Parameters Related to	Building Parameters	Value in Intact Condition	Value in Damaged Condition	Increment in Percentage
C1	C2	SF (kN)	5.6452	105.7145	17.72
		BM(kN-m)	7.2080	164.1008	21.76
	C8	SF (kN)	28.2608	32.3064	0.143
		BM(kN-m)	42.0848	51.2568	0.217
	C9	SF (kN)	8.6241	17.1114	0.984
		BM(kN-m)	11.0436	27.0589	1.45

Table 6 Comparisons of Values for the Corner Column Removed on Story 3

Removed Column	Parameters Related to	Building Parameters	Value in Intact Condition	Value in Damaged Condition	Increment in Percentage
C1	C2	SF (kN)	9.4836	89.6540	8.45
		BM(kN-m)	13.2205	139.3912	9.54
	C8	SF (kN)	31.3706	29.3719	-0.063
		BM(kN-m)	45.5276	42.4043	-0.068
	C9	SF (kN)	14.3684	15.9995	0.113
		BM(kN-m)	20.0561	22.6757	0.130

Table 7 Comparisons of Values for the Corner Column Removed on Story 4

Removed Column	Parameters Related to	Building Parameters	Value in Intact Condition	Value in Damaged Condition	Increment in Percentage
C1	C2	SF (kN)	12.7480	76.7596	5.021
		BM(kN-m)	18.2009	118.8495	5.529
	C8	SF (kN)	35.7689	32.5017	-0.091
		BM(kN-m)	52.5867	47.7900	-0.091
	C9	SF (kN)	19.2042	18.6416	-0.029
		BM(kN-m)	27.4496	26.9575	-0.017

Table 8 Demand Capacity Ratios of the Adjacent Member of the Critical Columns

Story	Parameters Related to	Building Parameters	DCR Values	Permissible Limit	Remark
1	C2	SF (kN)	36.48	1.5	Failed in Shear
		BM(kN-m)	40.27	1.5	Failed in Bending
	C8	SF (kN)	0.95	1.5	Passed in Shear
		BM(kN-m)	0.97	1.5	Passed in Bending
	C9	SF (kN)	1.64	1.5	Failed in Shear
		BM(kN-m)	2.99	1.5	Failed in Bending

2	C2	SF (kN)	18.72	1.5	Failed in Shear
		BM(kN-m)	22.76	1.5	Failed in Bending
	C8	SF (kN)	1.14	1.5	Passed in Shear
		BM(kN-m)	1.21	1.5	Passed in Bending
	C9	SF (kN)	1.98	1.5	Failed in Shear
		BM(kN-m)	2.45	1.5	Failed in Bending
3	C2	SF (kN)	9.4	1.5	Failed in Shear
		BM(kN-m)	10.54	1.5	Failed in Bending
	C8	SF (kN)	0.93	1.5	Passed in Shear
		BM(kN-m)	0.93	1.5	Passed in Bending
	C9	SF (kN)	1.11	1.5	Passed in Shear
		BM(kN-m)	1.13	1.5	Passed in Bending
4	C2	SF (kN)	6.02	1.5	Failed in Shear
		BM(kN-m)	6.53	1.5	Failed in Bending
	C8	SF (kN)	0.90	1.5	Passed in Shear
		BM(kN-m)	0.90	1.5	Passed in Bending
	C9	SF (kN)	0.97	1.5	Passed in Shear
		BM(kN-m)	0.98	1.5	Passed in Bending

CONCLUSIONS

1. From the bowing minute and shear power outlines it is seen that the when the corner segment is expelled the neighboring sections will take the heaps.
2. It is seen that the C2 section is bombing in both the shear and twisting which is having more than 1.5 admissible points of confinement and there is diminishing in the Demand Capacity Ratio as increment in the Storys.
3. The neighboring segment C8 is passed in both the shear and twisting which is inside as far as possible in all the storys.
4. The segment C9 is bombed in Shear and Bending in the story 1 and 2 yet in story 3 and 4 it is passed.
5. The C8 and C9 is passed in both the shear and twisting from the story 3 or more yet on account of C2 there is decline in the Demand Capacity Ratio as the story increments, thusly an uncommon consideration ought to be taken when the corner section is evacuated.

REFERENCES

1. Yash Jain, Dr.V.D. Patil, "Assessment of Progressive Collapse for a Multi-Storey RC Framed Structure using Linear Static Analysis Technique" International Journal of Engineering Trends and Technology (IJETT) – ISSN: 2231-5381 Volume 60 Number 3 - June 2018.
2. Ruchika Mishra, Sima Padamwar and Manish Saklecha, "Progressive Collapse Analysis on Reinforced Concrete Structures" Indian J.Sci.Res. 14 (2): 323-326, ISSN: 2250-0138 2017.
3. R. Jeyanthi, S. Mohan Kumar, "Progressive Collapse Analysis of a Multistorey RCC building using Pushover Analysis", International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, Vol. 5 Issue 03, March-2016
4. Sonu Mangla, Dr. Shailendra Kumar Tiwary, Rishabh Sharma, Mohd. Tauseef Husain, "Progressive Collapse Behaviour of Reinforced Concrete Building Based on Non-Linear Static Analysis", International Research Journal of Engineering and Technology (IRJET), e-ISSN: 2395-0056, p-

ISSN: 2395-0072, Volume: 05 Issue: 05, May-2018.

5. Mrs. Mir Sana Fatema, Prof. A.A. Hamane "Progressive Collapse of Reinforced Concrete Building" International Journal of Emerging Trends in Science and Technology, December2016.

BIOGRAPHIES

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