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Progressive Collapse Analysis of RC Shear Wall Building

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***Abstract*—Thisresearchpaperpresentsa progressive collapse analysis of sixteen storey RC shear wall building under extreme loads. The progressive collapse analysis of RC shear building is evaluated under various column removal conditions. Linear static analysis and linear dynamic analysis are carried out for different column removal conditions. Change in demand capacity ratio of building is also identified. As load combinations are different, changes are found in collapse pattern. The outcome of this study has provided reference for progressive collapse prevention designs of high rise RC shear wall building. This study also aimed to understand the progressive collapse process and to discover new methods and ideas for designing structures that would prevent any such type of failure.**

Keywords— High Rise Building, Reinforced Concrete, Shear Wall, Progressive Collapse, ETABs

I. INTRODUCTION

The planning and design stage of building structures require the right choice of structural frame configuration and construction materials in delivering an efficient building that meetsclients requirements.The terminology of progressive collapse is defined as 'the spread of an initial local failure from element to element, eventually resulting in the collapse of an entire structure or a disproportionately large part of it' [1].

There are basically two approaches when dealing with the evaluation and prevention of progressive collapses in a given structure. The first indirect approach consists in ensuring that the structure satisfies prescriptive design rules (such as requirements on structural integrity and ductility or the presence of vertical and horizontal ties). The second direct approach uses two possibilities depending on whether local failure is allowed or not [2].Resistance of building structures to progressive collapse has been an important task for the development of structural design codes. Some study results, code approaches, and design strategies or standards have been reviewed, discussed, and/or compared in the literatures [3]. The assessment presented in this paper is limited to sixteen storey RC building structure.The evaluation of frame structure focuses on joint displacement responses and redistribution of internal forces as a result of sudden column loss.

Shear wall is a structural member used to resist earthquake forces acting on the structure. In high rise buildings, shear walls are generally located at the centre of the building normally in the form of core wall system to accommodate vertical translation system such as lifts.Failure pattern of building elements like beam column depends upon the location of shear wall.

Thesubsequentsectionsofthisresearchpaperwillpresentdetailedmethodologies,results,andanalysestoshowcase the advantages of using shear wall in building with respect to progressive collapse analysis.

II. METHODOLOGY

This work entails utilizing ETABs computer software to analyse a multi-storey structure under various damage scenarios. In these instances, vertical structural components are removed from various locations, which shows local damage and examines how they affect the structure. An analysis is carried out and the geometric parameters of the building used are defined.

1. Thesixteen storeyshear wall building is designed in ETABs according to IS code, and output data for moment, shear force and axial force are produced without deleting any column.
2. A column is withdrawn from the location under consideration, and linear static and linear dynamic analysis are performed to the modified structure using load combinations.
3. The load combinations are entered into the ETABs software and run the analysis in ETABs and results are obtained for each case of location of column removal on the model.
4. Demand in terms of shear force, bending moment and axial force are evaluated from the analysis. Capacity at critical sections is obtained from without column removing model which is designed in ETABs and find out the Demand

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Capacity Ratio of members.

5. If the Demand Capacity Ratio exceeds permissible values, the element is considered failed.

1. Structural Model Description

For the purpose of this investigation, sixteen storey building is used as shown in fig. 1.

1. Seismic Zone : IV
2. Type of soil : Medium
3. Importance Factor : 1
4. Response reduction factor : 5
5. Number of Stories : G + 15
6. Length in X Direction : 35m
7. Length in Y Direction : 35m
8. Storey Height : 3.5m
9. Materials : HYSD 415, M30
10. Unit Weight of RCC : 25 kN/m^3
11. Unit Weight of Masonry : 20 kN/m^3
12. Thickness of Slab : 150mm
13. Codal Provision : IS 456: 2000, IS 1893:2016, IS 800:2007
14. Live load : 4 kN/m^2
15. Floor Finish : 1.5 kN/m^2
16. External Wall : 13.34 kN/m
17. Internal Wall : 8.7 kN/m
18. Beam 450mm X 600mm
19. Column 600mm X 750mm
20. Wall 200 mm Thickness
21. Clear Cover to beam : 25mm
22. Clear Cover to column : 40mm

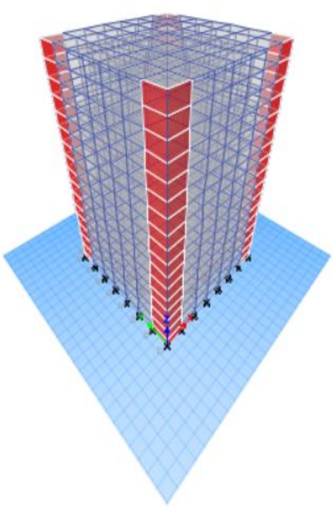

Fig. 1. Building with shear wall

2. Study locations of the columns

These locations are the edge column removal scenario (ECRS), corner column removal scenario (CCRS) and the interior column removal (ICRS). These locations are shown on
the floor plan of the building.

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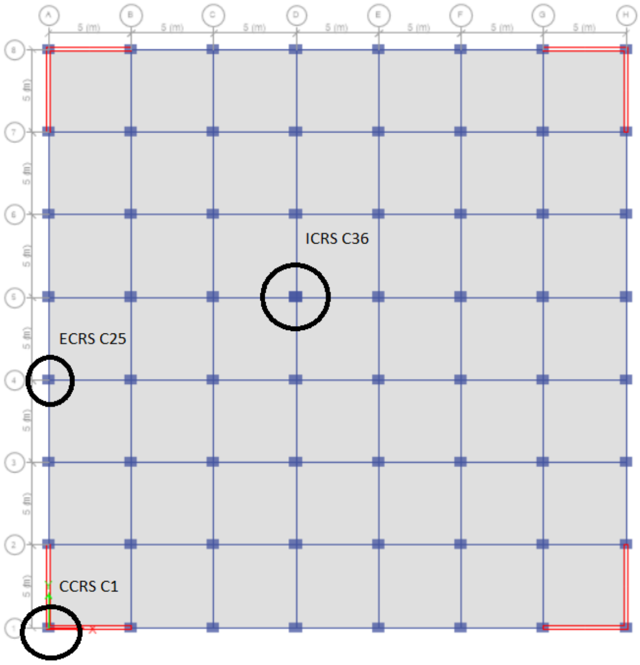

Fig.2. Locations of columns C1, C25 and C36

III. RESULTS AND DISCUSSION

1. Linear Static Analysis
In linear static analysis, vertical element is eliminated from the position being considered and linear static analysis with gravity load i.e. dead load, live load and seismic load on the structure has been conducted.
This table shows basic parameters considered for seismic analysis

TABLE I. SEISMIC PARAMETERS

Total Weight of structure	Wi	504653.6819KN
Zone Factor	Z	0.24
Importance factor	I	1.2
Response reduction factor	R	5
Average response acceleration coefficient		
	Sa/g	2.5
Design horizontal seismic coefficient (Ah)		0.04
Base shear		5783.1643KN

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Mass Participation		
Building with Shear Wall		
First Mode	UX	0%
T = 1.552	UY	71.31%
	RZ	0
Second Mode	UX	71.56%
T = 1.498	UY	0%
	RZ	0%
Third Mode	UX	0%
T = 1.085	UY	0%
	RZ	68.43%
Cumulative Participation	UX	71.56%
	UY	71.31%

This table shows the time period and mass participation ratio i.e. the percentage of how much the structural mass of the model is participating for a given direction and mode

TABLE II. MASS PARTICIPATION AND TIME PERIOD

Removal of single column, one at a time, is studied for load combination of DL, LL and EQ load in X direction with a load factor of 1.2

For Model, columns are removed at ground storey

1. C1
2. C25
3. C36

After removal of column C1 and C25 no failure of beams and columns are observed. After removal of C36 four beams failed. By considering demand and capacity of the structure members demand and capacity ratio is calculated.

TABLE III. SINGLE COLUMN REMOVAL CASE

No. of Column	**Negative Moment (Max D/C)**	**No. of failed Beams**	**Positive Moment (Max D/C)**
C36	2.43	B52, B59, B60, B67	3.12

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.g.3. Location of single columnsremoved at ground storey

Removal of two column, two at a time is studied for load combination of DL, LL and EQ in X direction with a load factor of 1.2 After removal of column C1 and C2 no failure of beams and columns are observed.

For Model, columns are removed at ground storey

1. C1 and C2
2. C36 and C37

By considering demand and capacity of the structure members demand and capacity ratio is calculated.

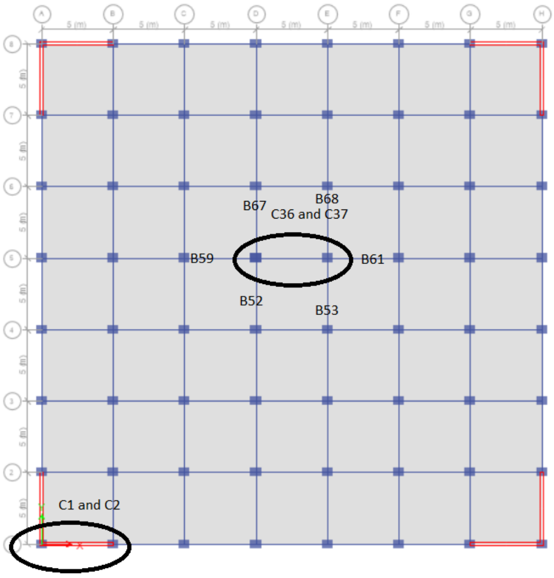

Fig.4. Location of two columns removed at ground storey

TABLE IV. TWO COLUMN REMOVAL CASE

TABLE V. SHEAR FORCE, AXIAL FORCE AND BENDING MOMENT VALUES BEFORE AND AFTER REMOVING COLUMNS AND BEAMS

	Axial force before removing column(kN)	**Axial force after removing column(kN)**	**Shear force before removing column(kN)**	**Shear force after removing column(kN)**	**Bending Moment before removing column(kNm)**	**Bending moment after removing column(kNm)**
C2	5488.8647	5431.8640	31.4601	41.1745	39.1032	43.1322
C9	2490.6529	2433.7376	1.8888	1.4751	75.7726	73.9185
B6	17.2997	18.5991	126.9027	127.8010	93.0133	94.8889
B12	15.0883	15.7575	129.5236	128.8786	87.3327	86.0302

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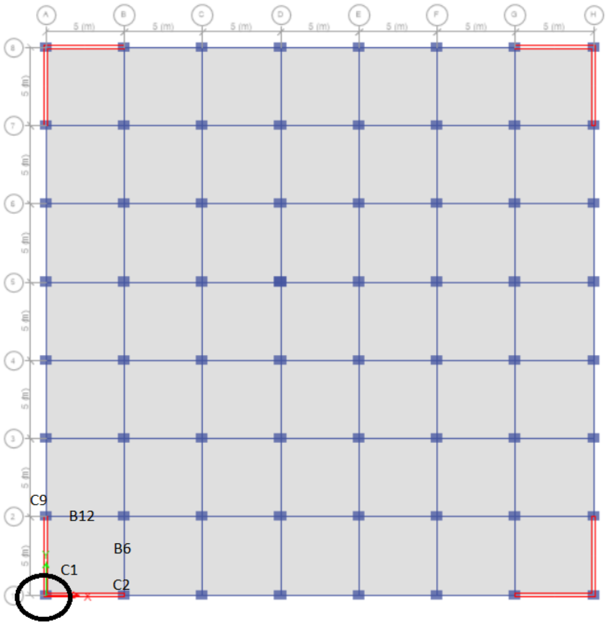

Fig.5. Location of columns C1, C2, C9 and Beams B6, B12

TABLE VI. SHEAR FORCE, AXIAL FORCE AND BENDING MOMENT VALUES BEFORE AND AFTER REMOVING COLUMNS

Fig. 6. Location of columns C17, C25, C33andBeams B34,

	Axial force before removing column(kN)	Axial force after removing column(kN)	Shear force before removing column(kN)	Shear force after removing column(kN)	Bending Moment before removing column(kNm)	Bending moment after removing column(kNm)
C17	6042.7846	7774.3189	23.4579	10.4730	95.1835	83.9157
C33	6851.0375	8610.1119	25.7701	9.7648	95.7161	83.8607
B34	3.5415	40.4844	96.5156	382.0250	69.2535	674.3943
B42	16.3593	125.2337	141.5838	386.6627	110.6541	660.8897
B49	8.2312	38.8618	94.6145	380.5044	65.5667	671.1806

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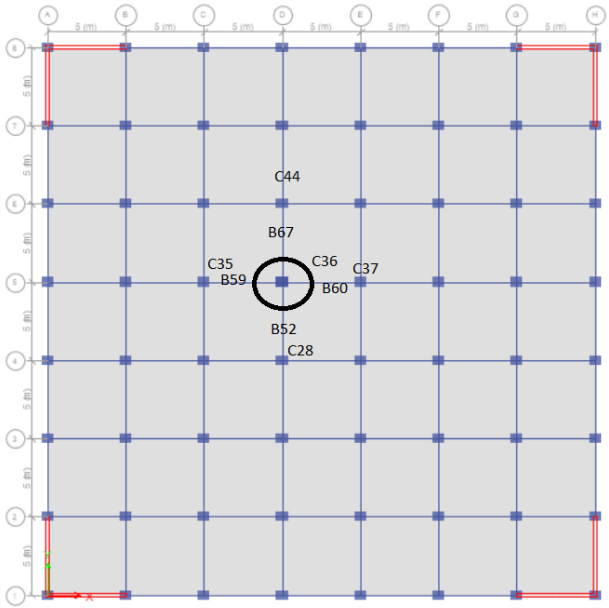

Fig. 7. Location of columns C28, C35, C36, C37, C44 and Beams B52,B59, B60, B67

TABLE VII. SHEAR FORCE, AXIAL FORCE AND BENDING MOMENT VALUES BEFORE AND AFTER REMOVING COLUMNS

	Axial force before removing column(kN)	Axial force after removing column(kN)	Shear force before removing column(kN)	Shear force after removing column(kN)	Bending Moment before removing column(kN)	Bending moment after removing column(kN)
C28	10393.8027	12212.2276	51.0918	54.5196	100.4776	104.6193
C35	10239.5217	12074.7732	49.3315	213.4565	99.6864	298.8391
C37	10535.6787	12371.7859	51.1440	199.6168	100.8643	279.4635
C44	10804.4498	12592.3997	51.0996	6.8986	101.0446	9.6580
B52	0.4902	18.6834	127.0516	459.9155	93.2342	810.2621
B59	15.7448	16.3346	141.5406	450.9801	115.8975	764.6361
B60	13.9629	14.9447	142.3727	483.6788	119.2021	842.1948
B67	1.9114	3.2011	127.7694	456.4183	94.6286	800.4328

Response Spectrum:

This method allows for the consideration of building's response. A structure response can be defined as a collection of many different particular forms that corresponds to harmonics in a vibrating string. This modes of structure can be determined through computer modelling.

TABLE VIII. MASS PARTICIPATION, TIME PERIOD

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BASE SHEAR AND RESPONSE SPECTRUM VALUES

EQX	5783.1643KN
EQY	5783.1643KN
RSX	5834.2987KN
RSY	5834.2987KN
First Mode	T= 1.552, UY = 71.56%
Second Mode	T= 1.498, UX= 71.31%
Third Mode	T= 1.085, UX= 0%, UY= 0%

IV.CONCLUSION:

1. The axial force at the base is greater in the column removed case than in the normal case.
2. The interior column removal case at the base is discovered to be the most critical case for progressive failure than the corner and edge column removal.
3. The shear wall restricts the structure from failure but only at the place where shear wall is provided.
4. Top floor column gives less damage as compare to ground or bottom storey column removal.

V. REFERENCES:

1. ASCE. SEI/ASCE 7-05 minimum design loads for buildings and other structures. Washington (DC): *American Society of Civil Engineers*; 2005
2. Kokot, S., Anthoine, A., Negro, P., and Solomos, G. (2012), "Static and dynamic analysis of a reinforced concrete flat slab frame building for progressive collapse." *Engineering Structures;*40, 205-217.
3. Meng-Hao Tsai.,Bing-Hui Lin.,(2008), "Investigation of progressive collapse resistance and inelastic response for an earthquake-resistant RC building subjected to column failure*." Engineering structures; 3619-3628.*