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Progressive Collapse Analysis Of G+14 Structures With Column Removal And Belt Wall Implementation Using Etab

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ABSTRACT: Progressive collapse is a major structural safety concern in multi-story buildings, where the failure of a load-bearing column can cause load redistribution and subsequent failure of surrounding structural members. This study investigates the progressive collapse behaviour of a G+14 reinforced concrete building using ETABS under different column-removal scenarios. Key structural responses, including joint displacement, bending moment, shear force, axial force, and load redistribution, are evaluated. The study also examines the effectiveness of a belt wall system in improving structural performance after localized column failure. A comparative analysis of structures with and without a belt wall is conducted to assess its influence on stiffness, deformation, load transfer, and overall structural stability. The results provide insights into vulnerable structural locations and the effectiveness of belt walls as a mitigation measure for improving the robustness and progressive-collapse resistance of reinforced concrete buildings.

Keywords: Multi Story, High Rise Building, Belt Wall, Progressive Collapse.

I. INTRODUCTION

The Progressive collapse refers to the structural failure of a building or infrastructure due to the sequential spread of localized damage, initiating a chain reaction that leads to partial or total collapse [1]. This phenomenon gained significant attention following pivotal incidents such as the dismantling of the Ronan Point apartment complex in 1968. The term itself emerged as engineers investigated the aftermath of specific events, notably instances where a localized incident triggered a catastrophic series of failures, causing extensive damage and collapse.

This concept highlights the potential vulnerability of structures to propagate failure beyond the initial point of impact, leading to widespread structural instability [4]. The term "progressive collapse" encapsulates the idea that a seemingly minor failure or damage in a particular area can propagate throughout the entire structure, resulting in disproportionate and often catastrophic consequences. Understanding progressive collapse is crucial in engineering, architecture, and disaster management as it involves analyzing the structural integrity of buildings to mitigate the risk of such catastrophic failures [5]. It necessitates the implementation of designs and safety measures that can prevent or minimize the potential for progressive collapse, ensuring the resilience and safety of buildings and infrastructure under various conditions and stresses [9]. The belt wall serves as a retaining wall and is typically made of reinforced concrete. It consists of a continuous horizontal concrete beam or wall constructed around the perimeter of an excavation site [3]. This wall runs parallel to the excavation's edges and functions by resisting the lateral pressure exerted by the surrounding soil. The construction process involves excavating the area in stages while simultaneously constructing the belt wall to support the exposed soil. Engineers carefully design and plan the dimensions, depth, and reinforcement of the wall to withstand the lateral forces exerted by the soil, groundwater, and any additional external loads.

Reinforcement techniques, such as the use of steel bars or tiebacks anchored into the soil behind the wall, are often incorporated to enhance the structural integrity of the belt wall. These reinforcements help distribute the lateral pressures and increase the wall's stability, ensuring it can withstand the forces acting upon it during and after excavation. Moreover, various construction methods, including cast-in-place concrete or prefabricated panels, can be employed to build the belt wall depending on the specific requirements of the project and the soil conditions encountered. The belt wall plays a crucial role in maintaining safety and structural stability during construction activities, allowing for deeper excavations in urban environments without compromising the integrity of adjacent structures or risking potential soil collapses. Its design and implementation are fundamental in ensuring the success and safety of below-grade construction projects.

II. METHODOLOGY

This section involves the study and outlining the research methodology. The aim is to utilize ETABS software alongside the response spectrum method to carry out modeling work. This chapter constitutes the primary focus of the project, encompassing detailed procedures, plans, and analyses conducted on a specific section of a building. It will include the structural investigation, methodologies used in modeling, and the essential data derived from the analysis.

Table 1: Basic Specification of Model

Data	Value
Grade of steel	Fe375
Grade of concrete	M35
Belt Wall	200mm
No. of stories	G+14
No. of bay along X-direction	5
No. of bay along Y-direction	7
Span along X-direction	5m
Span along Y-direction	5m
Floor height	3m
Column size	500X500,600X600, 400X400mm
Beam size	600X500, 600X400mm
Depth of Slab	150mm
Dead load	---------------
Live load	2.5kN/m^2
Software	CSI ETABS with Response Spectrum

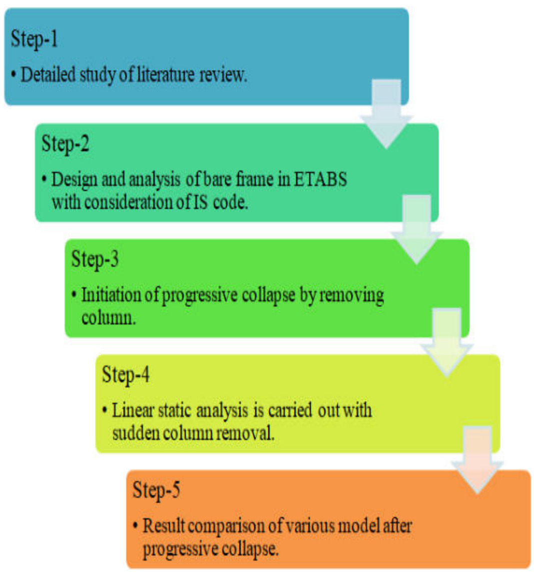

Fig 1: Flow Diagram to proposed Work

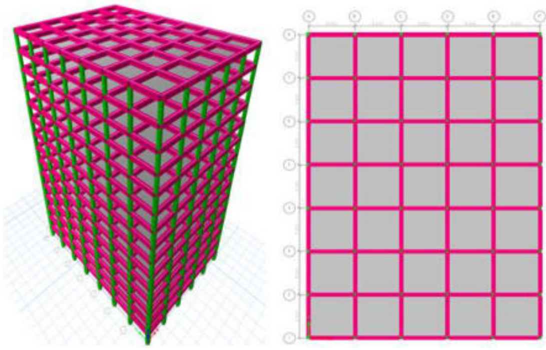

Fig 2: Model of G +14

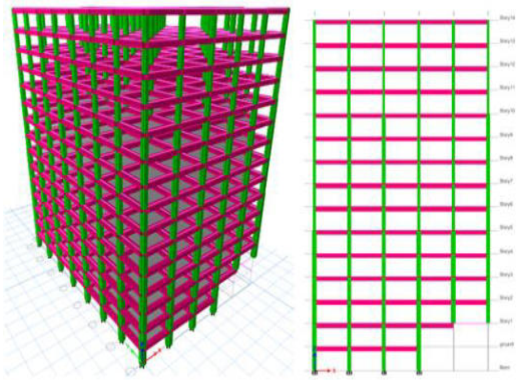

Fig 3: Model with corner column removed from one side

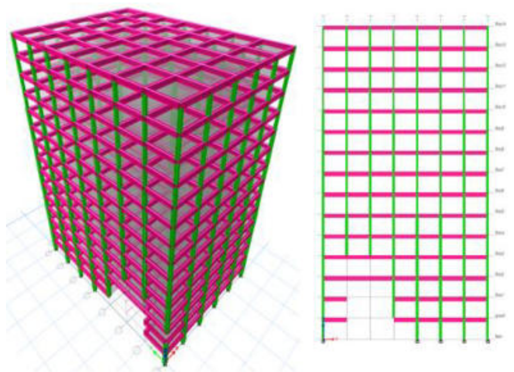

Fig 4: Sudden loss of column from long side edge

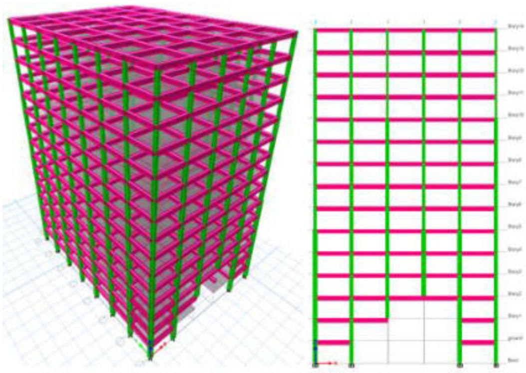

Fig 5: Sudden loss of column from short side edge

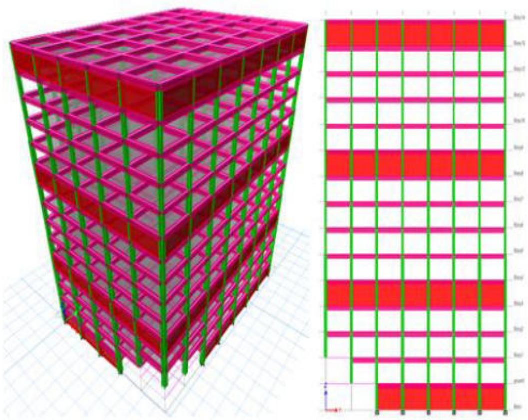

Fig 6: Model with belt wall with critical case of removed column

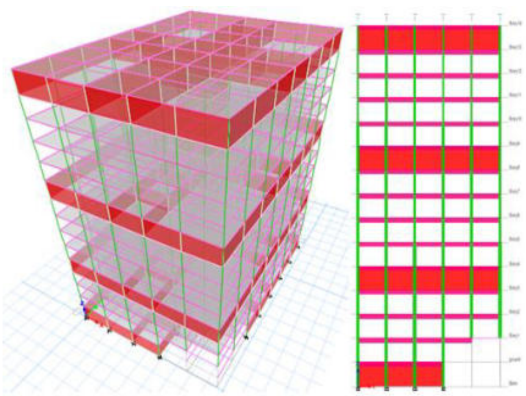

Fig 7: Model with belt wall connected with centre in critical case

III. RESULTS AND DISCUSSION

In this section address specific parameters such as storey displacement, base reaction, bending moment, shear force, and demand capacity ratio. The detailed study will involve gathering data from the analysis conducted using ETABS 2016 and presenting the findings through graphical representations. A comparative analysis will be performed to juxtapose the results obtained from different parameters, leading to conclusive remarks regarding their relationships and implications.

Table 2: Story Displacement Data of All Cases

Storey's	Storey Height (m)	Case-1	Case-2	Case-3	Case-4	Case-5	Case-6
14	45	86.668	121.36	96.071	106.913	77.925	47.062
13	42	84.131	115.498	93.659	103.76	76.864	45.853
12	39	79.793	108.269	89.055	98.376	71.493	42.694
11	36	73.797	99.787	82.43	90.944	63.424	38.696
10	33	66.382	90.231	74.08	81.758	53.91	34.221
9	30	60.31	81.692	67.371	74.228	48.333	30.383
8	27	53.642	72.699	59.94	65.962	47.116	29.178
7	24	46.775	63.547	52.27	57.451	40.556	24.847
6	21	39.859	54.327	44.538	48.88	31.78	19.724
5	18	33.423	44.837	37.336	40.905	23.905	14.874
4	15	27.375	36.273	30.663	33.406	18.774	11.088
3	12	21.21	27.638	23.856	25.767	17.547	10.179
2	9	14.983	18.986	17.03	18.26	12.302	6.755
1	6	8.83	10.536	10.234	11.042	5.312	2.928
ground	3	3.204	3.518	3.841	3.947	0.353	0.185
Base	0	0	0	0	0	0	0

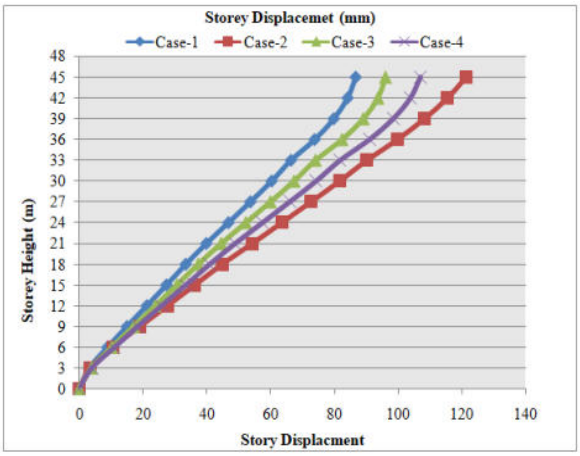

Fig 8: Story Displacement of Bare Frame and Cases from Column Removal at Different Location

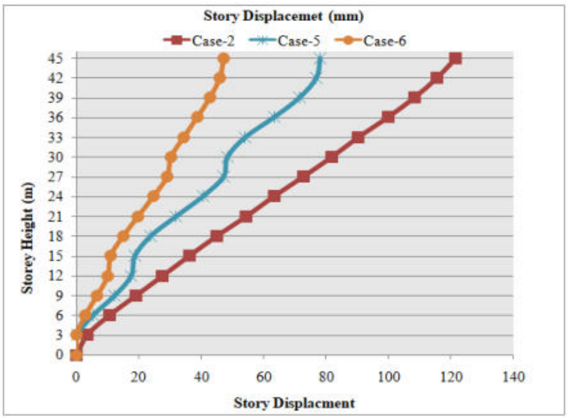

Fig 9: Comparative Story Displacement Controlled by Belt wall at Different Location

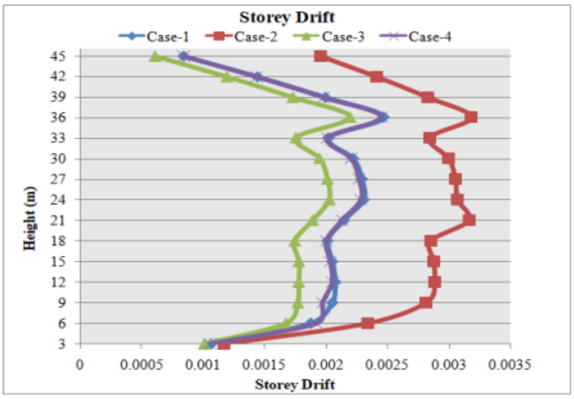

Fig 10: Story Drift of Bare Frame and Cases from Column Removal at Different Location

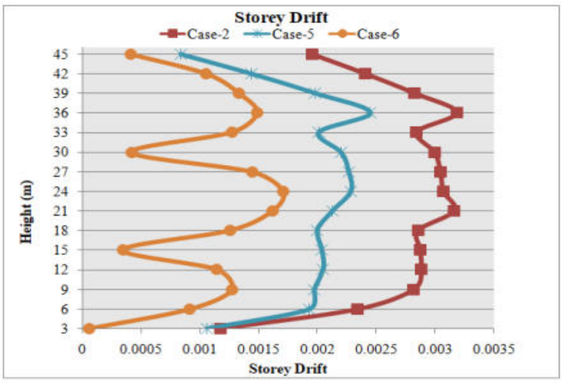

Fig 11: Comparative Story Drift Controlled by Belt wall at Different Location

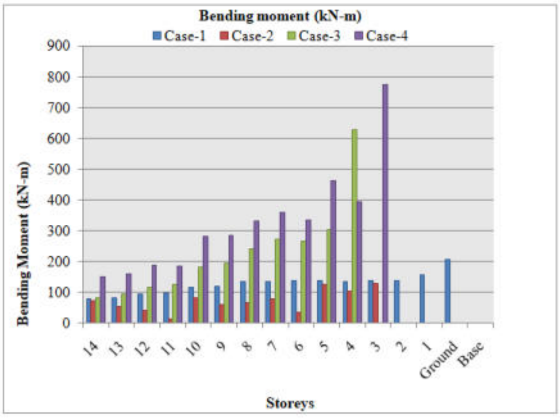

Fig 12: Story Drift of Bare Frame and Cases from Column Removal at Different Location

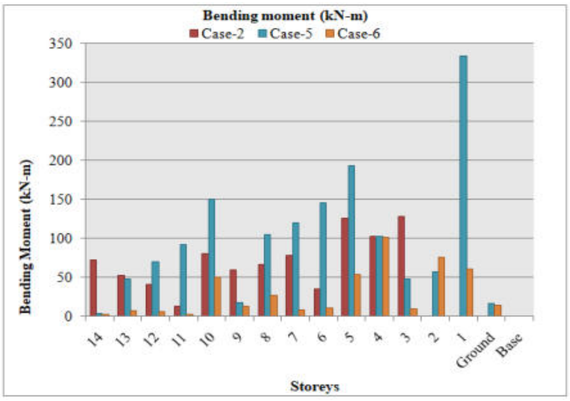

Fig 13: Comparative Story Drift Controlled by Belt wall at Different Location

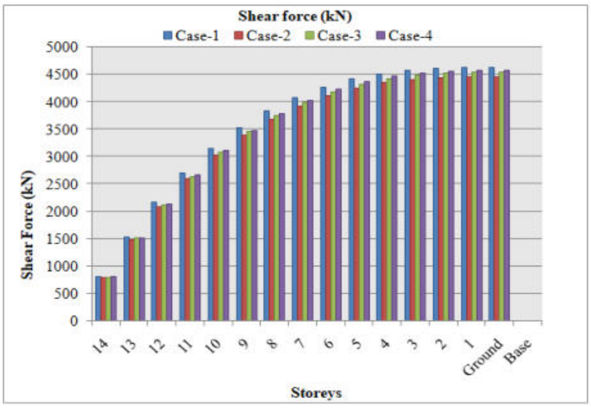

Fig 14: Shear Force of Bare Frame and Cases from Column Removal at Different Location

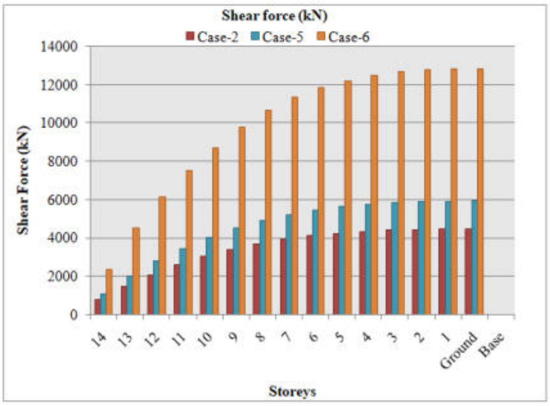

Fig 15: Comparative Story Drift Controlled by Belt wall at Different Location

IV. CONCLUSIONS

The present study provides an assessment of the progressive collapse behaviour of a G+14 reinforced concrete building subjected to different column-removal scenarios using ETABS. The analysis highlights the importance of column location and structural configuration in determining the response of the building following localized loss of a load-bearing member. Column removal can cause significant redistribution of gravity loads to adjacent structural members, resulting in changes in displacement, bending moments, shear forces, axial forces, and overall structural stability.

The study also investigates the implementation of a belt wall as a structural mitigation system. The belt wall provides an additional mechanism for stiffness, continuity, and force redistribution within the structural system. Its interaction with the existing beams, columns, slabs, and other structural components can influence the response of the building following localized column failure. The comparative analysis of structures with and without belt wall implementation provides an understanding of its contribution to controlling deformation and improving the structural response under column-removal conditions.

The findings demonstrate the importance of considering structural redundancy, continuity, stiffness, strength, and alternative load paths when assessing progressive collapse resistance. The analysis of different column-removal scenarios helps identify potentially vulnerable locations and provides useful information regarding the behaviour of the building under localized damage.

Overall, the study contributes to the understanding of progressive collapse mechanisms in G+14 reinforced concrete structures and the potential application of belt walls as a mitigation measure. The results can provide useful guidance for structural engineers in developing robust and resilient building systems capable of accommodating localized damage and reducing the possibility of disproportionate failure. Further investigations involving nonlinear analysis, different belt wall configurations, additional column-removal locations, and experimental validation can provide a more comprehensive understanding of progressive-collapse resistance.

REFERENCES

[1] Lakshya Poonia, Hemant Kumar Sain, "Design and Performance Evaluation of an RCC Overhead Water Tank at G+10 Levels", International Journal of Engineering Trends and Applications (IJETA) – Volume 13 Issue 3, pp. 666-672, 2026.

[2] Nitesh Kanwat, Hemant Kumar Sain, Mr. Kapil Karadia, "An Advance Study On Industrial Roof Truss With Consideration Of IRC Loading", International Research Journal of Modernization in Engineering Technology and Science, Vol. 04, Issue. 11, November 2022.

[3] Tarak Banerjee and Arya Banerjee, "A Study on Optimizing the Positioning of Shear Walls for a Plus Shaped Irregular Building", International Research Journal of Engineering and Technology (IRJET), Vol. 8, Issue. 10, pp. 1164-1168, October 2021.

[4] Hemant Kumar Sain, Basant Kumar Meena, "An experimental analysis on concrete containing GGBFS and meta kaolin with CCR", AIP Conference Proceedings 2901(1), 050008, pp. 1-13, 2023.

[5] Manoj Kumar Sharma and Hemant Kumar Sain, "Develop Approximate Analytical Models for Separated Seismic Analysis of Connected Buildings by SAP 2000", International Journal of Engineering Trends and Applications (IJETA), 2024.

[6] Sneha Mathew, Hemant Kumar Sain, "An Innovative Study on Utilisation of Pareva Dust and Quartz Sand in Concrete", Key Engineering Materials 961, pp. 135-140, 2023.

[7] Nitesh Kanwat, Hemant Kumar Sain, Mr. Kapil Karadia, "A Study of Different Type of Industrial Roof

Truss With Applications of Various Load Combinations", International Research Journal of Modernization in Engineering Technology and Science, Vol. 04, Issue. 11, November 2022.

[8] Kusum Choudhary, Hemant Kumar Sain, "Seismic Behavioural Analysis of One Bay Structure With Composite Beam and RCC Columns", International Journal of Engineering Research and Generic Science (IJERGS), Vol. 7, Issue. 6, pp. 27-36, 2021.

[9] Massimiliano Ferraioli, Biagio Laurenza, Angelo Lavino and Gianfranco De Matteis, "Progressive collapse analysis and retrofit of a steel-RC building considering catenary effect", Journal of Constructional Steel Research, 2024.

[10] Yogesh Ajmera and Anil Kumar Sharma, "Behavioral Analysis of a System Consisting of a 20-Story Structure RC Frame and a Shear Wall using ETABS", International Journal of Engineering Trends and Applications (IJETA), 2024.

[11] Lakshya Poonia, Hemant Kumar Sain, "A Comprehensive Review of Design and Performance Evaluation of RCC Overhead Water Tanks", International Journal of Engineering Trends and Applications (IJETA) – Volume 13 Issue 3, pp. 659-665, 2026.