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Structural Performance Of Rectangular Columns And Special-Shaped Columns Using ETABS (2021)

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ABSTRACT:

These days, architects usually prohibit column lengths to make the most of the available space and preserve the building's appealing aspect when no columns protrude from walls or corners. Structural member developments and lateral force resistance techniques are frequently used in modern construction to provide a more robust and safe structure. Solid constructions with non-rectangular uniquely molded delicate segments are discovered to be feasible, in contrast to the previously noted issue. It is discovered that non-rectangular specially formed delicate segments function effectively in general, with all research findings falling below tolerable cutoff points.

The goal of the current study is to compare a multi-story G+12 building with a plan measurement of 63.20 m x 29.50 m with a structure developed with particularly shaped columns that takes seismic stresses into account. The ETABS (2021) coordinated building outline programming presents and analyzes the outcomes, which are reinforced by conventional columns. Both dynamic response range and proportionate static analysis are applied to the construction.
The construction with the rectangular column in this study had a bending moment of 827 kN-m, whereas the structures with the T-shaped and plus-shaped columns had bending moments of 734 and 567 kN-m, respectively. This suggests that less reinforcement was needed for the plus-shaped case.

Shear forces show that the structure is stable because they are highest in the rectangular instance (942 kN) and lowest in the plus-shaped example (840 kN).
Lateral stability is comparatively higher for constructions with plus-shaped column casings than for those with traditional rectangular columns. The displacement decreases from 89 mm to 66 mm when a lightweight structure is utilized.

Keywords: lateral forces, columns, seismic, shear force, maximum bending moment, and ETABS (2021).

I. INTRODUCTION :

Concrete structures with non-rectangular specially shaped thin columns found out as analternative to the above said problem and it is found out that non-rectangular speciallyshaped thin columns performs well structurally with all analysis results within acceptable limits. This type of construction complies with the junction and space requirements of corners, preventing the appearance of visible edges or conspicuous columns in the buildings. As a result, the structures' actual useable floor area is increased and can accommodate more furnishings. Because of this, frame structures with uniquely shaped columns work well, particularly for villas and multistory buildings. The behavior of structures with rectangular columns and buildings with particularly shaped columns is explained in this study, along with the values of several parameters based on lateral loads, such as story drift, story displacement, story stiffness, etc.

Structural design is a science and art of understanding the behavior of structural members subjected to loads and designing them with economy along with safety, serviceability and as a durable structure. Due to its versatility, RCC structural members are widely used; this study will be the focus of the current dissertation work. In essence, a column is a structural component designated to support compressive loads. It distributes the axial loads from beams to footing. Numerous methods are used to differentiate the columns, and numerous varieties are noted. Columns are classified as short or long based on their slenderness ratio. The long column breaks by buckling, whereas the short column breaks by crushing. Axially loaded columns, axial columns with uniaxial bending, and axial columns with biaxial bending are all possible depending on the loading pattern.

2. OBJECTIVES OF THE PRESENT STUDY

(1) To investigate how the structure responds to lateral loads such as wind and seismic loads.

(2) Calculating the buildings' wind and seismic induced deflections, storey drifts, storey stiffness, and storey overturning moment.

(3) To evaluate the differences in performance between the construction of rectangular columns and special-shaped columns.

3. LITERATURE REVIEW

In this chapter we are reviewing the literatures and research publications of authors related to analysis of cocrete structure with lateral loadings and different lateral load resisting elements.

Yang et al. (2008) The research paper presented structural seismic response contrasts between extraordinarily shaped column structure and customary rectangular frame structures. Because of the minor moment of latency contrasted and the uncommonly formed sections, the firmness of the edge with rectangular segments with a similar territory was substandard compared to the edge with exceptionally moulded segments. The L-formed corner sections were in the biaxial twisting and pivotal forces coupling conditions. Under the stronghold seismic movements, the most extreme steel malleable strain of the corner sections and mid-segments of the uncommonly formed segment outline structure was bigger than the rectangular segments. The greatest cement compressive strain diminishes in the request for mid-section, side segment and corner segment. The greatest cement compressive strain of the uncommonly moulded segment outline structure was larger than the rectangular sections, however, was less than the solid extreme compressive strain.

Zhou et al. (2015) The research paper analyzed the biaxial loading conduct of L- designed SCFT sections thinking considering Failure modes, the collaboration of mono-segments, and the impacts of eccentric angle and separation on column conduct. Test outcomes were contrasted against finite element examination. A sensible streamlined computing equation was proposed dependent on the investigation and was demonstrated adequately through the examination with test results. The conclusion expressed that Mono-segments could cooperate when the whole segment bears the offbeat burden. The SCFT section exhibits great offbeat loading conduct demonstrated reasonable for private structures. The strain circulation and loading mode demonstrated that the disappointment of examples under unconventional loading was brought about by precariousness, while steel yielding caused the disappointment of axial loading specimens. The association plate could be diminishedto a binding bar with a point of 35° to 45°.

Mathew and Krishnachandran (2016) The study report's goal was to use limited component examination programming (ANSYS17) to control the steel form, length of segment, and thickness of the steel container of the tubed steel strengthened solid section in a parametric report. For steel form, ISMB150, ISMB125, and ISMB100 are used.

Agrawaland and Pajgade (2016) The research paper assessed the response of differentshapes of columns on RC Building with and without shear walls by considering G+14business RC structures with uniquely shaped columns and G+14 business RC structureswith uniquely shaped columns along with shear walls. The modelling and examinationof the structure were finished utilizing ETABS v9.7.4 programming for Amravati city which lied in seismic zone III.

Kareem and Mathew (2016) The exploration paper introduced the conduct of G+8 storey R.C outline structures (H shape in plan, with T and square Shaped section) exposed to tremor, situated in seismic zone III was introduced utilizing STAAD. Professional programming. Gravity burdens and laterals stacks according to IS 1893- 2002 are applied on the structure and it was planned utilizing IS 456.

Wang et al. (2017) The study report detailed an examination of the confinement mechanism of L-shaped concrete columns constrained by stirrups under axial rehashed loads. ANSYS programming was used to finish the finite element analysis of five segments in light of the trials.

The findings implied that the skeleton bend, top displacement, and pinnacle load figures were in reasonable agreement with the test results. This proved that the examination model made sense and could be applied to decipher the mechanical behavior of L-shaped solid segments restrained by stirrups under pivotal rehashed loads. The limitation element of stirrups under hub rehashed loads was included, as shown by the estimate consequences of the solid pressure circulation. The compelling limitation region, the powerless imperative region, and the unconstraint zone are the three components that make up the effective need, which was the most grounded inside the stirrup plane. The region of effective limitation appeared to be curved. Moreover, the center segment was the most delicate requirement segment, the weak critical area between adjacent stirrups was also a curve conveyance, and the curve stature decreased as the stirrup spacing decreased.

Subhan (2017) In order to understand maximum distortion, load it can bear, and stress conveyance, the research paper offered a nonlinear finite element analysis of cement-encased steel section subjected to switch cyclic, clasping, and monotonic loading conditions. ANSYS programming was used to create a liberally nonlinear model with suitable limit conditions.

Shet et al. (2018) The study report included an analysis of the C-shaped equivalent legged RC segment's interaction curve using an ETABS-designed investigative technique.

The findings showed that, in C-molded RC concrete, the most severe load and moment conveying limit increases as the steel and cement grades are evaluated more. Parabolic pressure square was taken into consideration for the manual analytical estimation; however, as ETABS uses Whitney's proportionate pressure block for calculus, differences in results were seen for loads and moments. The manual diagnostic computation for loads in steel was finished utilizing TABLE-A of SP 16 codebook, however ETABS gave strain in steel and modulus of flexibility. For manual diagnosticestimation, the estimation of K extended in the middle of 1.05 to 4, however, ETABS considered the estimation of K went in the middle of the 1.05 to 1.2.

Paul and Vargheese (2019) The research paper dissected Crisscrossed moulded columns associated by the lacing bar, Single vertical steel plate with stiffeners, Double vertical steel plate, Effect of tallness, Effect of width and axial compressive conduct. Using ANSYS 16.2, the finite element investigation's features were applied to the material parameters and imposed limit conditions.

The results suggested that whereas mono columns connected by a lacing bar had a lower load-carrying limit, mono segments connected to double vertical steel plates had a higher load-carrying limit. Compared to binding bars, mono segments connected by a single vertical steel plate with stiffeners offer a greater load-carrying capacity. Load conveying limit contrarily propositional to the stature of the segments. Load conveying limit relies on the width of the steel plate. The measure of confinement concrete increased load- carrying capacity.

Majid and Alnuman (2020) In this paper a typical analysis approach for determining robustness against the local failure and accidental occurrences for a RC framed structure has been attempted in this study to evaluate the demand capacity ratio and robustness to evaluate the safety of the structure, which reckons as a fundamental step in decision-making. A finite element model has been developed for the 12 storey building. Then the analysis of reinforced concrete framed structure under critical column removal has been carried using the linear and non-linear static analysis methods as per the guidelines provided in GSA (2003) and FEMA: 356 guidelines respectively taking into consideration provisions of IS1893:2002 codes to simulate dynamic collapse problems using ETABS software v16.2.1 (software for modelling or analysis of structure) to assess the vulnerability to progressive collapse.

Shinu and eedhidas (2021) The disproportionate collapse disasters of the past few decades have drawn attention to codified bodies worldwide, which has raised interest in the field of "disproportionate collapse" research. Structural systems used in civil engineering are vulnerable to disproportionate collapse when abnormal loads exceed the maximum capacity of crucial structural elements. The total collapse of the structure could occur from the sudden loss of essential structural elements. Currently, researchers simulate the loss of a major load-supporting part for the assessment of disproportionate collapse using several modeling approaches. The purpose of this research is to investigate the recommended procedures for mitigating the risk of disproportionate building collapse. This research uses cutting-edge software, such as E-TABS, to analyze and simulate unusual types of structures in efficient ways. A G+10 story reinforced concrete building was examined and designed for dead load, live load, wind load, and seismic load with a safety factor in this dissertation project. For the purpose of the comparison study, the bending moment and steel area needed by the elements are noted. Only a few crucial components that can cause the gradual collapse are investigated. The crucial element is removed hypothetically, and the building is examined solely for gravity loads.The structure's performance varies as a result of the removal of important components. These modifications are acknowledged, and the sections are adjusted as needed to avoid a disproportionate collapse.

Ehtisham and Khaja (2022) Because vertical expansion has become more common than horizontal development due to population growth, there is a greater need for multi-story structures, which now make up between 60 and 70 percent of the urban infrastructure. These days, a variety of design tools is utilized for the design and analysis of civil structures. The most popular and commonly used programs are Revit Structures (BIM) and E-Tabs. One of the most popular BIM applications is Revit which for design employs an external program called Robot Structures. ETABS, on the other hand, is a software for analysis and design. The primary focus of this research project is the design and study of a multi-story reinforced concrete structure utilizing the independent programs ETABS and REVIT Structure, as well as a comparison of the results obtained.When designing buildings, these two pieces of software adhere to the Indian Standard Code of Practice's Limit State Design principles. This paper examines a G+10 structure that is susceptible to both static and dynamic stresses, such as wind and seismic loads. The plan arrangement contains four grids of 3.5 m × 3.5 m in both the X and Y axes. The primary goal of this research project is to identify the best balance between the design and cost estimation of reinforced concrete buildings (RC buildings) and to ascertain which software produces the best outcomes. Since these projects are small to medium-sized, the primary factor influencing them is construction costs. A comparison of the differences in shear forces, bending moment values, and reinforcing specifics from both pieces of software is included in the results. For the structural members, cost estimation is done using the design data.

Sivakuma et al. (2023) Indian standard code and boundary criteria are used in construction. In order for all structures to carry out their intended activities and endure the forces acting upon them during their useful lives, structural analysis establishes the general shape and appropriate size of each structure. The primary goal is to create a structure that is sturdy and capable of withstanding significant earthquakes that might occur during the building's useful life without suffering damage. In order to prevent failure during large earthquakes, structural materials must be sufficiently ductile to absorb and release energy during deformation. This implies that without significant strength, deformation above the yield point can be allowed. In this work, the seismic analysis of RC buildings (G 9) was conducted using the response approach. This study's structural analysis was conducted utilizing its ETAB software, and it is based on Indian standard code. With a magnitude of 3.8, the survey assessed the structure in seismic zone III and ground G9. My primary space is 986 square meters. Structural elements like stiffness, deflection, and deflection are impacted by seismic loads. Shear walls for stairwells and other vertical spaces, as well as many sections of beams and columns, make up the frame work. To examine the data, a response spectrum technique was applied.

Behera et al. (2024) For earthquake engineers, designing an effective building that is earthquake-resistant (EQ-resistant) is a difficult task. The design techniques for earthquake resistance that are currently accessible are intricate and costly to compute. Time history study of the planned structure utilizing real-time ground motion data is the most accurate analysis technique. In actual applications, this method is particularly challenging because adequate processing resources and realistic ground motion data are not accessible. Artificial intelligence (AI) models are currently being used to solve difficult real-world problems like seismic analysis and structural design. The literature that is now available shows that EQ resistant design with AI is on the rise. The use of AI models can expedite the process of creating an effective EQ resistant design. This paper examines a few buildings that have undergone validation for various types of earthquakes. Data generation was conducted using the ETABS software, and EQ ground motion (EQGM) was taken into account in the development of an AI model for EQ resistant design. Key EQGM parameters that were taken into account included peak ground acceleration (PGA), peak ground velocity (PGV), peak ground displacement (PGD), and time duration. Additionally, building parameters that were taken into consideration included maximum displacement, base shear, and story drift. Within an acceptable amount of computing time, the created feed forward back propagation artificial neural network (ANN) model could successfully forecast the design parameters of a typical target structure. This kind of meta-heuristic approach may have a great deal of research interest and applicability due to its reduced calculation time and effort.

4.METHODOLOGY

ETABS (2018) is a multipurpose program for investigation of structure.

The accompanying three exercises must be performed to accomplish that objective.

Modelling of the diverse cases in ETABS (2018).

Calculation and Provisions according to Indian gauges can be connected.

Analysis of structure to analyze forces, dislodging and moment producing in acasing.

Type of structure=Ordinary moment resisting RC frame
Grade of concrete=M 25
Grade of reinforcing steel=Fe 415
Plan area=63.20m x 29.50m
Number of stories=G+12
Total Height of Building=43.2 m
Floor height=3.6 m
Rectangle Shaped Column=230mm x 600mm
Plus Shape column=350mm x 750mm
T Shape Square column=350mm x 600mm
Beam size=500mm x 300mm
Wall thickness=230mm
Thickness of Slab=200 mm
Density of concrete=25N/ mm3
Live Load on Floor and roof=3 kN /mm2 and 1.5 kN/ mm2
Plan irregularity=T Shape and Plus Shape
Seismic Zone=II
Soil Condition=Medium Soil
Floor Finish=1.0 kN/m2

MODELLING

Step 1: Firstly literature survey should be done to determine the past research andNeed of study.
Step 2: To prepare concrete and other materials in ETABS (2018) and assign them tostructural members.

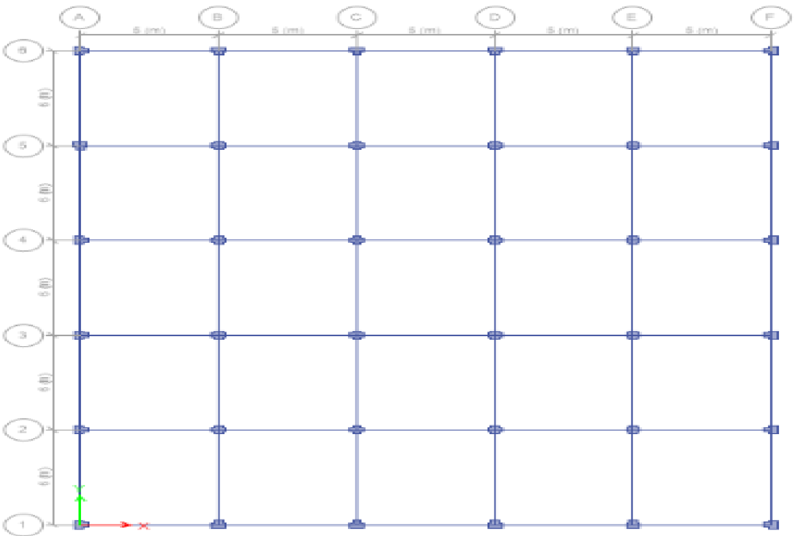
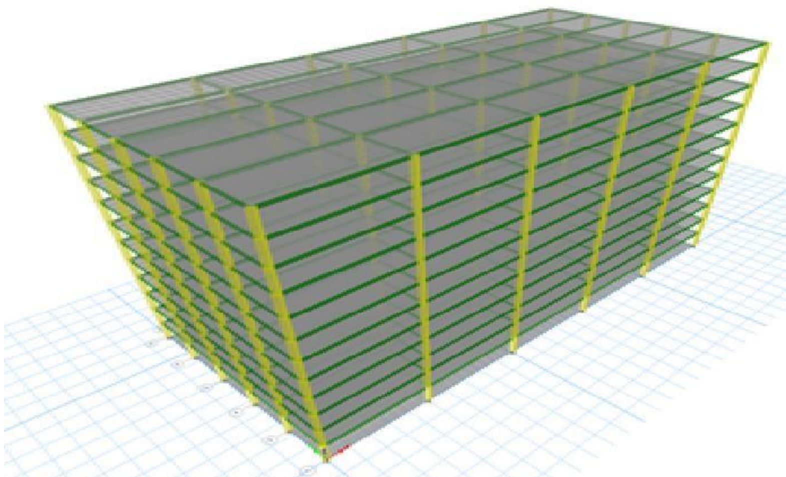


Fig 1 Grid Designing of the different cases.

Step 3: To prepare modelling of a symmetrical building frame (G+12) using ETABS 2018.

Figure 2 Model of the structure



Step-4 To assign properties and support conditions.

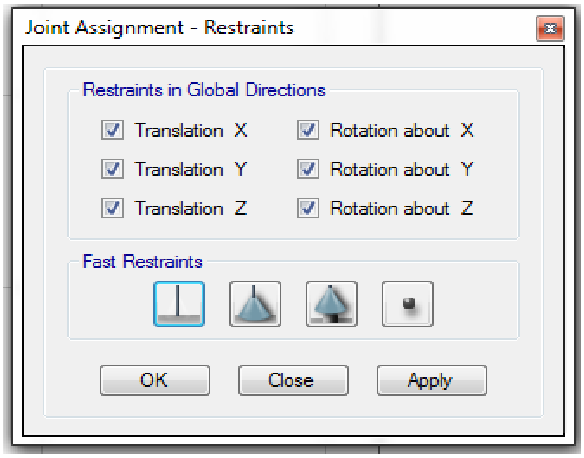


Figure 3 Assigning support conditions

Step-5 To compare the results of the structure.

ETABS (2021) software is exclusively made for modeling, analysis and design of buildings. Various facilities in the ETABS (2018) are listed below

- ETABS (2021) provide object based modeling. it takes slab as area object, column, beam, brace as a line object and support, mass, loads as point objects.
- ETABS (2021) has feature known as similar story. By which similar stories can be edited and modeled simultaneously. Due to which building is modeled very speedily.
- ETABS (2021) can do optimization of steel section
- ETABS (2021) has powerful facility of Section designer. By which different typesof composite sections can be made easily.

MODELLING OF STRUCTURE USING ETABS (2021)

Step1. Choosing the Building Geometry
↓
Step2. Grid Definition
↓
Step3. Story Definition
↓
Step4. Modelling of Selected geometry
↓
Step5. Defining the Material and their property
↓
Step6. Frame/ Slab x- Section Definition
↓
Step7. Load Case/ Pattern/ Combination Definition

Step8. Load Assignments/ Support Assignments

Step9. Analysis.

Step10. Extract Result/Study

5 . DISCUSSION ON RESULTS:

The results were analyzed on the parameters on bending moment, Shear force, Storeydisplacement.

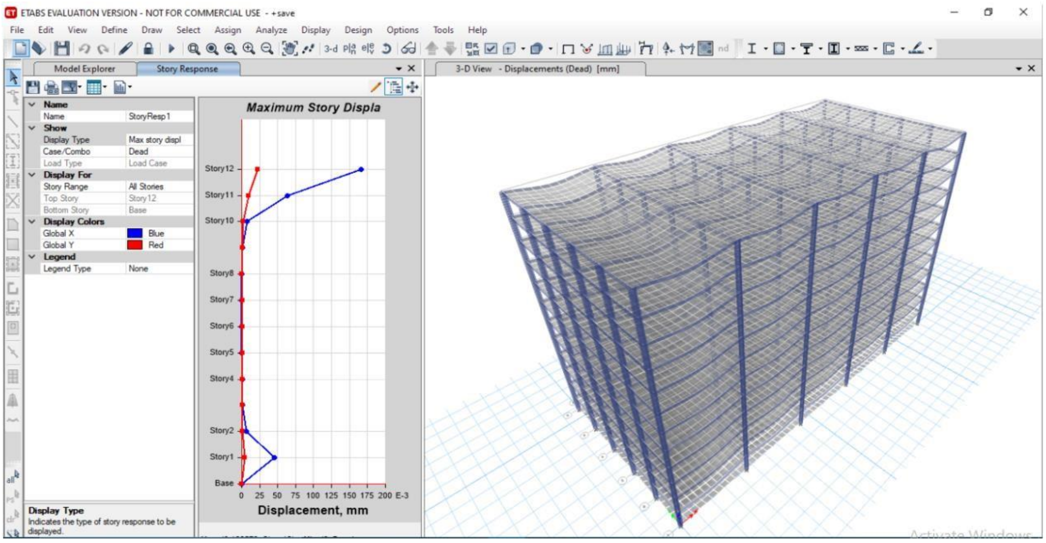


Fig 4 Structural Analysis

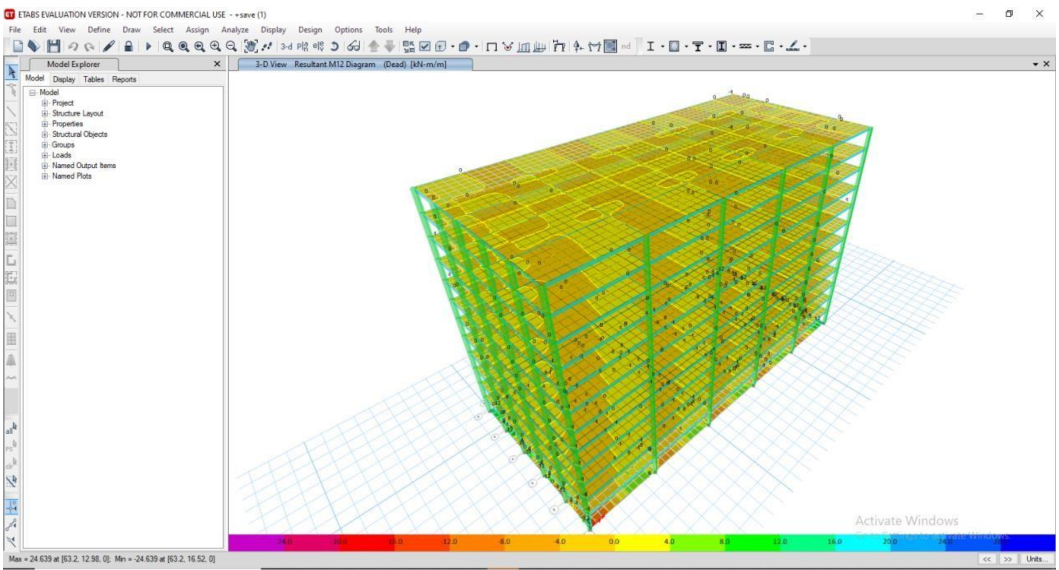
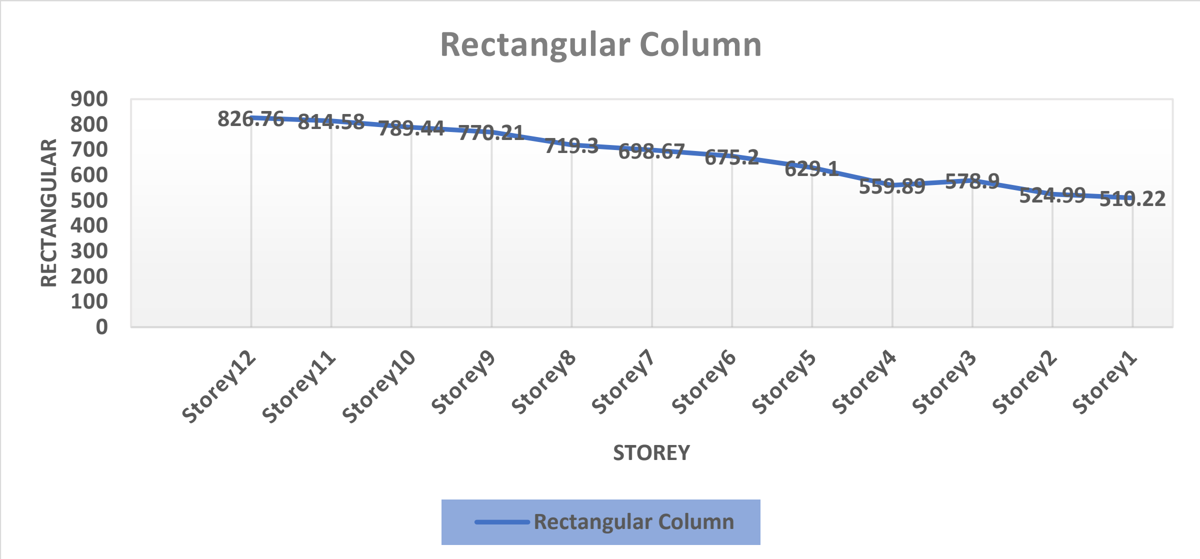
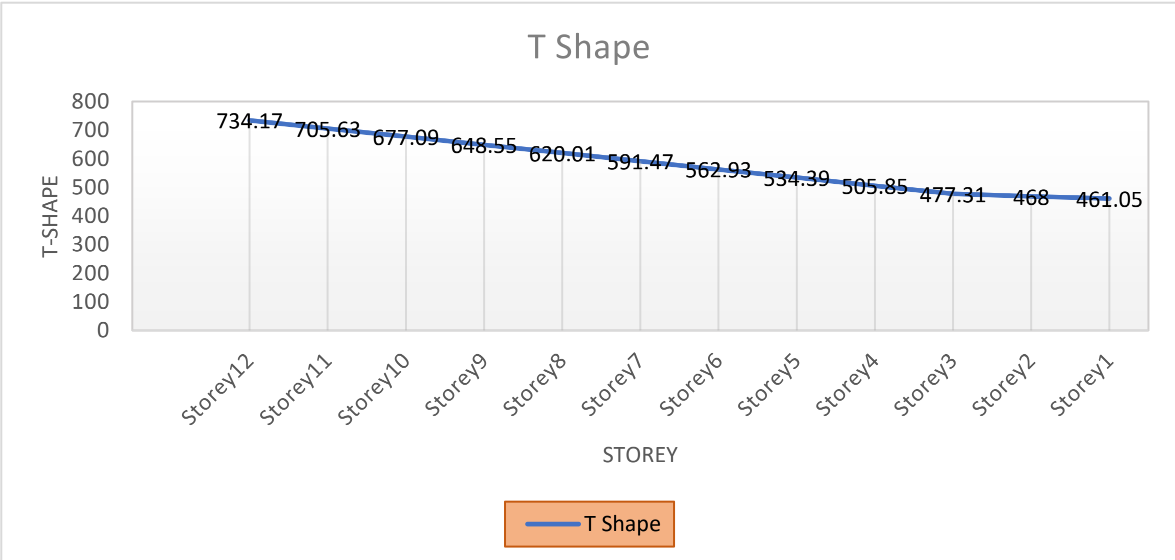


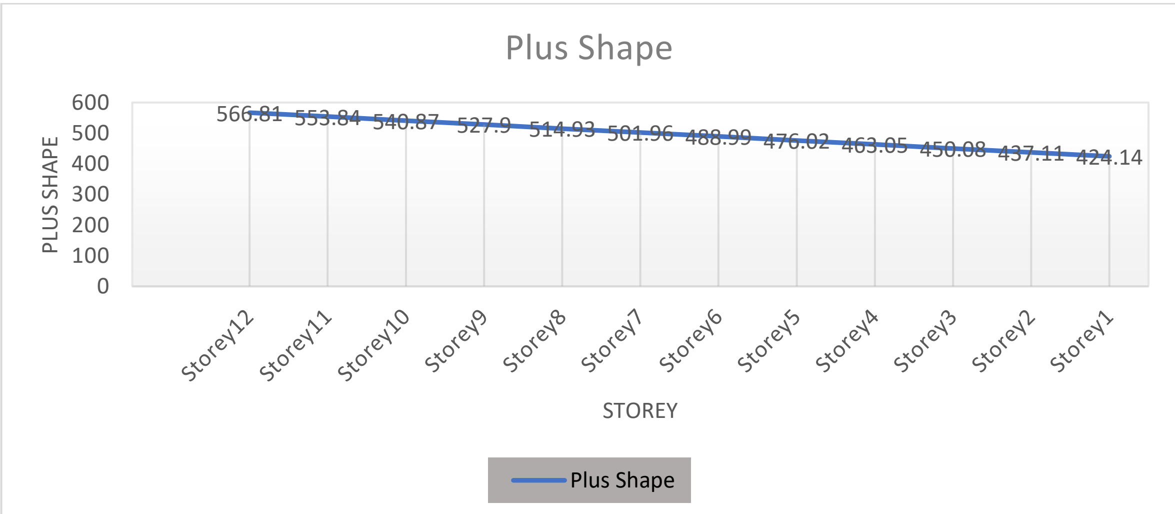
Fig 5 Stress Analysis



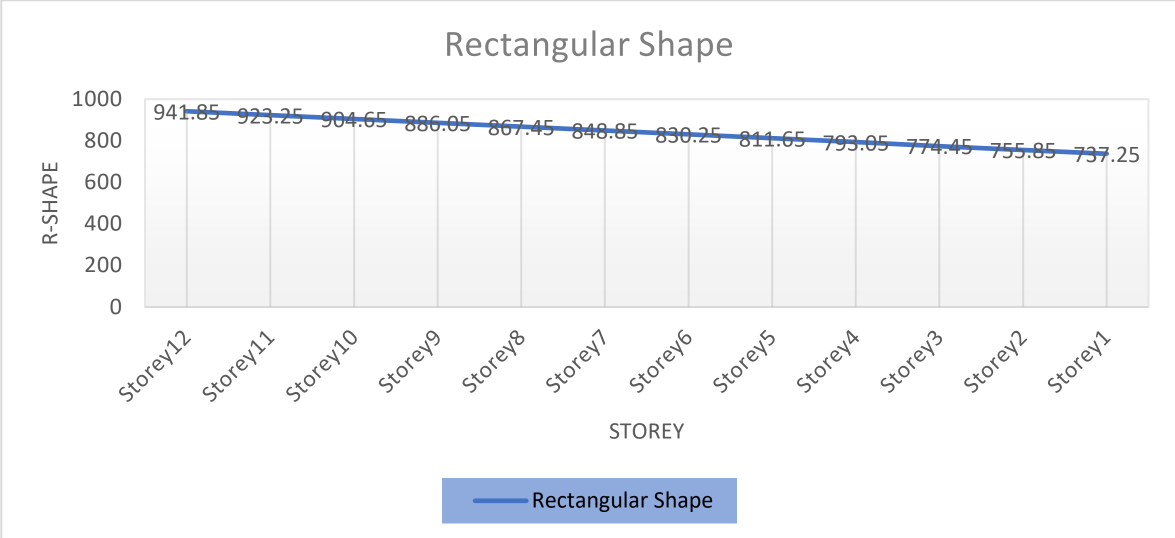
Graph 1: Max. Bending moment of rectangular column



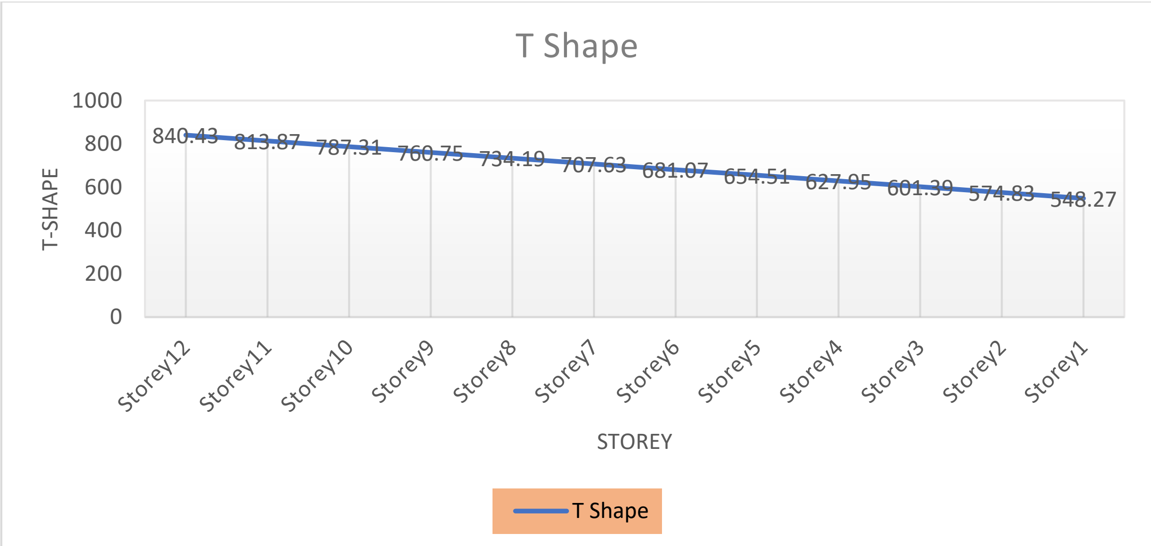
Graph 2: Max. Bending moment of T-Shape



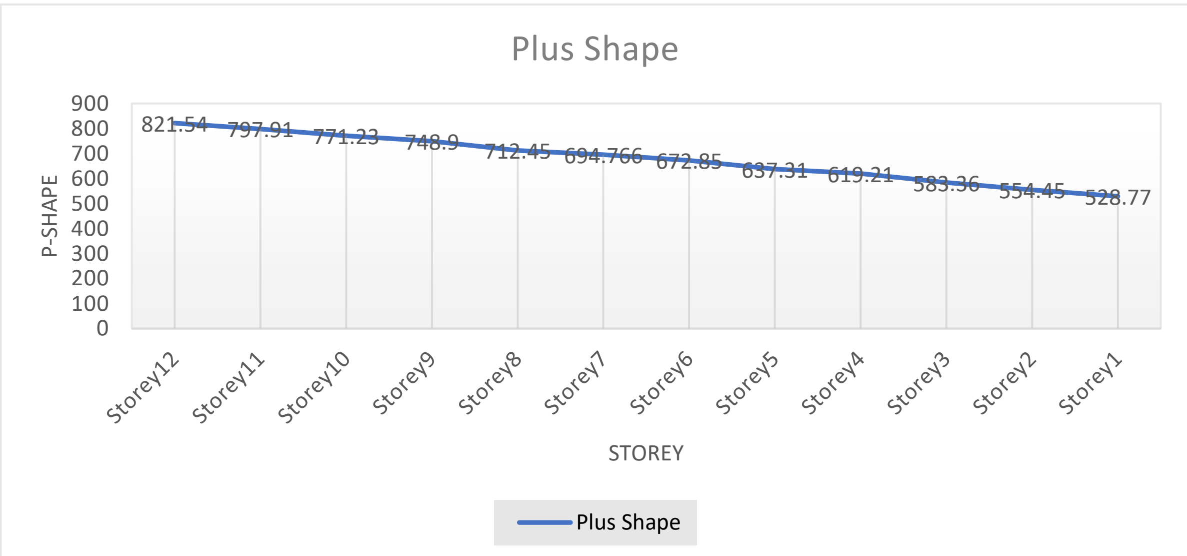
Graph 3: Max. Bending moment of Plus-Shape



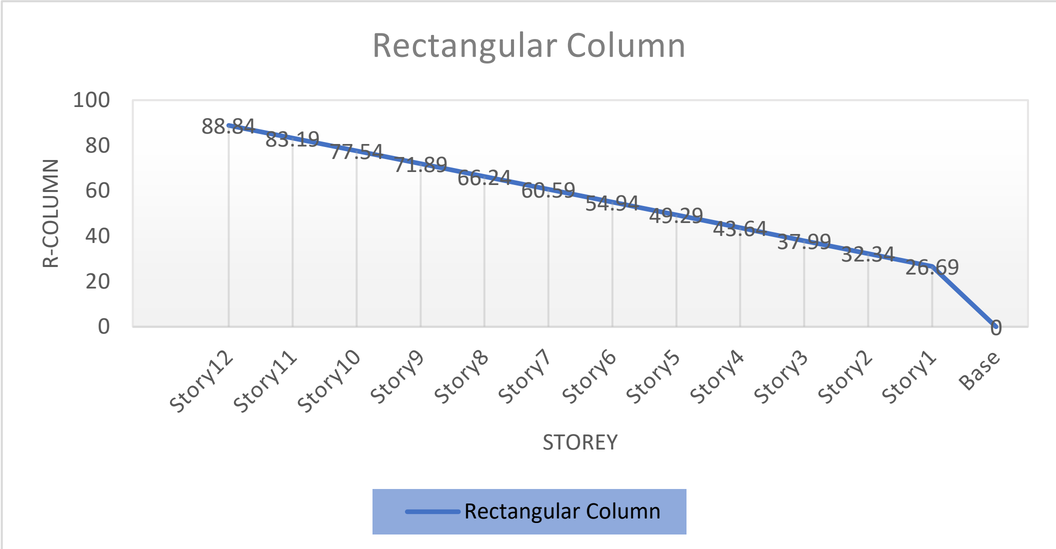
Graph 4: Max. Shear force of Rectangular Shape



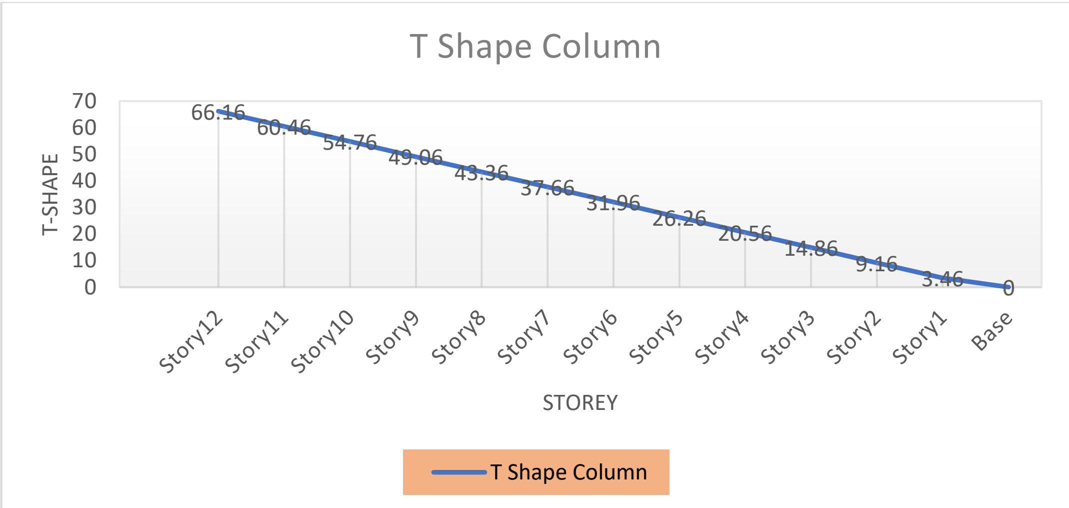
Graph 5: Max. Shear force of T-Shape



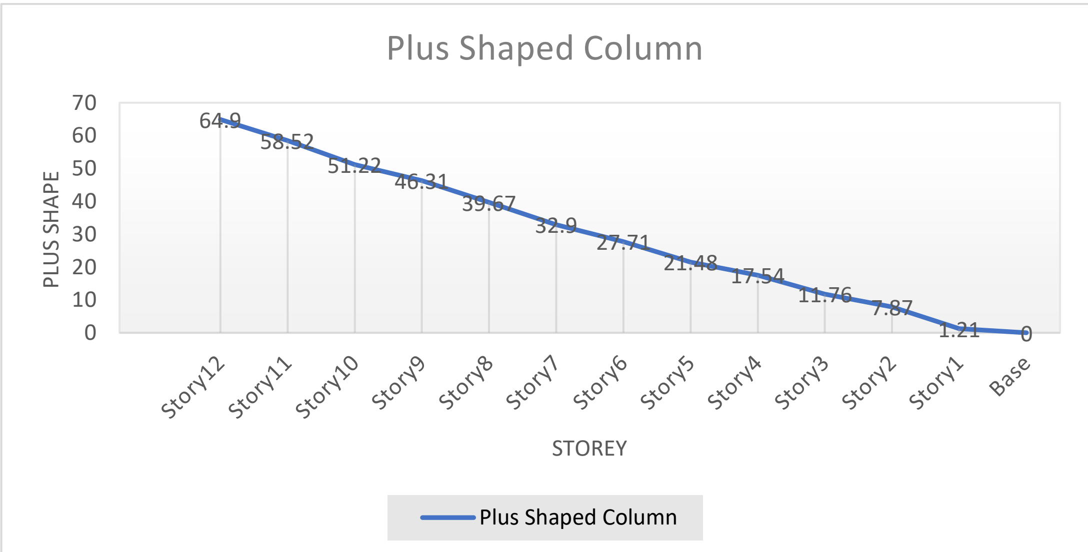
Graph 6: Max. Shear force of Plus Shape



Graph 4.10: Max. Storey Displacement of Rectangular Column



Graph 4.11: Max. Storey Displacement of T-Shape



Graph 4.12: Max. Storey Displacement of Plus-Shape

6 . CONCLUSION

Based on results following conclusions aredrawn from the study:

- **Maximum Bending Momen**

In the chapter above, it is clearly observed that bending moment in structure using Rectangular column was 827kN-m whereas structure using T shapes and Plus Shaped column showed less bending moment as 734 and 567kN-m, thus Plus shaped case requires less reinforcement.

- **Maximum Shear force:**

In above chapter it is observed that unbalance forces are maximum in rectangular case

942 kN whereas in Plus shaped case these are reduced to 840 kN which showsstability of the structure.

- **Maximum storey displacement:**

It is observed that lateral stability is comparatively increased in structure with plus shaped column case comparing to structure using traditional rectangular column. In case of light weight structure displacement is minimised to 66 mm instead of 89mm in bare frame.

- **Axial Force:**

In the above chapter it is observed that there is very minute variation in axial force as it is considered for same loading condition in both the cases.

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