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Analysis of a Tall Structure Considering Hollow Slab Using ETABS

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ABSTRACT

A significant amount of the construction budget and national capital is spent on the construction of concrete building structures as the number of residential, commercial, and institutional buildings rises. Precast Hollow Core Slabs (HCS) have, however, proven to be more desirable than RCC slabs in recent years due to the demand for economical and quick construction, and they have been suggested as a workable substitute for RCC slabs.

The comparative analysis of a G+9 storey structure using three different slab types—flat slab, precast hollow slab, and post tensioned slab—is shown in this research. Using the analytical application ETABS, the modelling and analysis of all case studies are carried out, and the results were compared in terms of the parameters of storey displacement, storey shear, base shear, bending moment, axial force, and storey drift.

Precast slabs consisting of pre-stressed concrete with tubular spaces around their perimeter are used in multi-story homes as flooring because they are inexpensive, have strong acoustic and thermal insulation qualities, and can be made across long distances at a reasonable cost. A hollow core plate was employed to reduce core shear in the X and Y directions independent of the area because of the overall light weight of the construction. The displacement conserved in both directions increased in all places while the time reduced uniformly across all of them.

Keywords: Precast Hollow Core Slab, Storey Drift , Story Shear, Lateral Displacement

I. INTRODUCTION

It is the structural engineer's responsibility to make sure that the built environment can withstand strong dynamic events like wind, earthquakes and traffic. All Builders need to know how their built environment reacts to these dynamic actions. A direct result of earthquakes is that many people die from the collapse of structures and rubble, and in the long run, thousands of people lose their homes due to the collapse of buildings and the uncertainty and reconstruction process and the engineering department plan the direct consequence of these program by better the seismic response of building structures and working continuously to improve the seismic design.

A structure moves laterally and vertically during an earthquake due to surface ground motion driven on by seismic waves. Usually, the lateral motion is significantly greater than the vertical motion, and the ground is moving more rapidly (ag). This lateral motion causes the building to experience inertial forces, which are calculated as the sum of the structure's mass (m) and acceleration (a). According to Newton's Second Law (Force = Mass x Accleartion). Fundamentally, how a building structure reacts to an earthquake occurrence depends on its mass, size, and configuration.

Flat Slab

The term "flat slab" refers to a square slab known as "drop panels" that has a one- or two-sided support system, with the sheer force of the slab being concentrated on the supporting columns. Drop panels are crucial in this situation because they increase the overall strength and capacity of the flooring system beneath the vertical loads while also improving the construction's cost-effectiveness. Typically, the height of drop panels is double that of the slab.

For the majority of construction projects as well as asymmetrical column arrangements like curved or ramped floors, flat slabs are considered to be suitable. Applying flat slabs has various benefits, including flexibility in design arrangement, flat soffit, and depth solutions. Even though constructing flat slabs can be expensive, it allows architects and engineers tremendous architectural freedom. The use of flat slabs has numerous advantages, not only in terms of future design and layout effectiveness but also for the entire construction process, particularly for streamlining installation processes and cutting down on construction time. Avoid using drop panels as much as you can, and make the most of the thickness of flat slabs instead. In order to maintain the advantages of flat soffits for the floor surface and to guarantee that drop panels are cast as part of the column, this is necessary.

Fig 1 Flat Slab

II. LITERATURE REVIEW

Vanteddu Satwika and Mohit Jaiswal (2022) In the research report, a flat slab was strengthened using the post tensioning approach. Comparing RCC flat slabs to post-tensioned flab slabs with various tendon profiles, both dispersed and banded tendons were used. The parameters were evaluated: thickness, supporting reactions, punching shear, and deflection as compared to conventional flat slabs. The models were constructed in accordance with ACI 318-14, and these slab models were developed using ETABS software.

The results indicate that post-tensioned flat slabs have better punching shear capacities even at deeper depths, leading to sections that are more economically sound. Lower deflection is another benefit of the inclusion of tendons.

In comparison to banded tendons, distributed tendons are more successful in reaching shallower depths. Because there was less dead weight in the post-tensioned flat slab, there were fewer support responses, which reduced the amount of construction materials needed. As a result, construction costs are lower. As a result of the lower support response for PT slabs, fewer sections and less reinforcement are required for the components that bear load from the slabs, such as columns and foundations, which lowers the cost of construction overall. By applying the post-tensioning approach, it is possible to raise the punching shear strength of a flat slab and do so even at shallower depths. By doing so, one of the main issues with the flat slab design is solved. By including post-tensioning tendons, downward deflections can be significantly decreased, resulting in good serviceability. The most efficient method, while taking into account the entire effectiveness of the flat slab, is the provision of dispersed tendons together with drop.

Dheekshith K and Prasad Naik (2021) research paper compared the response of RCC slab building and hollow core slab under the seismic load conditions for a G+9 storey structure modelled using analytical application ETABS considering shear walls on the sides. As hollow core slabs cannot be directly modelled by ETABS, Secondary Beams were adopted with the same dimensions as Hollow Core Slabs. The hollow core slab were modelled using ANSYS(Analysis of Systems software). Three models were evaluated for each RCC building in Zones 3, 4, and 5 and for each common ceiling structure.
Results stated that storey displacement increased for hollow core slab compared to RCC structure. Hollow core slab building acceleration in Storey is lower relative to the RCC building in the X direction, while it was higher in the Y direction. When compared to RCC building, hollow core slab construction takes less time and has less storey drift. In comparison to RCC construction, hollow core slab construction has a lower base shear since the building is lighter.

Omar Ahmad (2021) In a research work, a cost comparison of post-tensioned and reinforced concrete flat slabs was presented. According to the article, less concrete is needed for post-tension slabs than for flat slabs because the post-tension slabs are thinner and there are fewer columns provided. After the concrete is cast, special steel tendons that were utilised in post-tensioned slabs are extended by a hydraulic jack, and thus reduces the need for reinforcement steel bars. Although only post-tension slabs use tendons, there is less steel used in post-tension slabs than in flat slabs. The cost of the contractor's work varies depending on whether a flat slab or a post-tensioned slab is being built. The amount of concrete, steel, and contractor work costs were compared for the study.

Post-tension slabs are less expensive, according to the comparison study's findings between them and flat slabs of reinforced concrete.
OBJECTIVES:

- To simulate the seismic stress on a symmetrical 10-story RCC building.
- Model analysis was performed on a symmetrical, 10-story RCC building using hollow core, flat, and post-tensioned slabs.
- To evaluate the performance of RCC and hollow core slabs adapt to seismic load conditions. To calculate the seismic zone IV responses of RCC slab frame buildings and hollow core slab buildings.

III. METHODOLOGY

Step 1: The research papers were reviewed which used different slab systems for structural stability.
Step 2: Defining the grid system as per ETABS in x and y direction and preparing the plan of the structure for the structure storey data as G+9 storey structure is considered with typical storey height and bottom storey height is 3m.

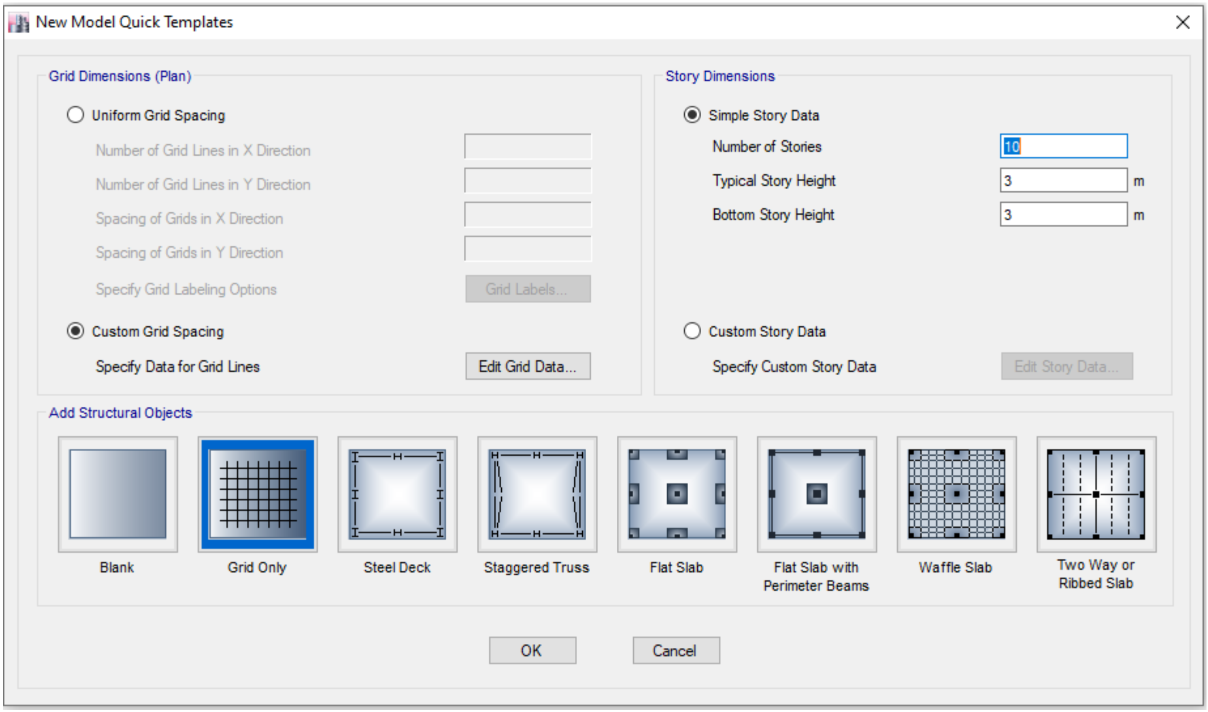


Fig 2 Model Template

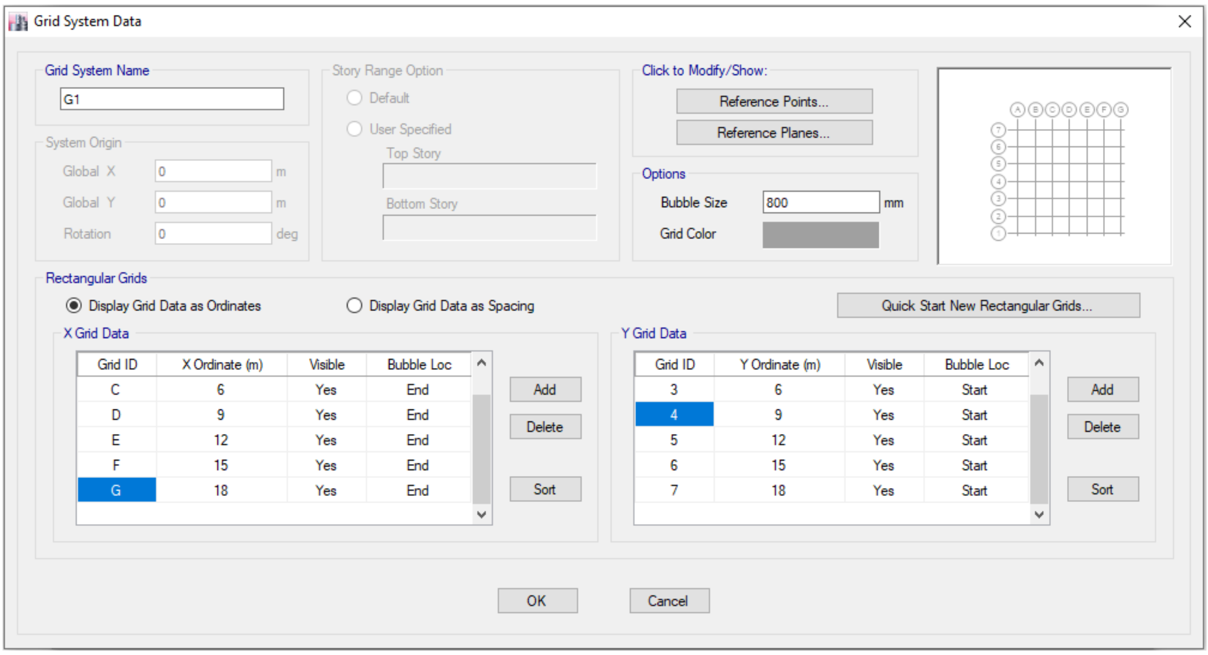


Fig 3 Grid System Data

Step 3: Defining material properties of column, beam and slabs.

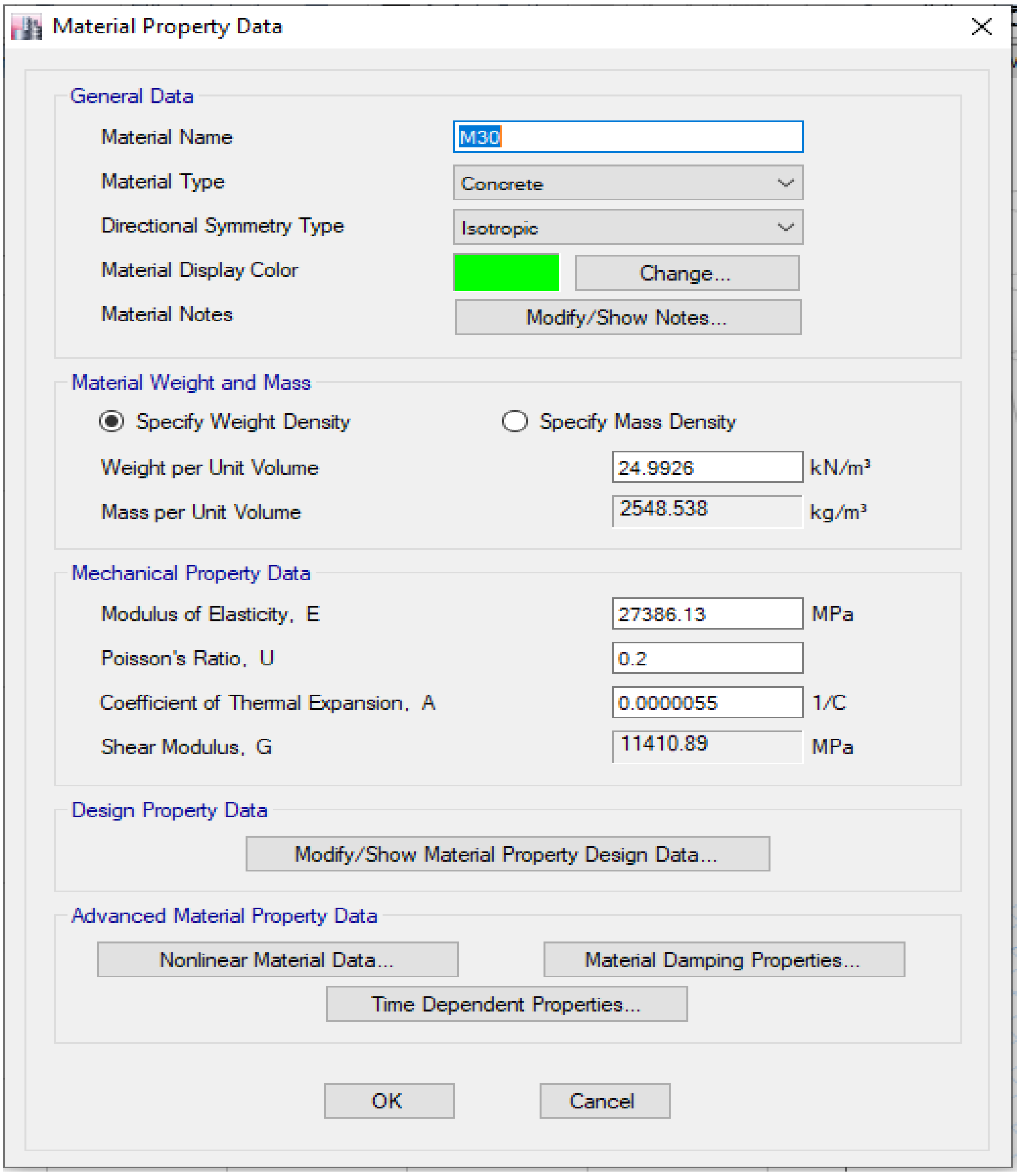


Fig 4 Material Properties for Concrete

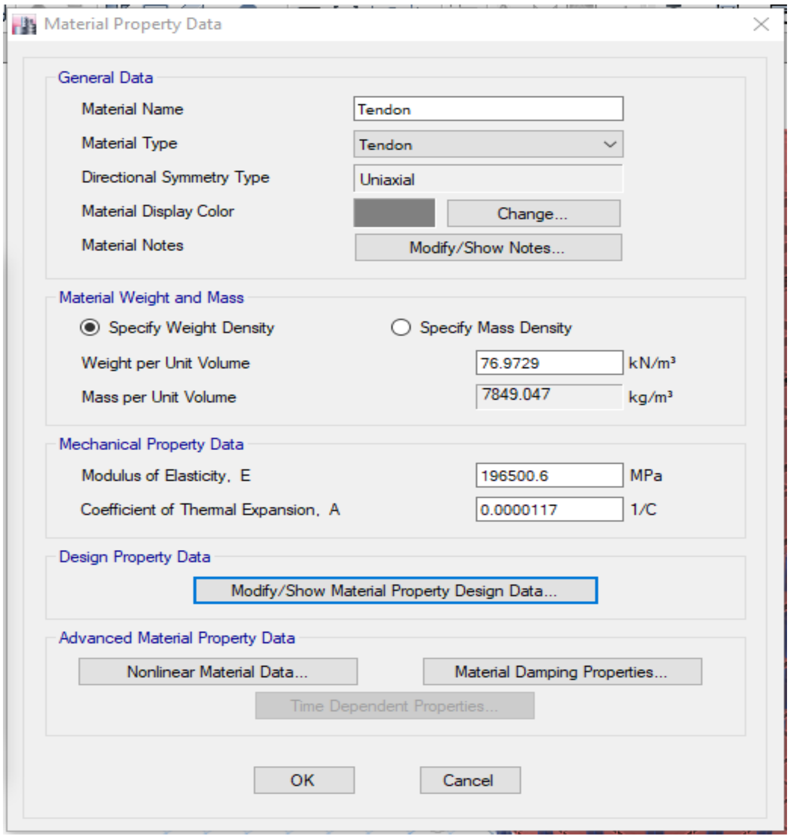


Fig 5 Material Properties for Tendons

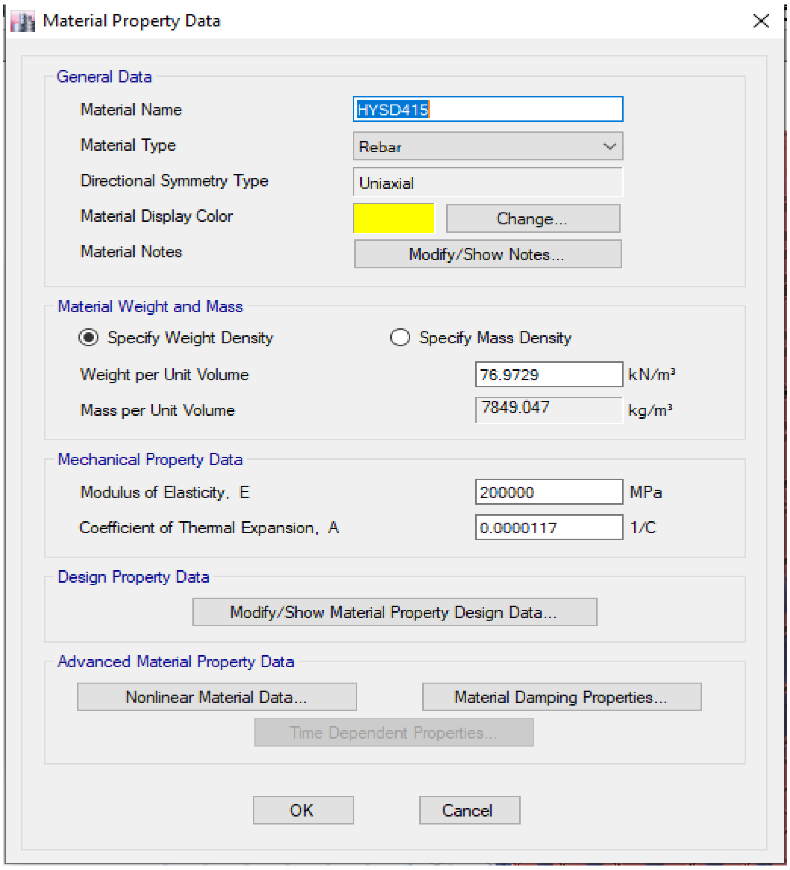


Fig 6 Material Property Data for Rebar

Step 4 Defining sections properties for the size of column, beams and slab.

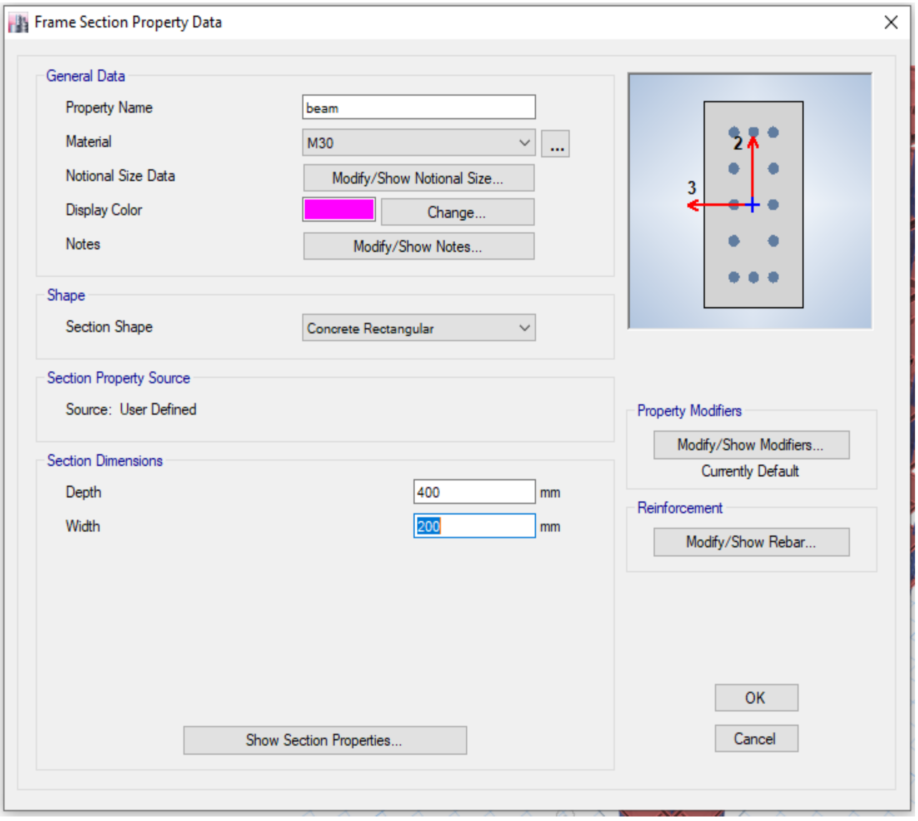


Fig 7 Section Properties for Beam

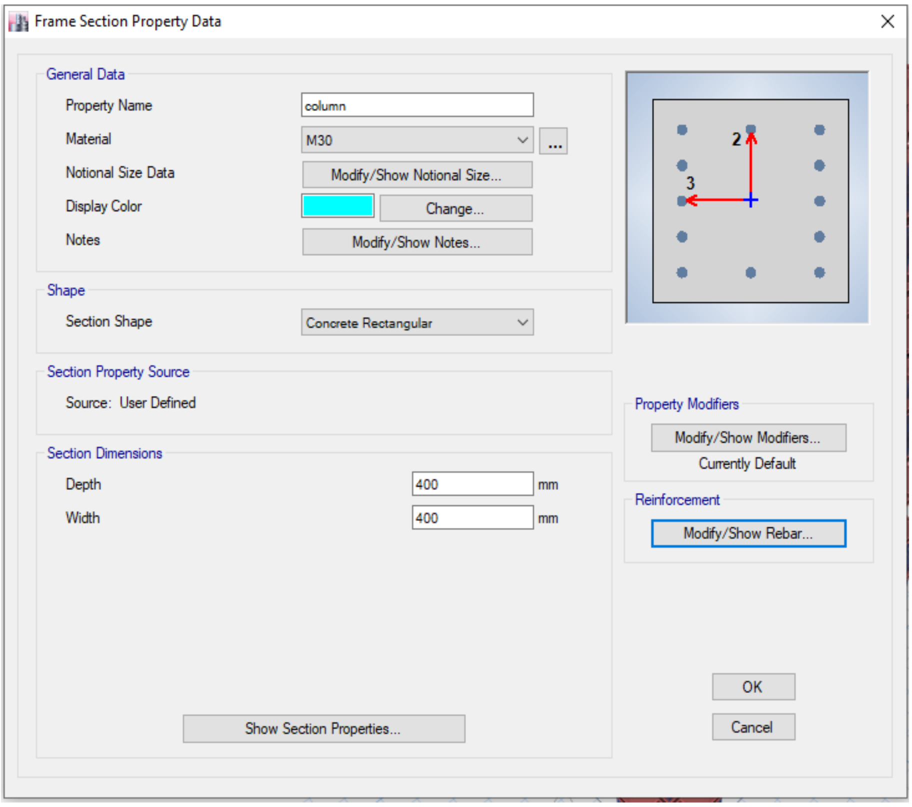


Fig 8 Defining section properties of beam and column.

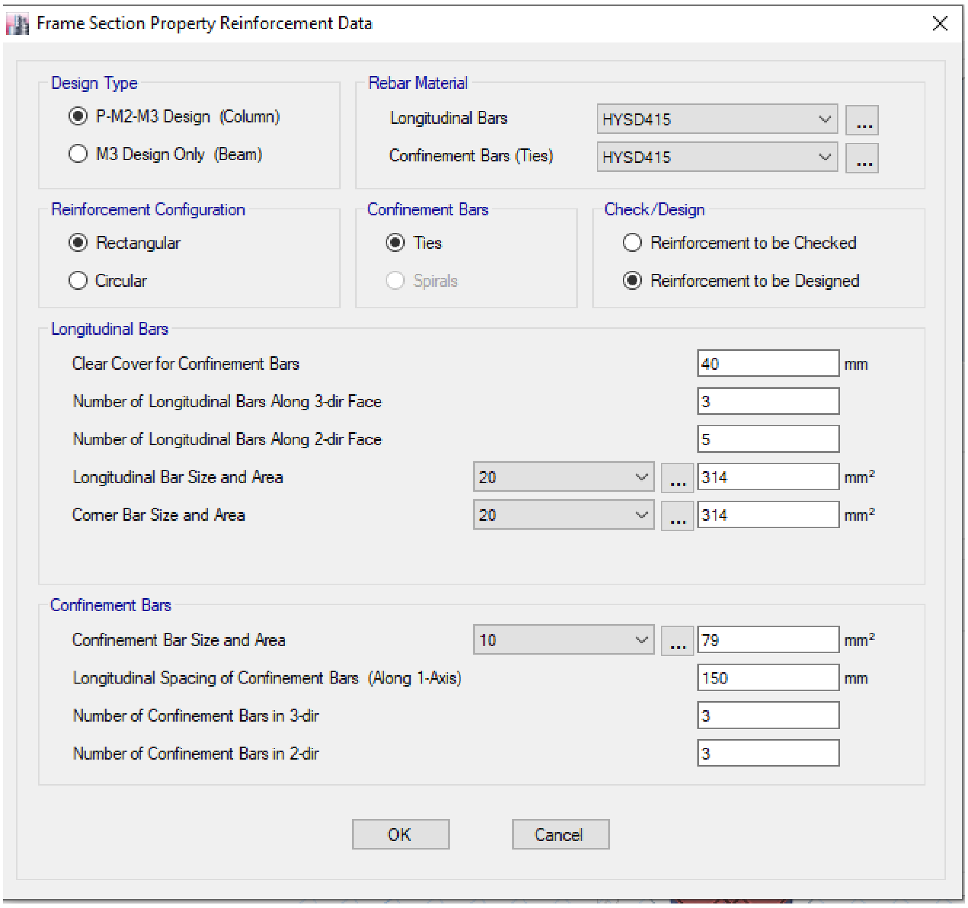


Fig 9 Frame Section Property Reinforcement Data

Step 5 Defining Properties of Slab Data

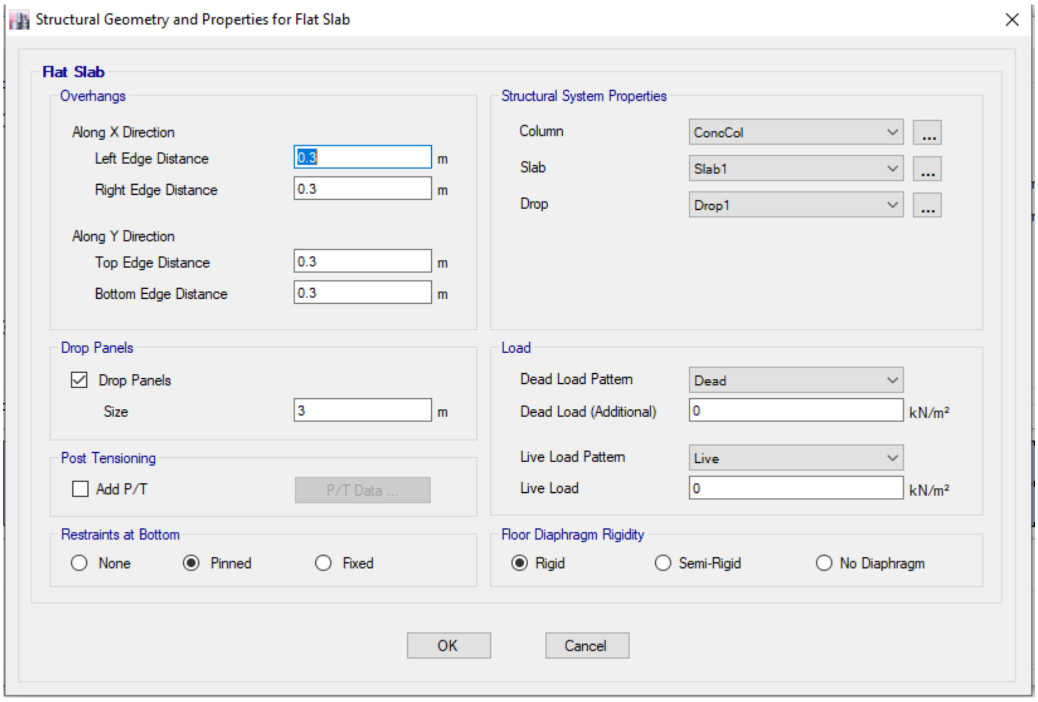


Fig 10 Structural Geoemtry and Properties for Flat Slab

Step 6: Defining Loading pattern for dead load, live load and earthquake load.

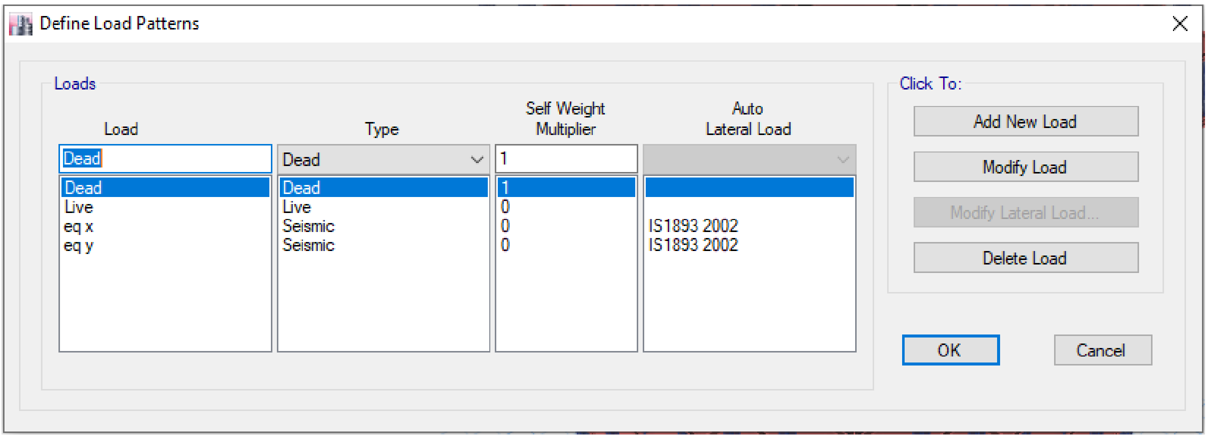


Fig 11 Load Pattern

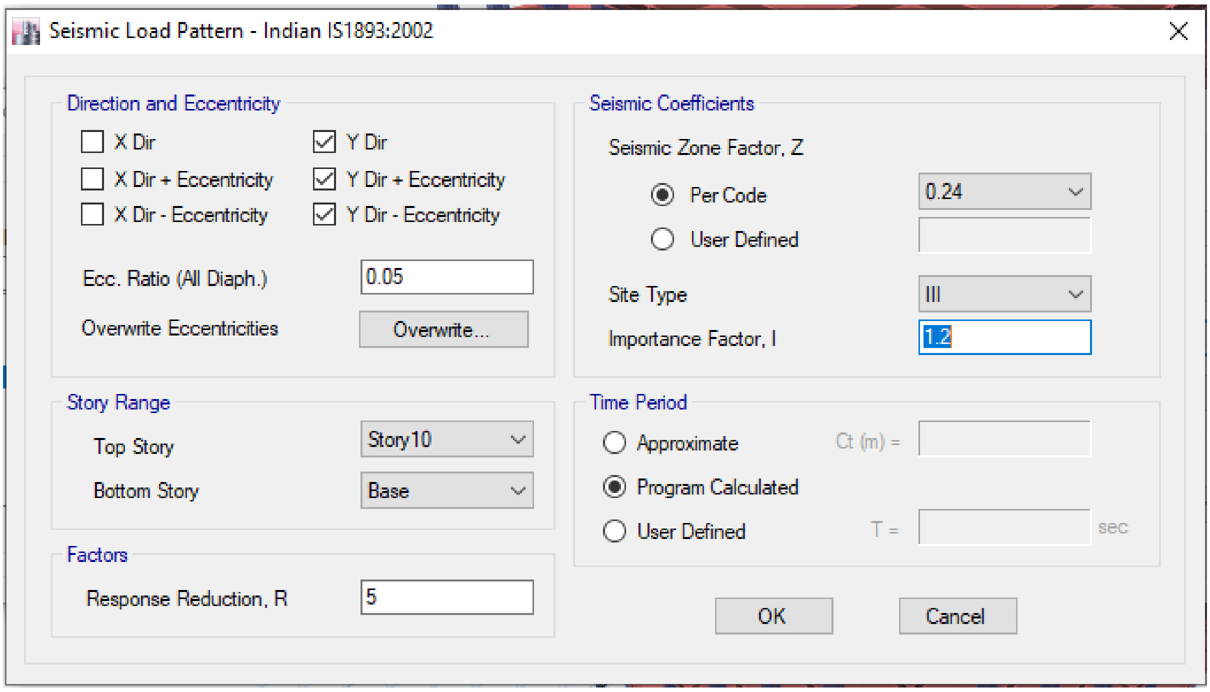


Fig 12 Defining Seismic Load Pattern as per IS 1893:2002.

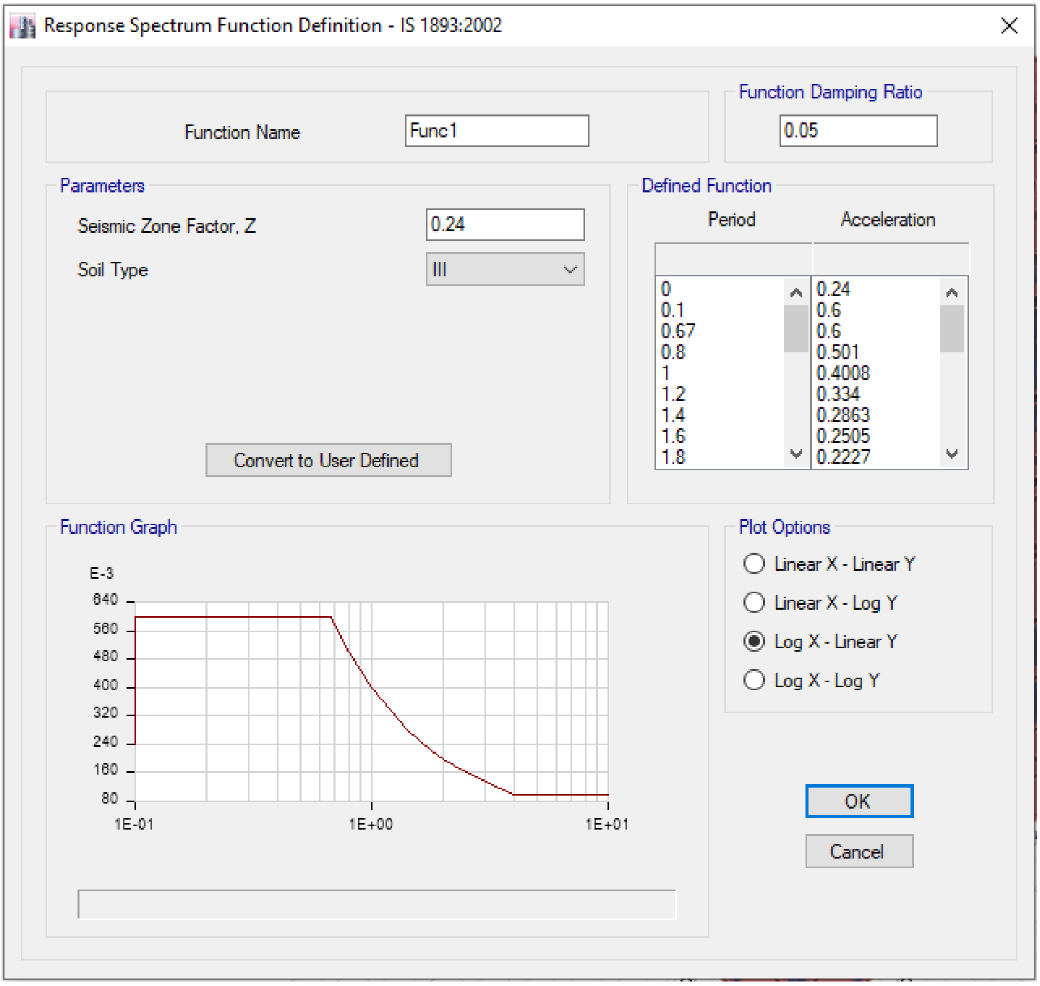


Fig 13 Response Spectrum Function as per IS 1893:2002.

Step 7 Analysing the structure on the parameters of displacement, drift and stiffness.

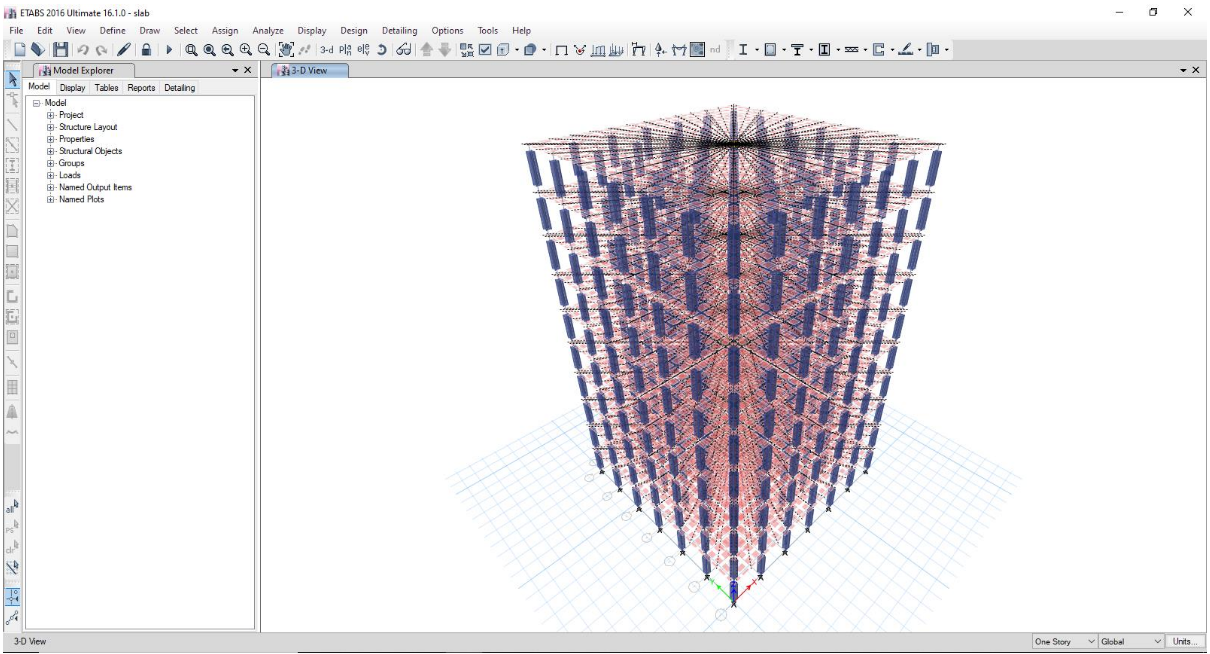


Fig 14 Stress Analsyis

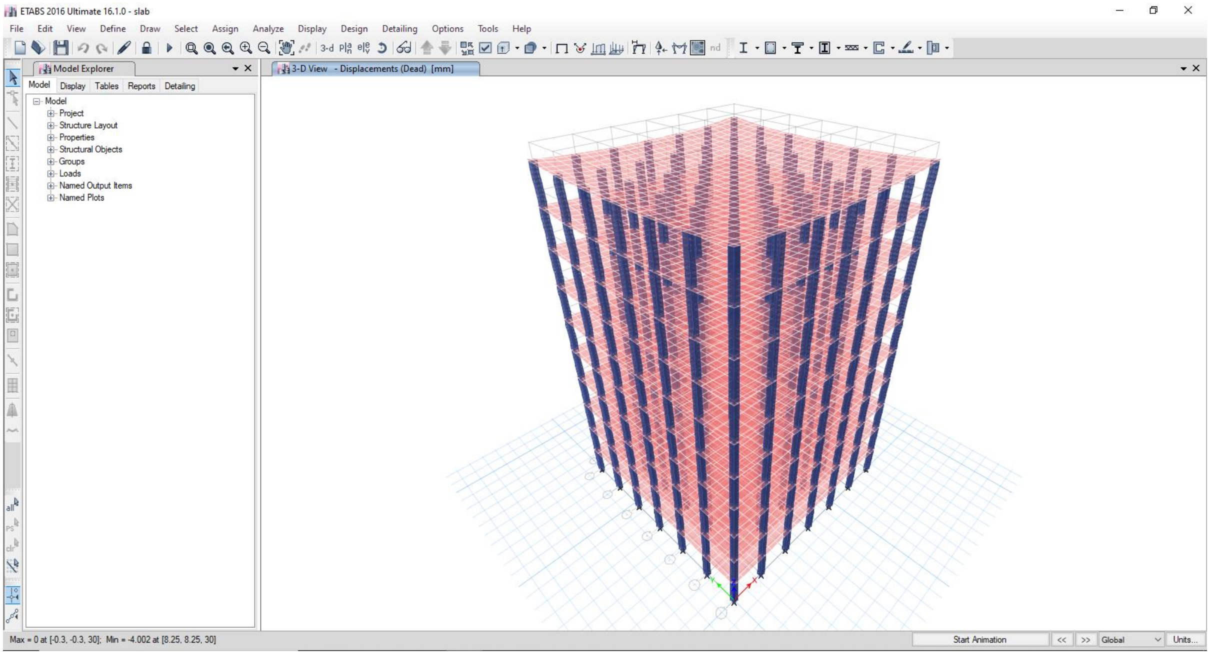


Fig 15 Dead Load

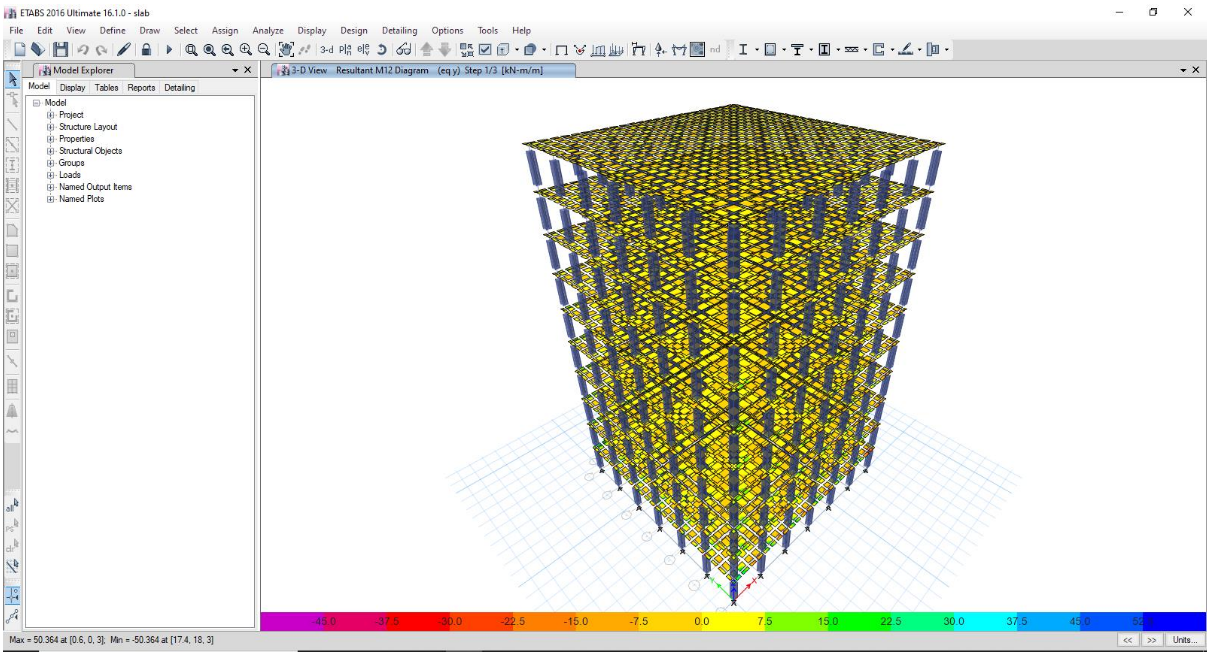


Fig 16 Concrete Slab Stress

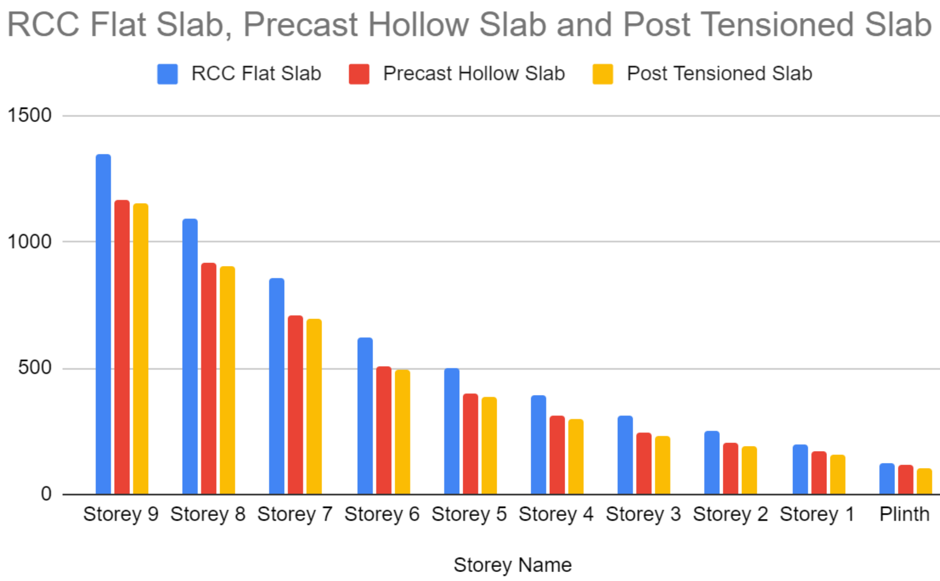
Step 8 Sumamrizing the results generated from ETABS for all the three cases and presenting the graphical representation as per the tabulated data.

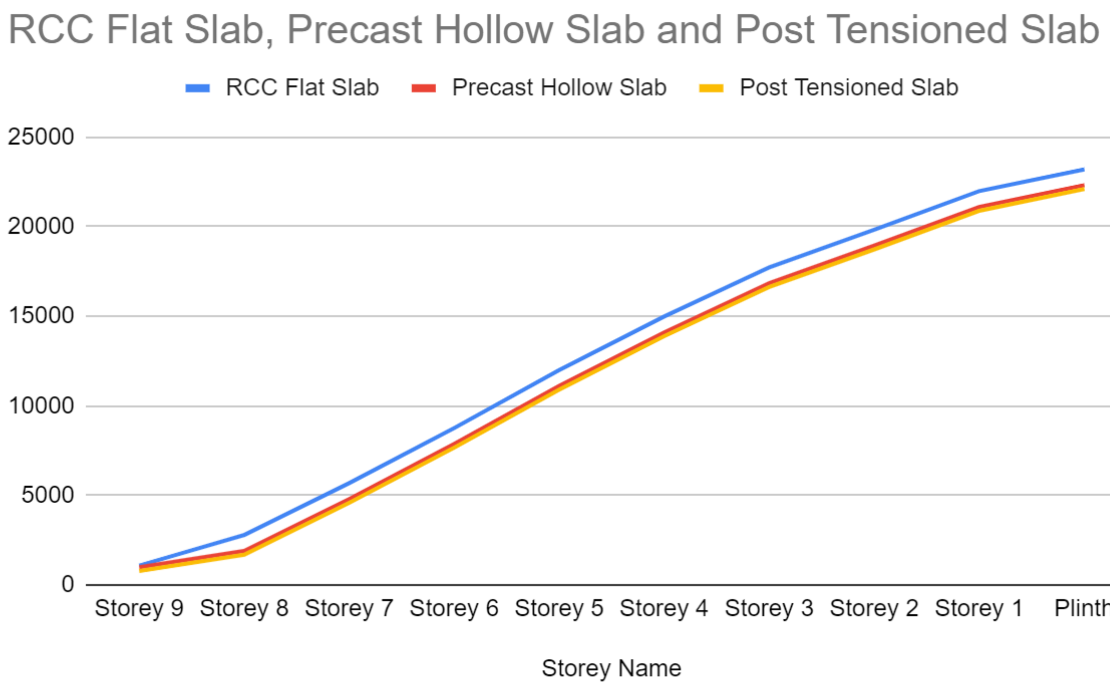
Table 1 Building Configuration

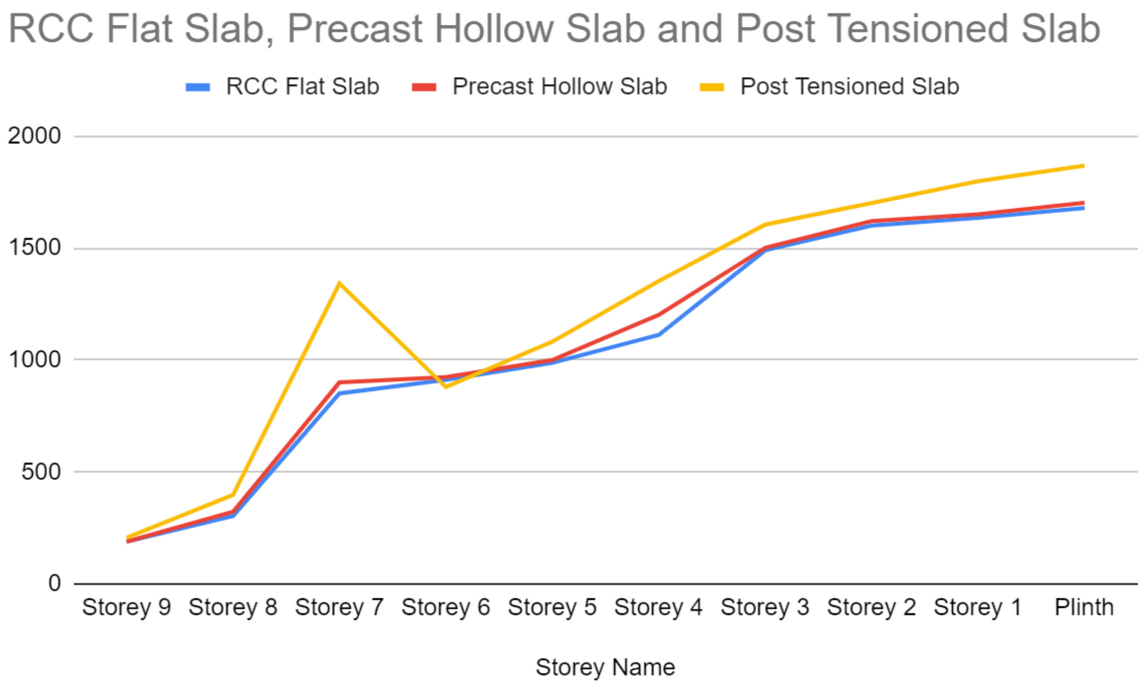
Building Description	
Description	Values
Building size	18*15 m
Number of storeys	G+9
Height of Storeys	3m

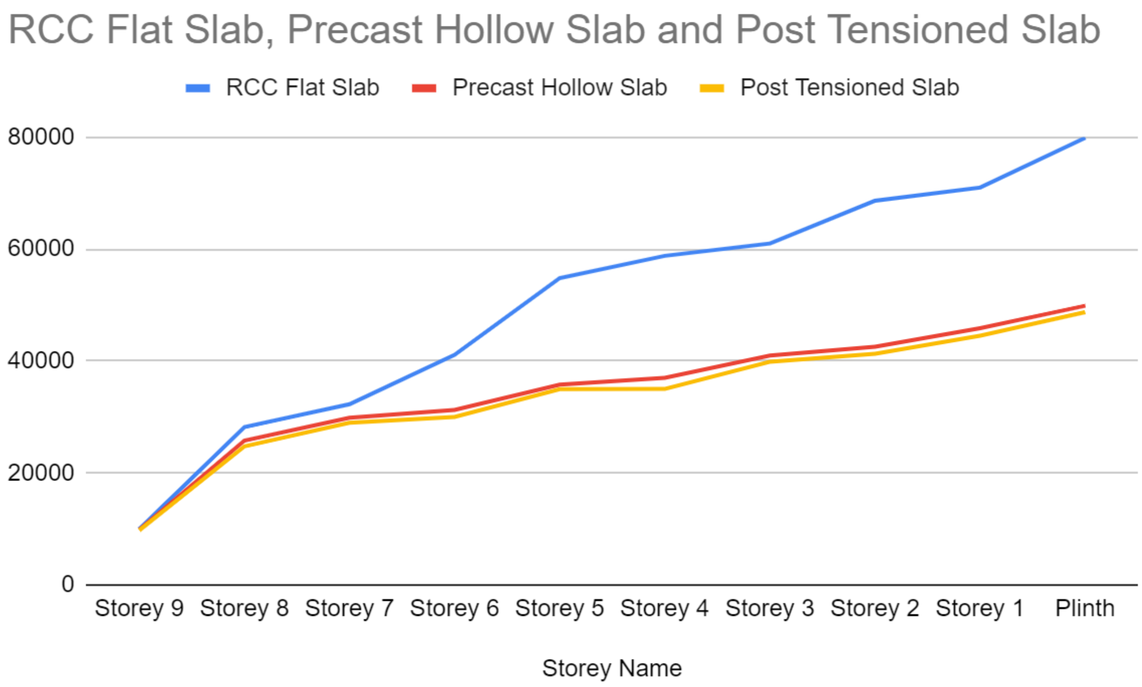
Bottom Storey Height	3m
Beam	400*200mm
Column	400*400mm
Flat Slab	210mm
Post Tensioned Slab	200mm
Precast Hollow Slab	175mm

IV. ANALYSIS RESULT









V. CONCLUSION

It was examined that PT slab stiffness is much efficient in comparison to Flat slab frame system and Precast Hollow Slab frame in reducing moment, storey displacement, peak displacement and forces.

Displacement- The lateral displacement of the story with respect to the basis is referred to as story displacement. The excessive lateral movement of the building can be controlled by the lateral force-resisting system. The acceptable lateral displacement limit in the case of a wind load is H/500 (but some people may use H/400). Storey displacement was found maximum at the top storey storey in structure with Flat slab 1349.921 mm when compared to structure with precast hollow slab 1167.116 mm and 1154.216 mm which states that storey displacement was storey displacement was 8% more when compared to Case II and 9% more when compared to case III. In terms of displacement it can be concluded that PT slab structure is comparatively more stable 25% less displacement as compared to RCC Flat slab structure.

Axial Force- The force operating on a structure in its axial direction is known as an axial tension force. The body will elongate linearly in the upward direction due to the pulling force, changing its dimension. Maximum stress was visible at the bottom of the structure with 23200.987 KN FLat slab. The structure with post tensioned slab was found to be supremely stable when compared to structure with precast hollow slab and structure with Flat Slab. It can be said that vertical distribution is generally same in both the cases. Variation of 8% is observed in PT slab as it is more resisting and distributing.

Shear Force- Shear force, like the pressure of air flow over an aeroplane wing, is a force that acts in a direction that is parallel to (over the top of) a surface or cross section of a body. The word "shear" in the term refers to the ability of such a force to cut through the surface or object that is being stretched. Shear force was maximum at bottom in structure with Post tensioned slab which reduced gradually at the top storey. Shear force was found least in the structure with flat slab. In terms of unbalance forces it was seen that unbalance forces are linear in all the three cases, and values on PT slab case is on the higher end with approximate variation of 5%.

Bending Moment- When an external force or moment is applied to a structural element, causing it to bend, the element responds by experiencing a bending moment. The beam is the structural component that is bent the most frequently or simply. Bending moment was maximum in structure with Flat slab whereas bending moment was found stable in structure with Precast Hollow slab and structure with Post Tensioned slab. In terms of bending moment it is observed that Pt slab structure is comparatively more economical and stable structure since ending moment observed is less by 15%.

Future Scope

- The building can be compared to post-tensioned slab construction techniques.
- the behaviour of structures in various seismic zones and the behaviour of buildings with flat slabs and drops..
- The effect of the shear wall on the structure can be examined.

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