Analysis of Post-Tensioned flat slabbed structures with and without shear walls

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Abstract - The building industry is at the pinnacle of any nation's growth in today's quick-paced and fiercely competitive world. Every human being admires high-rise structures. structures are often constructed using RCC, although in the modern world, high-rise structures are built using post-tensioning. The consumption and expenditure of materials are substantially higher in typical RCC constructions, making post-tensioned construction more cost-effective and long-lasting. More steel and concrete are saved by post-tensioned buildings than by RCC, and the clear span of the rooms is increased. The goal of this project is to use ETABS and SAFE to design a post-tensioned building. This software's primary function is to design multistorey buildings in a methodical manner in accordance with Indian Standard design guidelines.

Index Terms – Post-tensioned slab, PT Slab, Post-tensioned flat slab, Shear wall.

I. INTRODUCTION

A seismic event is among the most devastating natural catastrophes. It is described as a rapid and transient shaking of the crust of earth that happens naturally under the planet's surface. Earthquake are caused by the movement of linked tectonic plates, which causes strain to build up at plate boundaries and inside plates. Because of sliding, a great deal of disasters happens close to plate or fault borders. various records show that an event of shocks results in the damage of various properties and the death of plenty of individuals, which eventually has implications for the national economy. As the population expands, exists a steadily growing need for housing land. Towers with several stories are the only way to fulfil the demand for property for residential and industrial offices expansion. This type of growth requires prudence since multi-story structures are extremely vulnerable to increasing lateral stresses brought on by tremors and wind. the necessity of taking specific steps to lessen the distortions that multiple stories RC structures experience on account of heavy displacement. Disasters like earthquakes have the potential to set off cascade effects. Some examples of ensuing occurrences include gas lines breaking and igniting fires, power going out, transit routes being affected, mudslides bridge failures, or any other subsequent calamity brought on by the tremors. Since the flooring of a building contributes significantly to its overall cost, a posttensioned floor systems have been created, which decreases the amount of time required for construction and, consequently, the project's overall cost. There are numerous enormous skyscrapers being built successfully using post-tensioned flooring in nations including the US, the nation of Australia, the Republic of South Africa, the nation of Thailand, and India. This is resulting from the enormous financial and scientific gains.

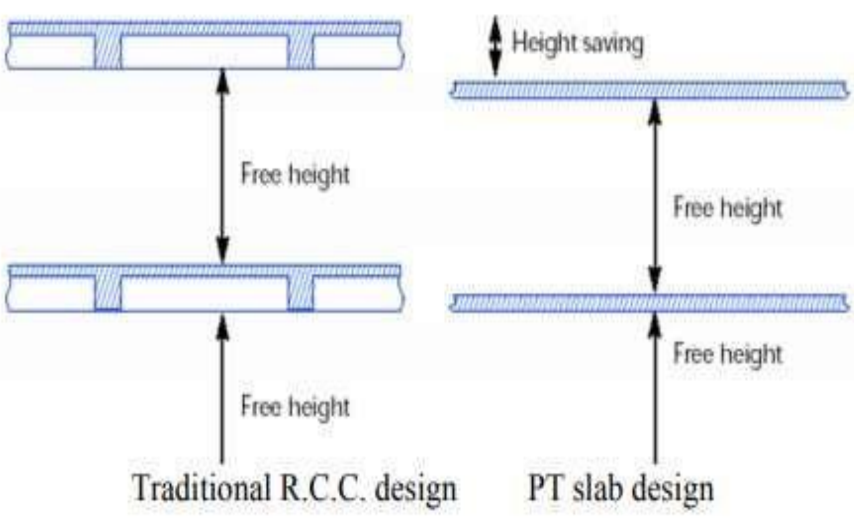


Fig.1 Representation of traditional R.C.C Slab vs PT Slab

II. LITERATURE SURVEY

Vanteddu Satwika and Mohit Jaiswal (2022)[1] In this study, a flat slab is strengthened using the posttensioning technique. RCC flat slabs and posttensioned flab slabs with various tendon profiles are contrasted. There are two distinct tendon: dispersed and banded. The models were made in keeping with ACI 318-14. The ETABS program was used to generate these slab models, and the parameters thickness, supporting responses, punching shear, and deflection were compared. in contrast to conventional flat slabs. The findings show 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.

Osama Khalid Abdelaziz and Dr.Hany Ahmed Abdalla (2021)[2] This study focuses on comparing the two while taking into consideration their costs, timeliness, and structural behavior. For each system, a thorough cost and time analysis incorporating all building resources is conducted. Numerous structural and project management computer programs are used in the analysis and the design buildings. These include Primavera, ETABS, SAFE, RAM, and REVIT. The findings showed that PT systems offer considerable cost reductions for spans greater than 6 m. PT slabs are more successful in resisting seismic straining effects, according to the structural analysis of both systems.

Lalit Balhar[1], Dr. J.N. Vyas[2] (2019)[3] "Analysis and/Design of RCC and Posttensioned Flat Slabs Considering Seismic Effect" The analysis is performed using the STAAD.PRO V8i program. The seismic susceptibility of flat slab constructions and typical RC frame structures highlights that there is additional guidance when creating and designing those structures in seismic areas, as well as for enhancing the productivity of flat-slab constructions and typical RC frame structures under seismic loading. The current study focuses on how flat slabs and typical RC slabs behave in multi-story buildings and how these types of structures perform when subjected to seismic pressures. The current study includes information on seismic base shear, storey shear, story drift, and lateral movement.

III. Methodology

Seismic codes are different for a particular region or a country. In India, Indian standard criterion for earthquake resistant design of structures IS: 1893(part-1)2002 is the main code that provides outline for calculating seismic design forces. ETABS is a powerful and widely used software application for structural analysis and design. Developed by CSI, it is one of the leading structural engineering software tools available in the market. ETABS stands for "Extended Three-Dimensional Analysis of Building System,"and it offers a comprehensive set of tools to analyze and design a wide range of structures, including buildings, bridges, towers, and other civil engineering projects. Response Spectrum method allows the multiple modes of response of a structure to be taken into account. This is required in building code for all except very simple or very complex structures. The response of a structure can be defined as a combination of many modes.

Table 1: Parameters considered for analysis of buildings

SL.NO	PARAMETERS	Respected Values
1	Length in X-direction	30m
2	Length in Y-direction	35m
3	Floor to floor height	3m
4	No of stories	6
5	Total height of the building	18m
6	Slab thickness	150 mm
7	Grade of concrete	M30
8	Grade of steel	HYSD 415,500
9	Wall size	230mm
10	Column size	400mmX400mm
11	Beam size	250mmx450mm
12	Live load in Floors	3kN/m^2
13	Live load in Terrace	2kN/m^2
14	Floor finish	1.5kN/m^2

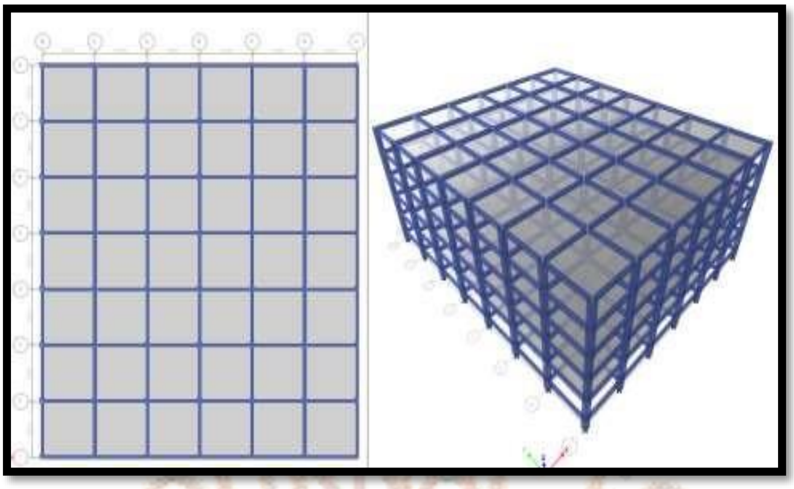


Fig 2: Building model with regular R.C.C conventional slab

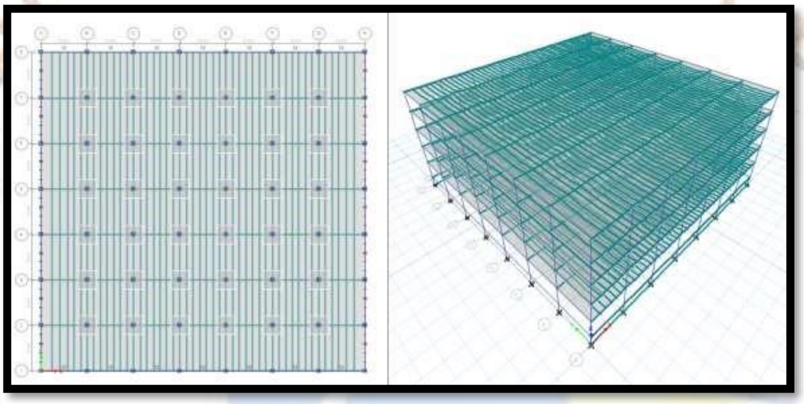


Fig 3: Building model with post tensioned flat slab

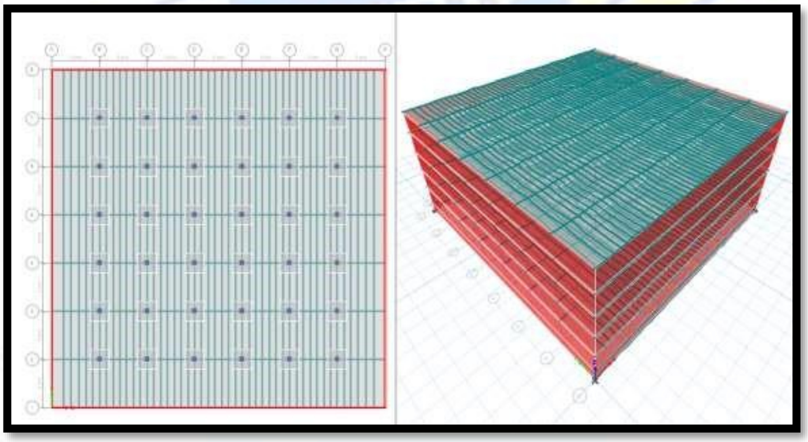


Fig 4: Building model with post tensioned flat slab with shear walls

Using ETABS three set of models are prepared for the study, where one set of models are building with conventional RCC slab where it is analysed in zone II, zone III, zone IV, zone V and second set of models are building with post tensioned flat slab where it is analysed in zone II, zone III, zone IV, zone V and third set of models are building with post tensioned flat slab with shear walls slab where it is analysed in zone II, zone III, zone IV, zone V.

IV. RESULTS AND DISCUSSIONS

Storey Displacement: Story displacement is the deflection of a single story relative to the base or ground level of the structure. Intuitively, we can expect higher total displacement values as we move up the structure. So, a graph showing the story displacement

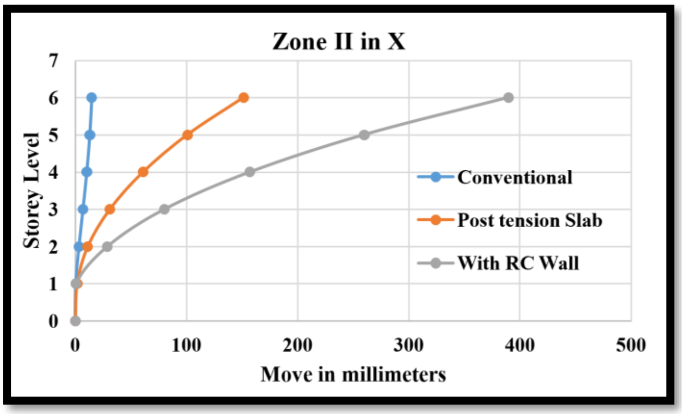


Fig 5 : Storey displacement in Zone II in X direction

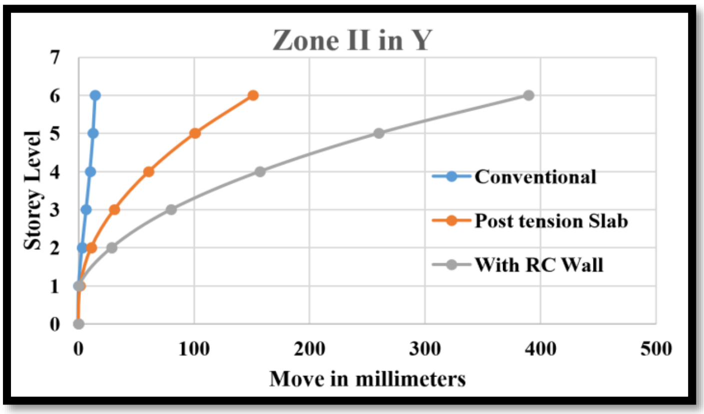


Fig 6 : Storey displacement in Zone II in Y direction

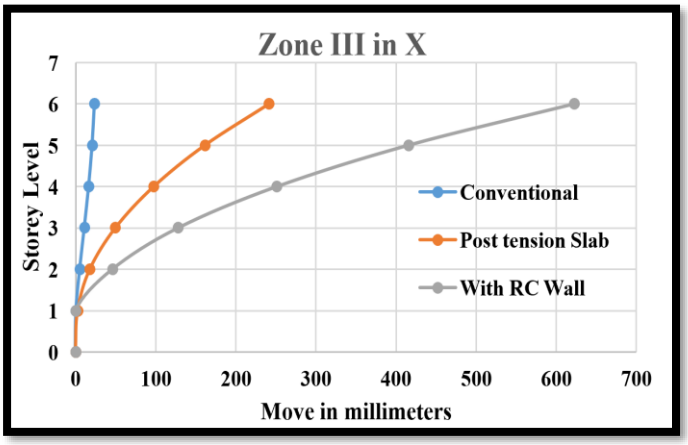


Fig 7 : Storey displacement in Zone III in Y direction

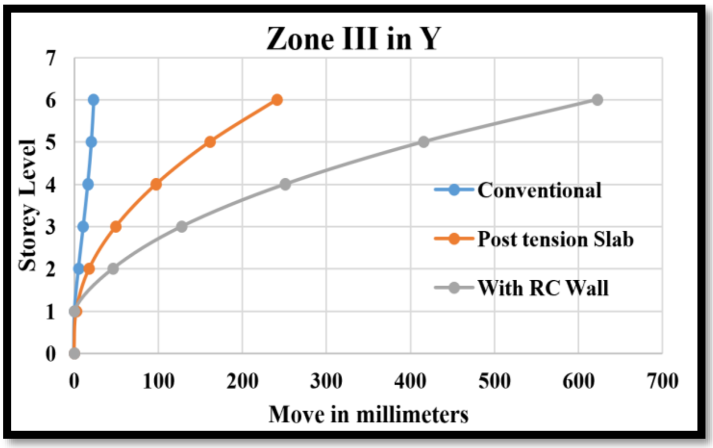


Fig 8 : Storey displacement in Zone III in Y direction

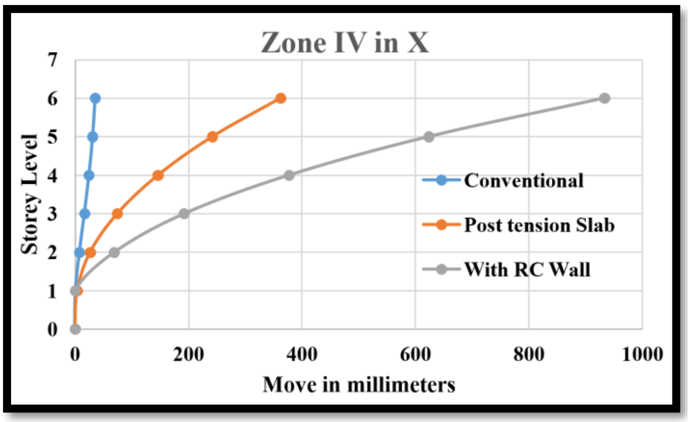


Fig 9 : Storey displacement in Zone IV in X direction

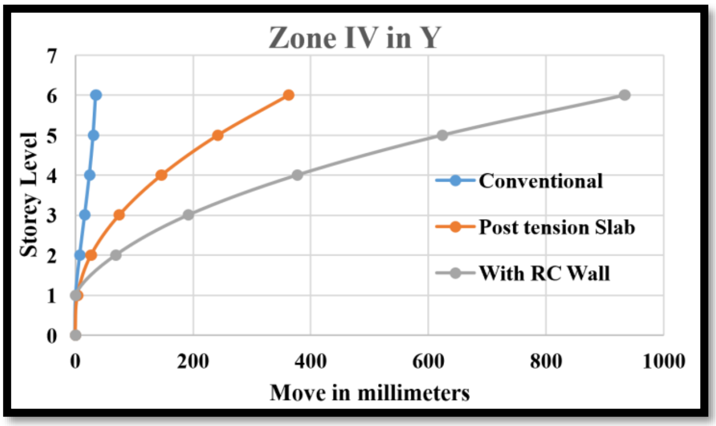
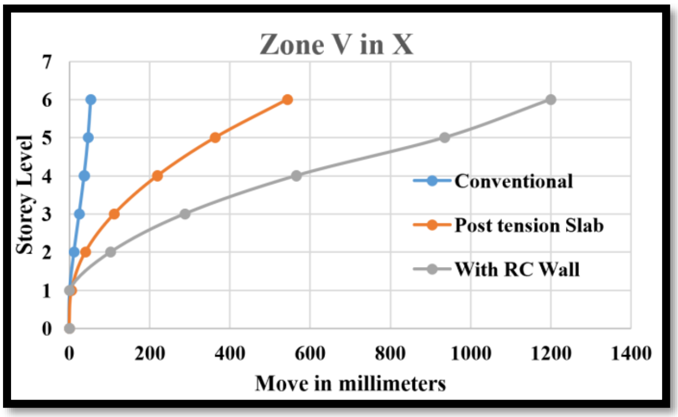


Fig 10 : Storey displacement in Zone IV in Y direction



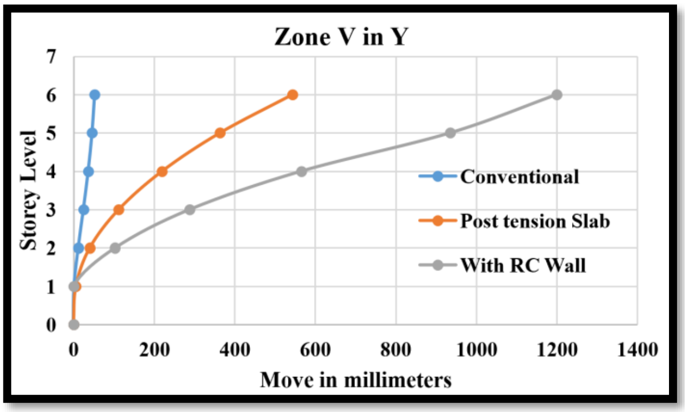


Fig 11 : Storey displacement in Zone V in X direction

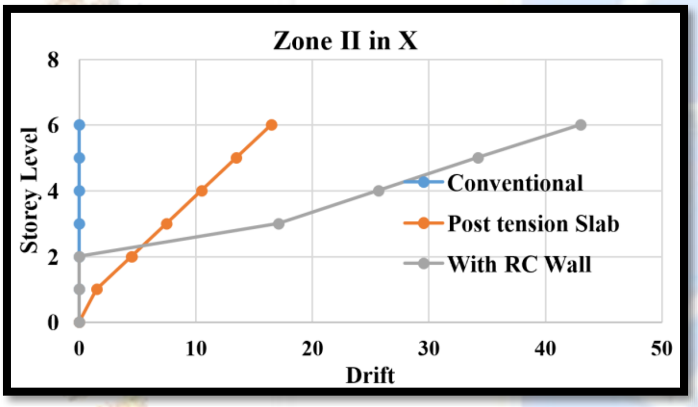
Fig 12 : Storey displacement in Zone V in Y direction

Observation and Discussion on Storey Displacement

However, as the floor height rises, so does the displacement. The tables and graphs above make it crystal evident that the post tension slab with flat slab structure and RC wall is displaying a bigger displacement than any other models. The storey displacement is increasing by 33% for each zone.

The structures with post tension flat slabs display 96% higher displacement values than all other models when it comes to post tension flat slabs. The primary concern, however, is that post tension flat slab displacement routinely exceeds the permitted limit. Conclusion: This kind of slab won't offer earthquake protection in high-rise constructions.

STOREY DRIFT : The term "storey drift" refers to the lateral displacement of a floor with respect to the floor below, while "storey drift ratio" is the product of the storey drift and the storey height. No story may have a storey drift greater than 0.004 times the storey height.



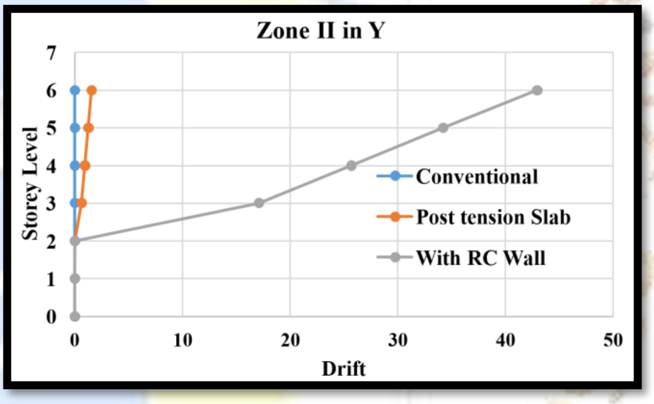
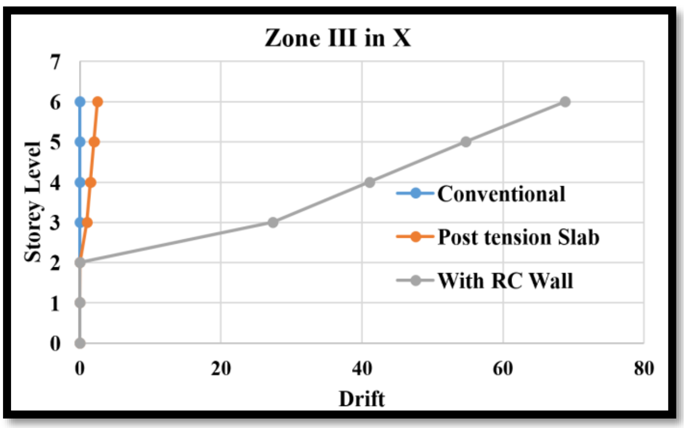


Fig 13 : Storey drift in Zone II in X direction

Fig 14 : Storey drift in Zone II in Y direction



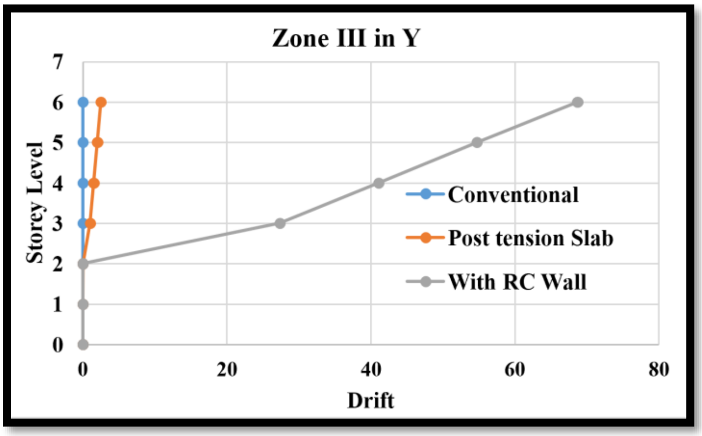


Fig 15 : Storey drift in Zone III in X direction

Fig 16 : Storey drift in Zone III in Y direction

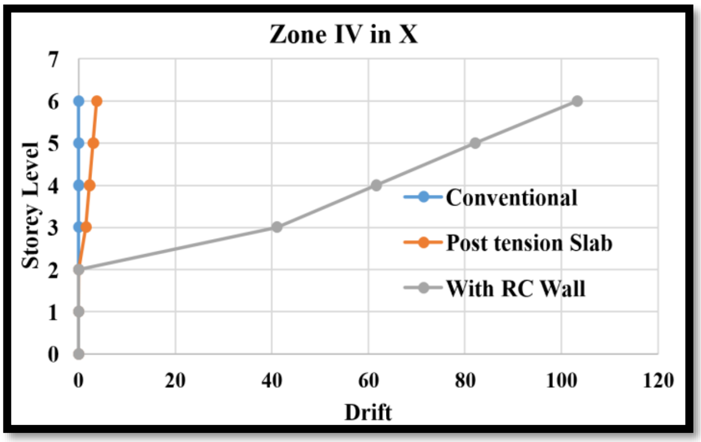


Fig 17 : Storey drift in Zone IV in X direction

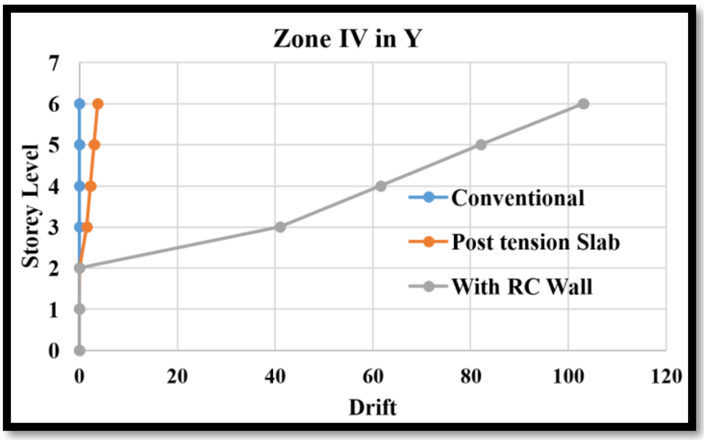


Fig 18 : Storey drift in Zone IV in Y direction

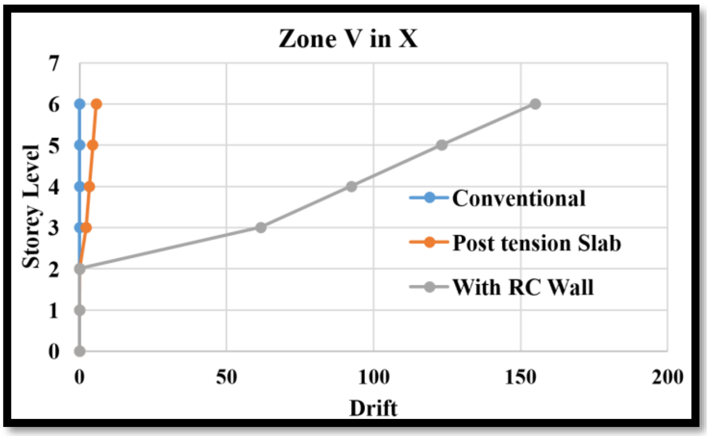


Fig 19 : Storey drift in Zone V in X direction

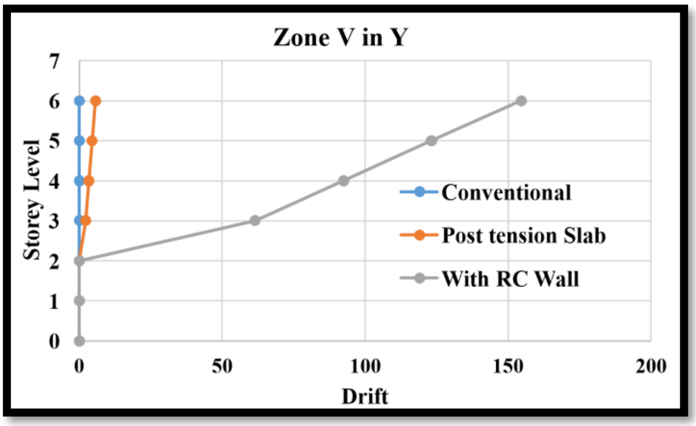


Fig 20 : Storey drift in Zone V in Y direction

Observation and Discussion on Storey Drift

The following graphs clearly show that, among all other buildings, the usual slab drifts the least, even if drift in both situations is more at the top story and less so at the lower story as the floor height increases. But we see that the drift of the post-tension flat slab frequently goes over the allowed limit. In the instance of post tension flat slab, post tension flat slab with RC wall reveals significantly more drift than all other models, with a drift ratio of 99.86% greater than any other design. Storey shear is increasing by 34% zone to zone.We might conclude that high-rise buildings won't be adequately protected from earthquakes by this kind of slab.

STOREY STIFFNESS : In this method, storey stiffness is estimated as the lateral force producing unit translational lateral deformation in that storey, with the bottom of the storey restrained from moving laterally, i.e., only translational motion of the bottom of the storey is restrained while it is free to rotate.

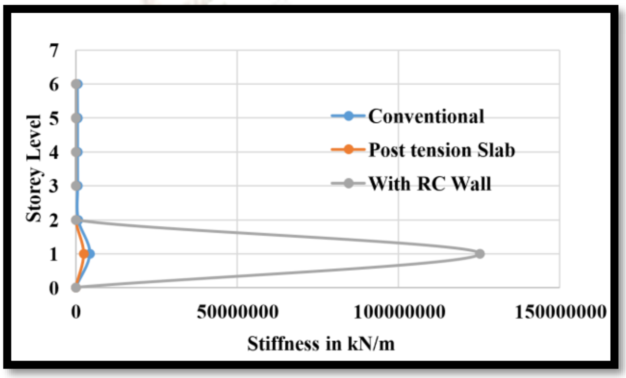


Fig 21 : Storey stiffness in Zone II in X direction

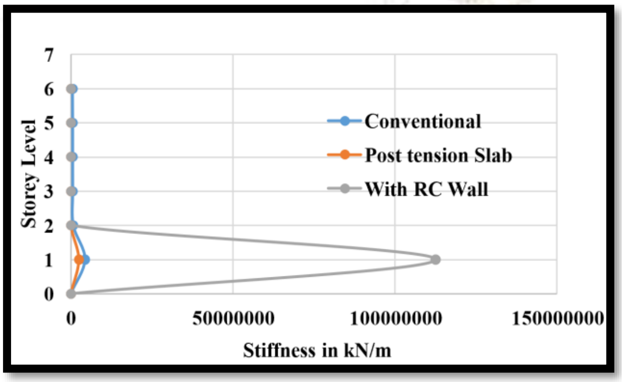


Fig 22 : Storey stiffness in Zone II in Y direction

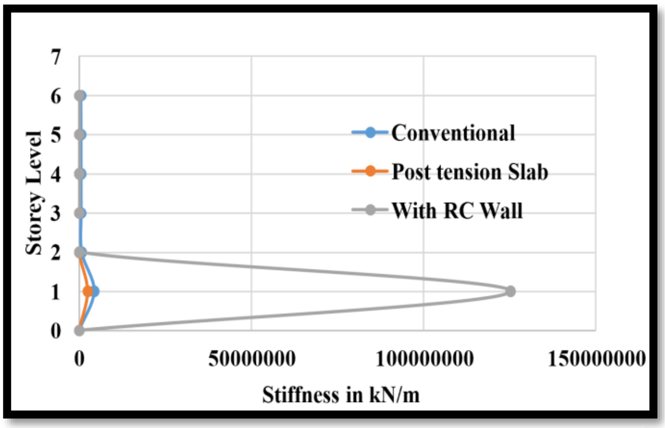


Fig 23 : Storey stiffness in Zone III in X direction

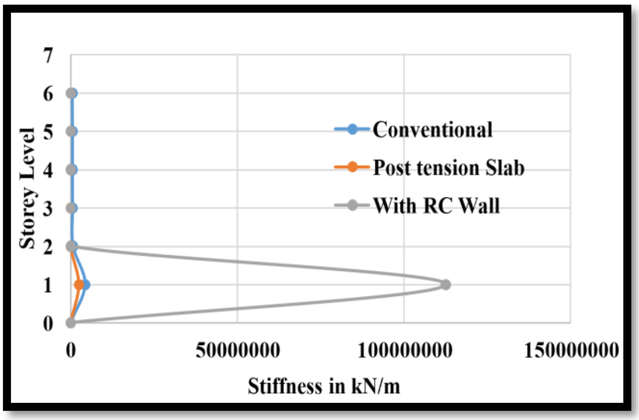


Fig 24 : Storey stiffness in Zone III in Y direction

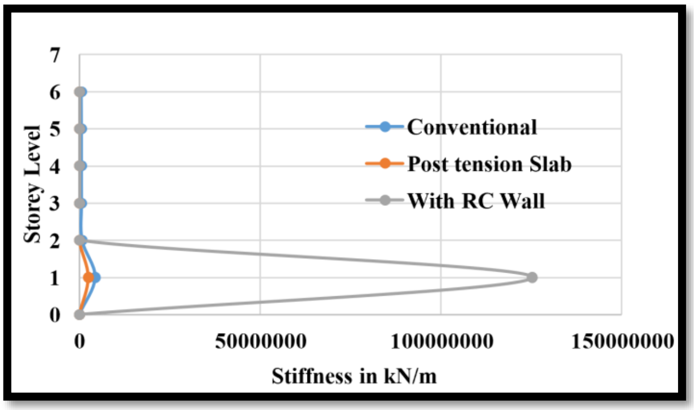


Fig 25 : Storey stiffness in Zone IV in X direction

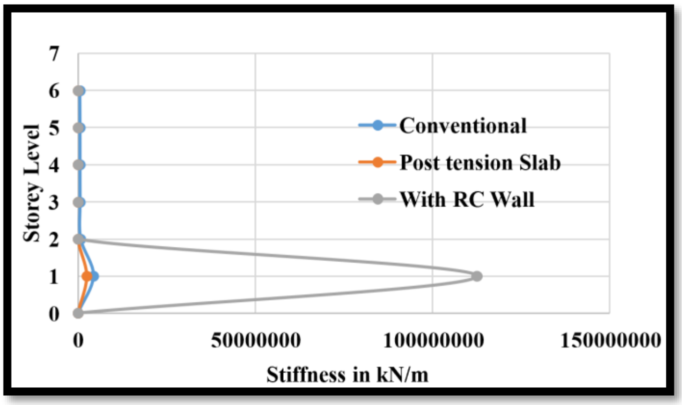


Fig 26 : Storey stiffness in Zone IV in Y direction

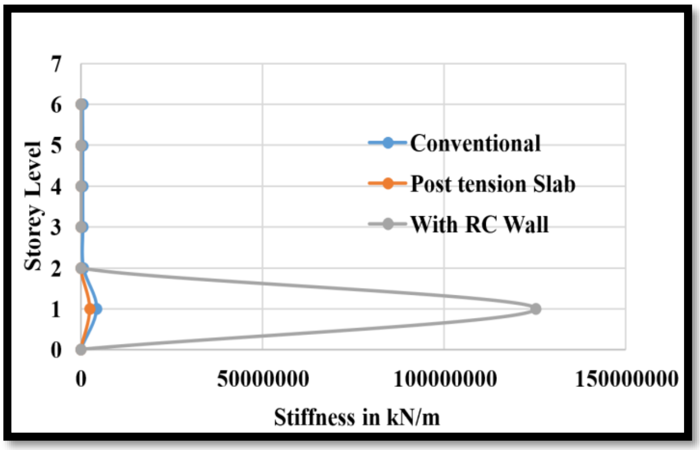


Fig 27 : Storey stiffness in Zone V in X direction

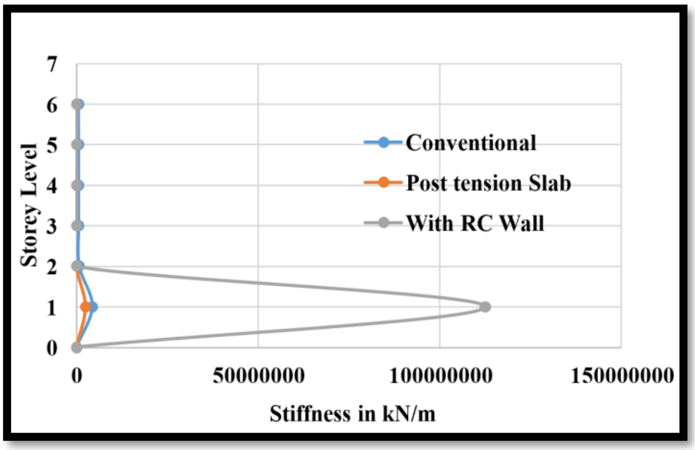


Fig 28 : Storey stiffness in Zone V in Y direction

Storey Stiffness Observation and Discussion

The lowest storeys of the flat slab have the maximum storey stiffness, and as the height of the structure increases, the stiffness keeps decreasing. The storey stiffness is increasing by 38% for each zone. The flat slab with shear wall has a rigidity that is 132% higher than all other types, whereas the bare frame with standard slab has a stiffness that is lower.

BASE SHEAR: Calculating base shear involves estimating the highest lateral stress that seismic activity is anticipated to place on the building's foundation. It is calculated using the seismic zone, soil composition, and lateral force formulas.

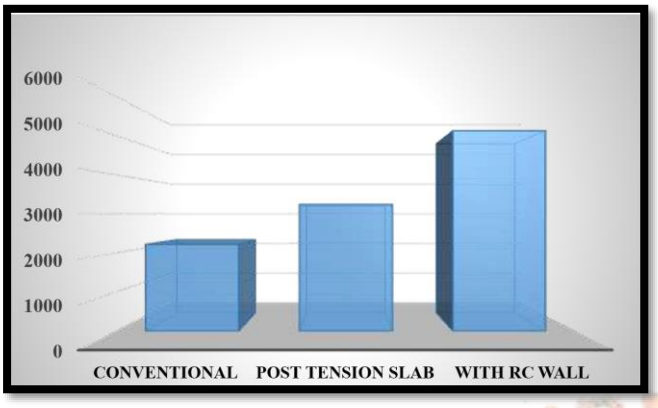


Fig 29 : Base shear in Zone II in X direction

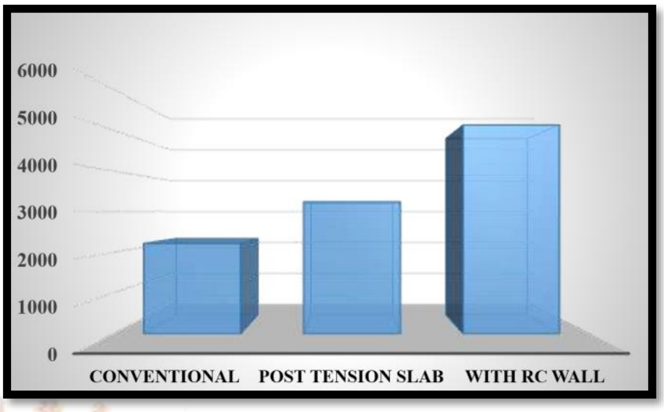


Fig 30 : Base shear in Zone II in Y direction

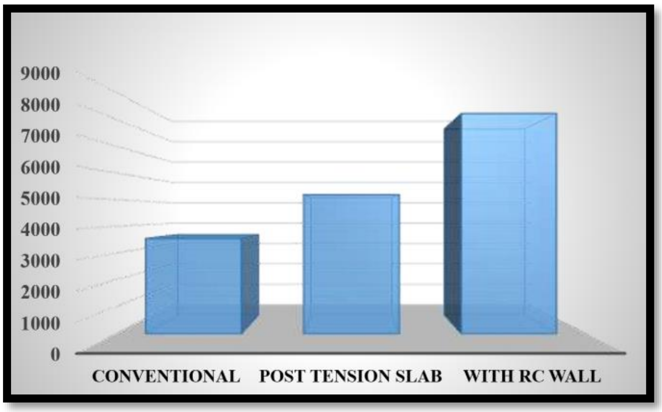


Fig 31 : Base shear in Zone III in X direction

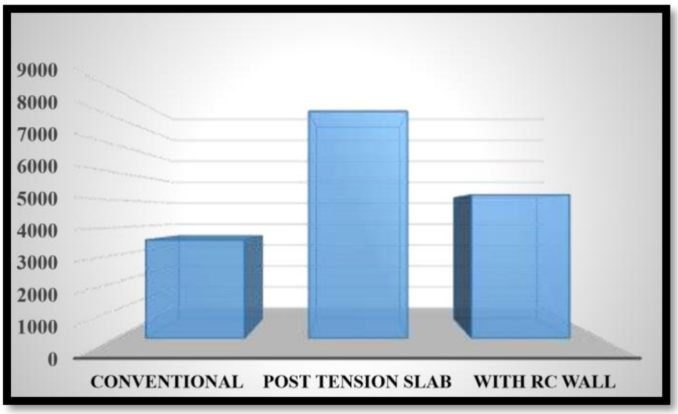


Fig 32 : Base shear in Zone III in Y direction

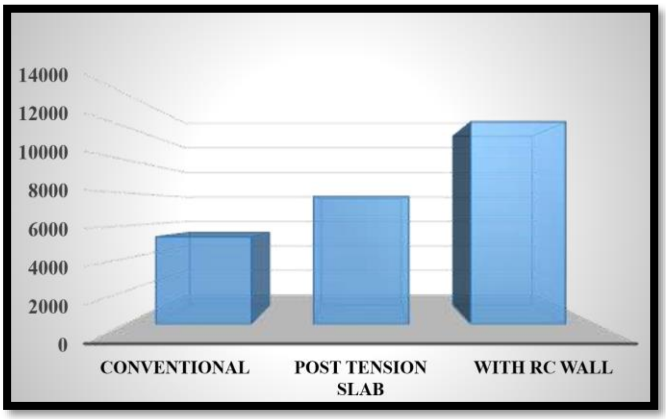


Fig 33 : Base shear in Zone IV in X direction

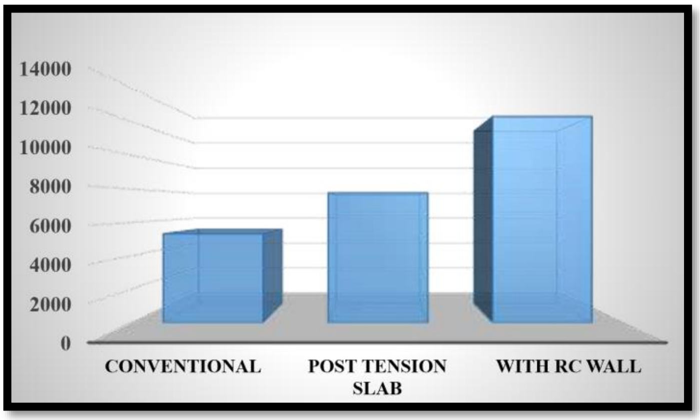


Fig 34 : Base shear in Zone IIV in Y direction

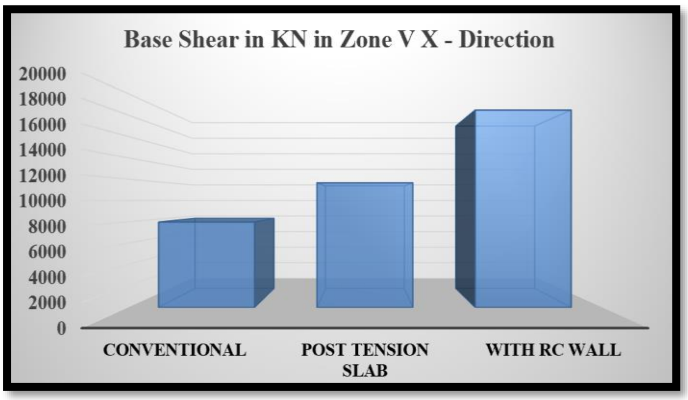


Fig 35 : Base shear in Zone V in X direction

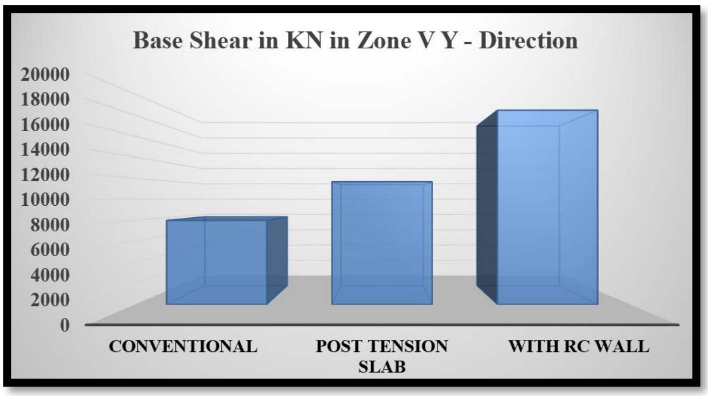


Fig 36 : Base shear in Zone V in Y direction

Discussion on Base Shear Based on Observation

Base shear is lowest in both directions for the bare frame with standard slab and is highest in the case of the post tension flat slab structure when compared to all other types. Base shear increases by 36% zone to zone. Both show 57% of the maximum base shear in both directions when compared to flat slab structures and post tension flat slab with RC wall constructions. But in both cases, the base shear increases with the structure's height.

V. CONCLUSIONS

The most effective technique to reduce structural vibrations brought on by outside disturbances is to incorporate energy dissipation or control mechanisms. The management of vibration caused by an earthquake's influence on a multi-degree-of-freedom structure attached to a shear wall is discussed in this study. Because of its lower lateral stiffness, the post-tensioned flat slab building exhibits inferior seismic response as compared to conventional slab buildings. It is observed that conventional slab more effectively resist lateral loads, when compare to post tension slab structure. In comparison to the other models, the structure with the post-tensioning A greater degree of displacement is visible in flat slab and RC walls. However, we can see that the displacement of post tension flat slabs frequently exceeds the permitted limit. When it comes to post tension flat slabs, the constructions with these slabs show bigger displacement values than those with other post tension models. We might conclude that high-rise buildings won't be adequately protected from earthquakes by this kind of slab.The structure with the post-tensioning flat slab and RC wall is showing a bigger 99% drift as compared to the other models. The structure with a post tension flat slab has a higher drift value than the other post tension models, however it is obvious that the drift of a post tension flat slab continuously exceeds the permitted limit. We can infer that in the case of high-rise constructions, this kind of slab won't offer earthquake protection.We can draw the conclusion that in the case of high rise structures, this kind of slab won't provide earthquake safety.

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