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Analysis of Multi-Storied Building with Prestressed Beam using ETABS

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***Abstract:** Concrete is good in compression and weak in tension and the steel is strong in tension. So the use of reinforced concrete to resist compression and to hold bars in position and to the steel resist tension. In India RCC structures are commonly used in residential as well as business buildings. Nowadays the Post Tensioning method is widely used due to its advantages. Post tensioning is a form of prestressing, that means the steel is stressed before the concrete has to support the service loads. In this paper is exposed to the assessment of execution of Reinforced concrete beam (RCC beam) and Post-Tensioning beam (PT beam) multistoried building structure framework with seismic load using ETABS software. And also evaluate the performance of PT beam under different seismic zone (zone I, zone II) evaluate the performance of PT beam under soil type (medium soil) and compare the performance of RCC deep beam and PT beam with multistory building system with seismic loading performance.*
***Keywords**: Post tensioned beam, Reinforced concrete beam, Seismic load, Prestressing, Storey Displacement.*

I. INTRODUCTION

In India RCC Structures are normally used in residential as well as business Buildings. At the present in construction industry the post tensioning method is widely used due to its advantages. Post-tensioning is a form of pre-stressing. It means that the steel is stressed before the concrete has to support the service loads. And most precast and pre-stressed concrete is actually pre tensioned the steel is pulled before the concrete is poured. It is commonly used for floor beams, piles and railways sleepers, as well as structures such as bridges, water tank and runways. And pre-stressed concrete is not necessary for columns and wall only economical for tall columns and high retaining walls. In ordinary reinforcement concrete which consist of concrete and mild steel. Concrete is good in compression and weak in tension. Compressive stress is resisted by concrete and tensile stress by steel but in the case of pre-stressed concrete, the concrete and steel are stressed prior to the application of external loads. The main advantages of pre-stressed concrete members are free from cracks and resistance to the effect of impact, shock, and stresses are higher than RCC structures. And also high tensile strength of steel and high compressive strength of concrete are used for pre-stressing that makes it more economical.

Two decade back there was a major issue that is lack of skilled workers for pre-stressing work. Nowadays there are endless workers for execution of a similar work and are less expensive. Analysis of RCC beam and PT beam section with multistory structure framework can be done by the software like ETABS. To calculate the multistory buildings strength and its property done by manually is very difficult and time consuming, however the software makes it with ease and rapidly. It also provides the multistory building 3D view. And evaluate the PT beam structure in different seismic zone condition (zone II, zone III) and under the soil type II. And compare the result with RCC beam structure.

A. Scope and Objectives

The main objective of the project is:

1) To conduct Response Spectrum method on PT beam and RCC beam building.
2) To evaluate the performance of PT beam under different seismic zone.
3) To analyse the Bending moment, Shear force and Storey Displacement.
4) To compare the results of PT beam building and RCC beam building at two Zone (II&III).

II. MODELLING

The modelling and analysis is carried out in ETABS 2019 software. A 15 storied building plan is used for this analysis. The building plan 20m X 25m and height of each storey is 3.5m. And analysis is done both in RCC beam and PT beam with different zone condition such as zone II and zone III. Seismic loads are applied in the structure.

Table.1 Geometric Details

Sl no	Description	Details
1	No. of stories	15
2	Plan dimension	20x25m
3	Floor height	3.5m
4	Grade of concrete	M 30
5	Grade of steel	Fe 415
6	Slab thickness	200mm
7	Colum size	600x600mm
8	Beam size	450x450
9	Seismic zone	I,II
10	Soil type	Medium soil

The plan of PT beam building and RCC beam building is shown below. Plan dimension is 20 X 25mm. And column, beam and slab size is given in the table1.

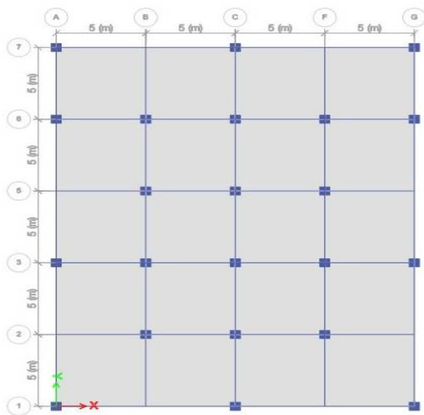
Fig:1 Plan of PT beam building

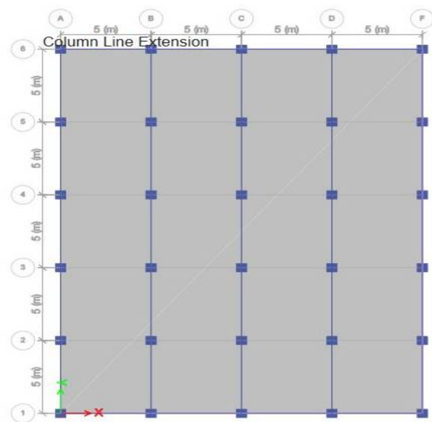

Fig:2 Plan of RCC beam building

A. Material Properties

The materials selected in this analysis are M30 concrete and Fe 415 grade steel. The data regarding the modelling of the buildings shown in table 1.

B. Sectional Properties

The sectional properties are selected in this analysis are PT beam and RCC beam of sectional size 450x450mm and column size is 600x600mm.

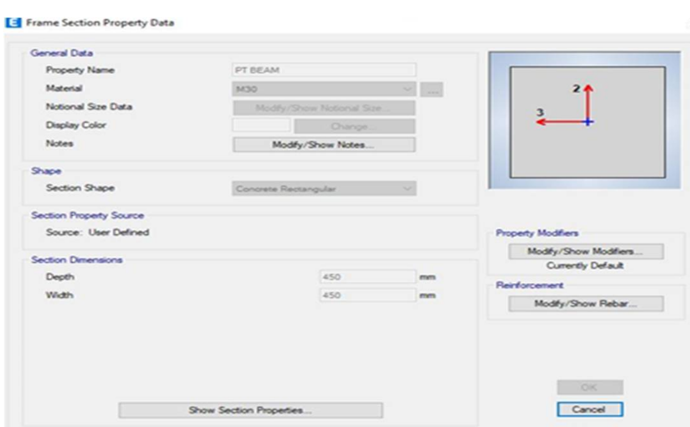

Fig 3: Sectional property of PT beam

C. Load Cases

In this analysis the loads will include Dead load (IS 875 part I), Live load (IS 875 part II) and seismic load (IS 1893-2002). The dead load assigned in the form of Super dead load that is wall load at the frames are 15.17 kN/m and floor load at the shells are 5 kN/m and floor finish is taken as 1 kN/m. the load Combinations are considered for the design and analysis are as per IS 1893:2002.

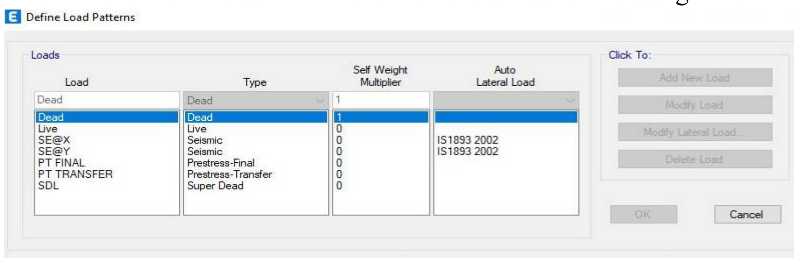

Fig 4: Load conditions

III. ANALYSIS OF THE STRUCTURE

The analysis is done by ETABS 2019 software and using Response spectrum method for the analysis of the structure. Response spectrum method is used to get the Storey Displacement, Storey Shear and Moment of the building.

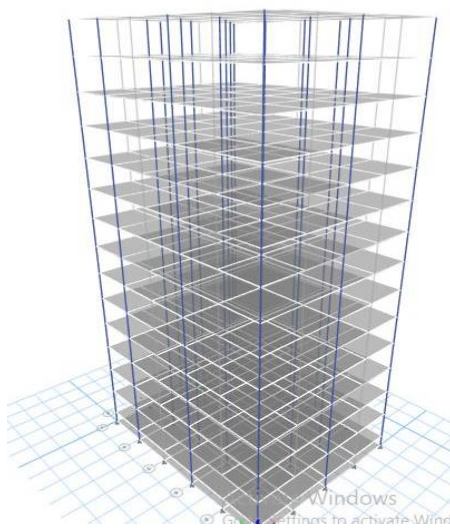

Fig 5: Modelling of PT beam structure

An RCC structure is a get together of beam, column and slab associated wit one another as a solitary unit. In this paper, we compare the bending moment, shear force and storey displacement of both RCC beam and PT beam structures. And also analyse the structures in different zone conditions.

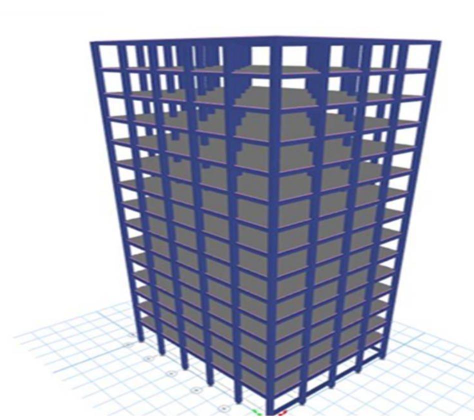

Fig 6: 3D Modelling of RCC beam structure

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From Response spectrum analysis results the Bending moment value of the Reinforced concrete beam structure and Post-Tensioned beam are given below.

Table 2: Bending moment of RCC beam and PT beam building at zone II

Storey	RCC beam (kNm)	PT beam (kNm)
Storey 15	95.321	46.341
Storey 14	94.241	45.809
Storey 13	93.104	45.5389
Storey 12	92.561	45.224
Storey 11	91.942	44.8357
Storey 10	91.110	43.7273
Storey 9	90.101	42.982
Storey 8	89.601	42.680
Storey 7	88.651	42.479
Storey 6	87.980	42.241
Storey 5	87.554	41.961
Storey 4	87.187	41.626
Storey 3	86.344	41.265
Storey 2	83.567	40.668
Storey 1	81.623	40.601

Table 3: Bending moment of RCC beam and PT beam at zone III

Storey	RCC beam (kNm)	PT beam (kNm)
Storey 15	95.321	46.341
Storey 14	94.241	45.809
Storey 13	93.104	45.5389
Storey 12	92.561	45.224
Storey 11	91.942	44.8357
Storey 10	91.110	43.7273
Storey 9	90.101	42.982
Storey 8	89.601	42.680
Storey 7	88.651	42.479
Storey 6	87.980	42.241
Storey 5	87.554	41.961
Storey 4	87.187	41.626
Storey 3	86.344	41.265
Storey 2	83.567	40.668
Storey 1	81.623	40.601

The bending moment is maximum at the top of the storey. The bending moment value goes on increasing as the height of the building increases. The value of bending moment is higher for RCC beam than PT beam.

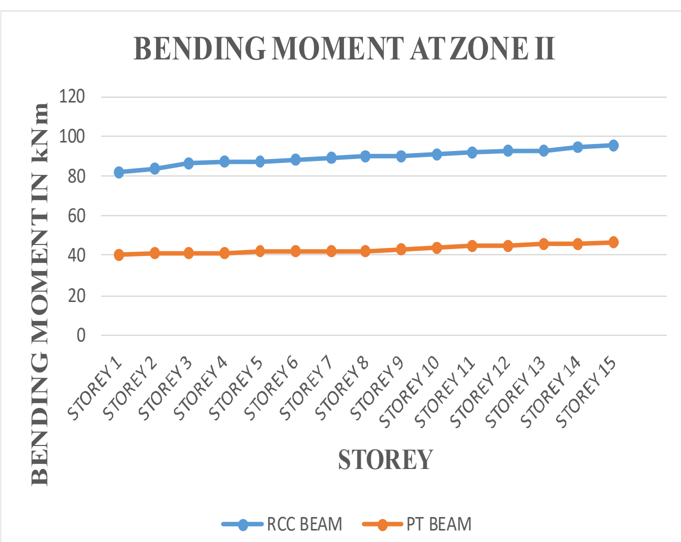

Fig:7 Bending moment at zone II

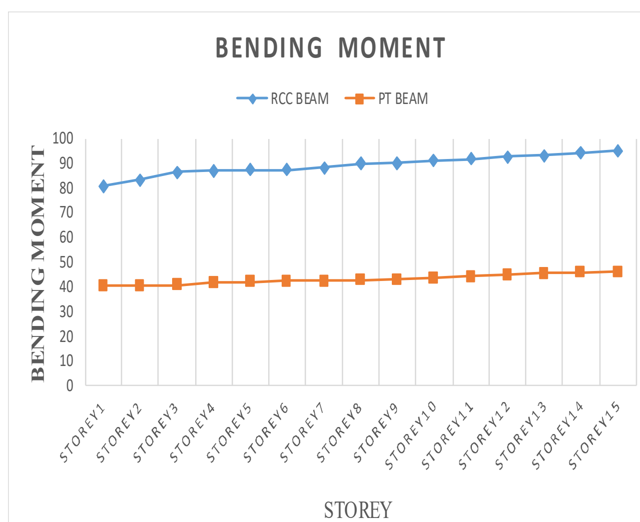

Fig 8: bending moment at zone III

Table 4: Shear force of RCC beam and PT beam

Storey No	RCC Beam(kN)	PT Beam(kN)
Storey 15	221.412	110.540
Storey 14	220.842	108.115
Storey 13	216.708	105.575
Storey 12	215.607	105.061
Storey 11	213.491	104.508
Storey 10	210.681	102.816
Storey 9	207.318	101.332
Storey 8	203.297	99.571
Storey 7	198.578	97.538
Storey 6	193.113	95.188
Storey 5	186.869	92.502
Storey 4	183.562	90.854
Storey 3	179.525	90.591
Storey 2	174.558	90.316
Storey 1	168.532	89.996

Table 5: Shear force of PT beam and RCC beam at Zone III

Storey No	RCC Beam (kN)	PT Beam (kN)
Storey 15	221.312	110.412
Storey 14	220.689	108.101
Storey 13	216.698	105.572
Storey 12	215.593	105.055
Storey 11	213.381	104.035
Storey 10	210.210	102.811
Storey 9	207.318	101.213
Storey 8	203.102	99.532
Storey 7	198.234	97.534
Storey 6	193.112	95.182
Storey 5	186.679	92.495
Storey 4	183.236	91.049
Storey 3	179.213	90.701
Storey 2	174.432	90.305
Storey 1	168.074	89.542

The value of shear force increases and lower values at the bottom storey levels. And compared to PT beam building RCC beam building has higher value.

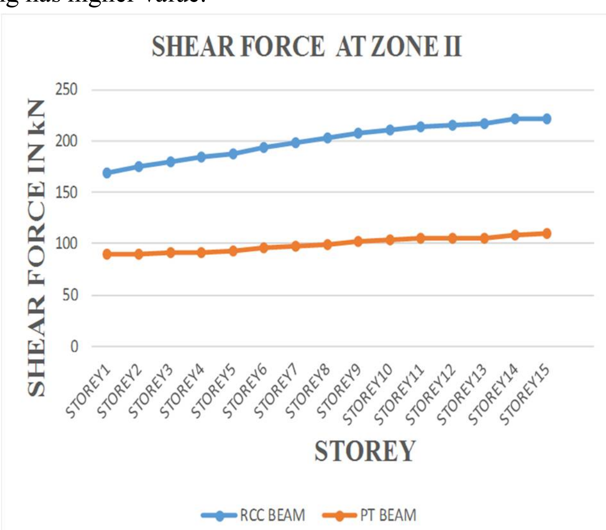

Fig 9: Plot of Shear force at zone II

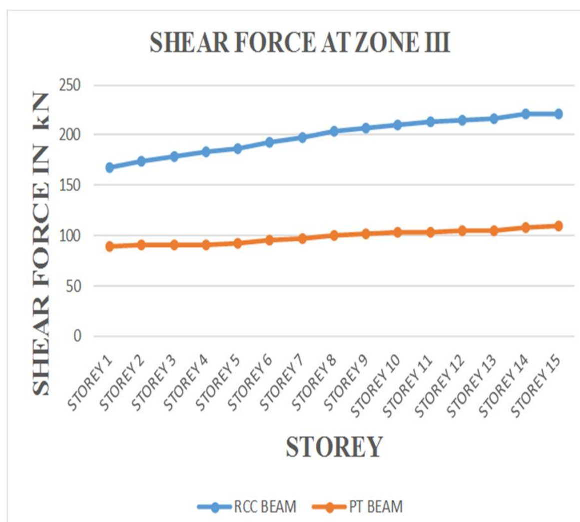

Fig 10: Plot of Shear force at zone III

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Table 6: Storey Displacement of PT beam and RCC beam

Storey	RCC Beam (mm)	PT Beam (mm)
Storey 15	28.305	11.037
Storey 14	27.281	10.973
Storey 13	25.968	10.94
Storey 12	24.391	10.894
Storey 11	22.581	10.83
Storey 10	20.585	10.693
Storey 9	18.447	10.329
Storey 8	16.208	9.722
Storey 7	13.905	8.909
Storey6	11.572	7.934
Storey 5	9.241	6.838
Storey 4	6.935	5.656
Storey 3	4.687	4.419
Storey 2	2.544	3.15
Storey 1	1.93	1.871
Base	0	0

Table 7: Storey Displacement of PT beam and RCC beam at zone III

Storey No	RCC Beam (mm)	PT Beam (mm)
Storey 15	23.533	8.998
Storey 14	23.189	8.945
Storey 13	22.714	8.891
Storey 12	22.085	8.834
Storey 11	21.085	8.766
Storey 10	20.378	8.648
Storey 9	19.317	8.358
Storey 8	18.133	7.881
Storey 7	16.832	7.249
Storey 6	15.421	6.493
Storey 5	13.901	5.645
Storey 4	12.281	4.733
Storey 3	10.428	3.776
Storey 2	8.01	2.78
Storey 1	3.061	1.744
Base	0	0

The value of displacement goes on increasing from the base of the building to the higher storey. So the displacement is directly proportional to the height of the building. Also the displacement value is more for RCC beam. Comparatively the storey displacement value is higher for zone II than displacement value of zone III.

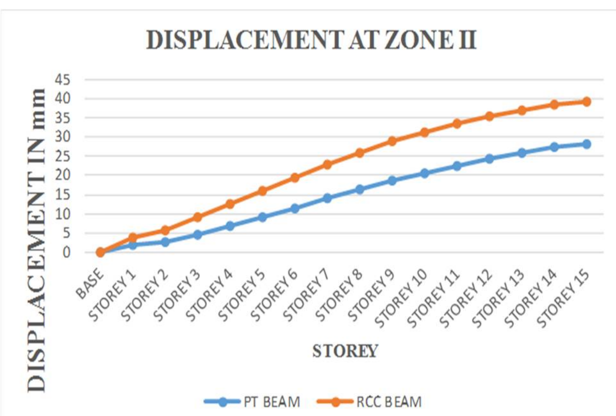

Fig 11: Shows the displacement of the PT beam and RCC beam building

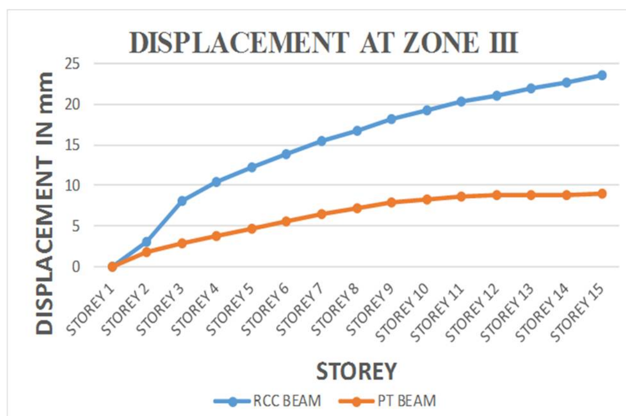

Fig 12: Shows storey displacement at zone III

IV. CONCLUSIONS

Based on the response spectrum analysis of a 15 storied high storey building with RCC beam and PT beam at two seismic zone III and zone II was analysed using ETABS 2019 software. And determined the parameters such as storey displacement, shear force and bending moment.

A. The shear force value increases with the increase in floor height and shear force value of RCC beam is more than the PT beam.
B. And also the value of bending moment for the RCC beam building is more than the PT beam. Comparatively the seismic zone II showed higher values than that of zone III shear force and bending moment value.
C. The value of storey displacement increasing from base of the building to the higher storey as the height of the building increasing. And the maximum value of storey displacement is 28.304mm.

D. The seismic zone II the storey displacement of the RCC beam building has higher than that of PT beam building and seismic zone III the storey height displacement is also higher in RCC building. The seismic zone II shows higher displacement values than that of zone III.

E. The values of Storey Shear shear, Displacement and Bending Moment are more for Zone II than that of comparing with Zone III values.

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