Comparative Analysis and Seismic Performance Improvement of RCC Post Tensioned Flat Slab with Steel Composite PT Flat Slab System using ETABS

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Abstract*- Looking at the modern trend of construction, RCC post tensioned flat slab are widely adopted in commercial and residential sectors due to its low cost of construction and aesthetic view. Post- tensioning, which is a form of prestressing, has several advantages over standard reinforcing steel (rebar's): It reduces or eliminates shrinkage cracking- therefore no joints, or fewer joints, are needed and Cracks that do form are held tightly together ,It allows us to build slabs on expansive or soft soil and It lets us design longer spans in elevated members, like floors or beams. Post-tensioning, or PT, has become increasingly popular over the past 30 years or so as the technology has been perfected. . While using PT method more precautions has to be made for shear and deflection criteria for the slabs since RCC post tensioning slabs are weak against lateral force. Post-tensioned slab structures have weak resistance to lateral loads. So to provide stiffness to structures against lateral forces steel columns are used. A study is carried out to compare the structure by replacing some of the RCC column with steel column to improve the stiffness of structure against lateral force. For this purpose a 15 storey RCC post tensioned flat slab in modeled using ETABS and analyzed for high seismic zone then improve the performance with different arrangements of RCC and Steel columns and the model is analyzed against the base shear, story drift, and story displacement. Also the cost analysis of RCC PT flat slab is compared with the composite PT flat slab

Key words- Post Tensioned Flat Slab, Steel RCC composite structure, StoreyDisplacement, Drift, Stiffness

I INTRODUCTION

As the floor system plays an important role in the overall cost of a building, a post- tensioned floor system is invented which reduces the time for the construction and finally the cost of the structure. In some countries, including .The U.S., Australia, South Africa, Thailand and India, a great number of large buildings have been successfully constructed using post-tensioned floors. The reason for this lies in its Decisive technical and economical advantages.In modern construction high tensile steel reinforcement known as tendons are widely adopted in post-tensioned flat slabs. Post- tensioned slab helps in reducing tensile stresses and cracks of the member. Post- tensioned slabs have proved to be economical and effective compared to normal RCC beam-slab and RCC flat slab.

PT Flat Slab: Post-tensioned (PT) slabs are **typically flat slabs, band beam and slabs or ribbed slabs**. PTslabs offer the thinnest slab type, as concrete is worked to its strengths, mostly being kept in compression. Longer spans can be achieved due to prestess, which can also be used to counteract deflections. Post-tensioned slabs use high-strength tensioned steel strands to compress the slabs, keeping the majority of the concrete in compression. This gives a very efficient structure which minimizes material usages and decreases the economic span range when compared to reinforced concrete.

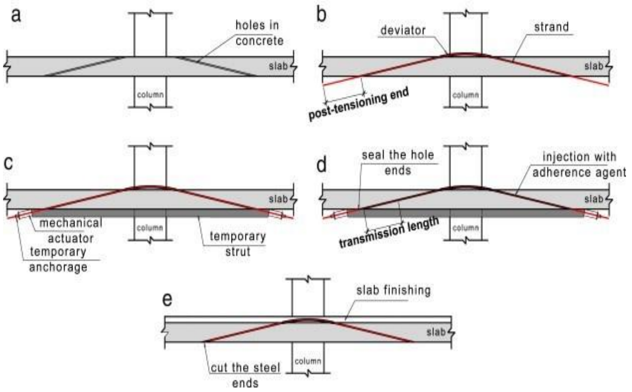

Fig.1.Post Tensioning Process

II OBJECTIVES

- To Model and Analyze RCC PT Flat slab for non linear time history analysis using Etabs
- To check the Storey Performance against real time PGA earth quakedata LOMAP
- To improve the stiffness of post tensioned flat slab by replacing theRCC column with steel column

- To compare the results with various models of Steel-RCC column combinations.
- To output results like Storey displacement, Storey Drift and storey Stiffness, in both RCC post tensioned flat slab& Steel composite post tensioned flat slab Models.
- To develop the steel composite model with best performance againstseismic force.
- To compare the analysis result for various composite models for storey displacement, storey drift and storey stiffness against RCC PT flat slab.

III SCOPE OF WORK

Of all Structural costs, floor framing is usually the largest component. Likewise, the majority of structure's formwork cost is usually associated with the horizontal elements. Consequently,the first priority in designing for economy is selecting the structural system that offers lowest overall cost while meeting load requirements. Post-tensioning is the key to cost-effective multifamily construction. In addition, Post- tensioned structures can be designed to have minimaldeflection and cracking, even under full load. Thinner floors provide lower building weight, which creates a corresponding reduction in other structural elements. There are also some associated labor and time savings.

But the stability of the structure decreases with increase in height. Since the post tensioned flat slab is weak against lateral load, steel column is used to improve the lateral stability. The structure is also analyzed in high seismic zone and storey drift, displacement, storey stiffness are compared for both RCC column post tensioned slab and RCC steel composite post tensioned flat slab Both the systems are analyzed using ETABS and subsequently MS Excel program was developed based on the design methodology. Finally, Storey displacement, storey drifts and storey stiffness graphs are plotted for RCC Post Tensioned slab systems and Steel RCC composite slab system on each Model. And the structure adequacy is checked for various steel column arrangements with minimum cost.

IV LITERATURE REVIEWSUMMARY

Overall study on PT flat slab proves that PT flat slab could be a better option compared to flat slab, in respect of cost of project. For the increase in the panel sizes, the cost is also increasing gradually .From both post- tensioned slab system building the post-tensioned flat slab with drop ismore economical than the post-tensioned flat slab without drop. Using a PT Slab is more advisable for a commercial building than using a R.C.C Flat Slab. Construction of a structure using PT Slab also leads to a lighter structure as the Dead Load gets reduced. To avoid functional failures (service limit state), it is essential to check long term cracked deflections in Post- Tensioned flat slabs.PT flat slab system has greater flexibility than conventional system due to more quantity of story displacement in case of seismic analysis. PT slabs are week against Lateral forces to overcome this Shear walls are placed on the outer face of the structure.

V VALIDATION

The most important part of ETabs analysis is validating the project, To evaluate the validity of PT Flat slab model a comparison has been made between the results obtained from the Analysis of post tensioned and RCC Flat slab in multi storey framed structures. Building details, properties of the building, post tensioned strand details, sectional properties of building and loads on the buildings are considered.

Table I DETAILS OF BUILDING

Plan Dimensions	27.5mx27.5 m
Total Height of building	54 m
Height of each storey	3.6 m
Total no. of storey's	15

Table II MATERIAL PROPERTIES OFBUILDING

Grade of concrete	M40
Grade of steel	FE 500

A. SECTIONAL PROPERTIES OF BUILDING

Beam dimensions for conventional structure- 300mm x350mm

Thickness of slab for conventional structure – 150mm

Thickness of slab for RCC post tensionedflat slab structure – 200mm

Column dimensions – 850mmx850mm

B. LOADS ON BUILDINGSeismic zone: Zone IV

Site Type – II Importance Factor- 1Terrain category – 4

Live Load on terrace – 1.5 KN/m2Live Load on Floors – 3 KN/m2

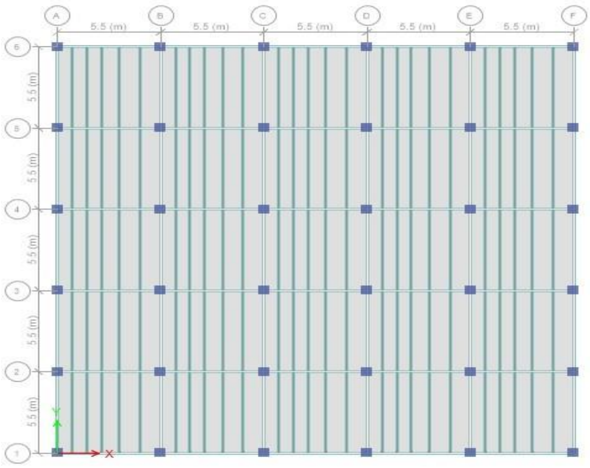

Fig 2: Plan and 3D model of RCCPT Flat slab

C. VALIDATION RESULT

Result is analyzed for Storey displacement, Storey Drift and Storey Shear in RCC post tensioned flat slab, RCC flat slab and RCC slab and found no percentage error of difference

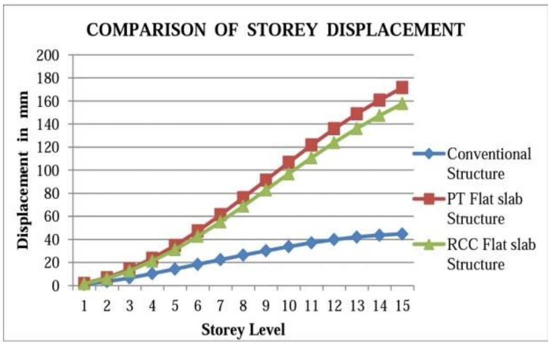

Fig 3 Graphical Representation ofStorey Displacement

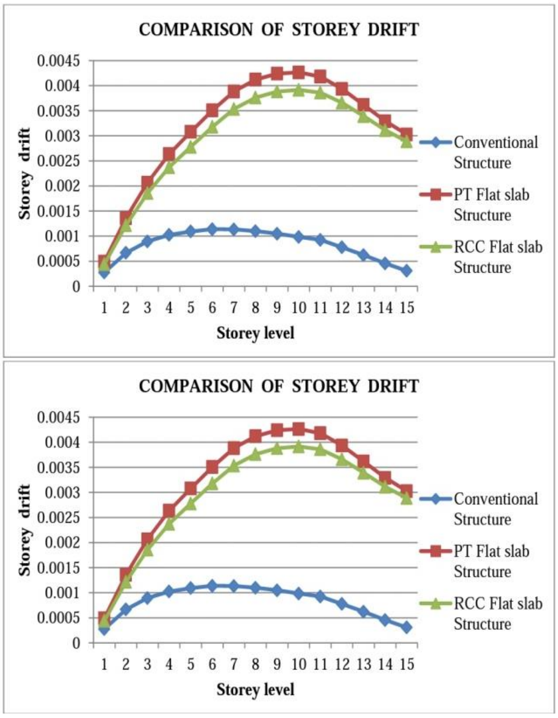

Fig 4 Graphical Representation ofStorey Drift

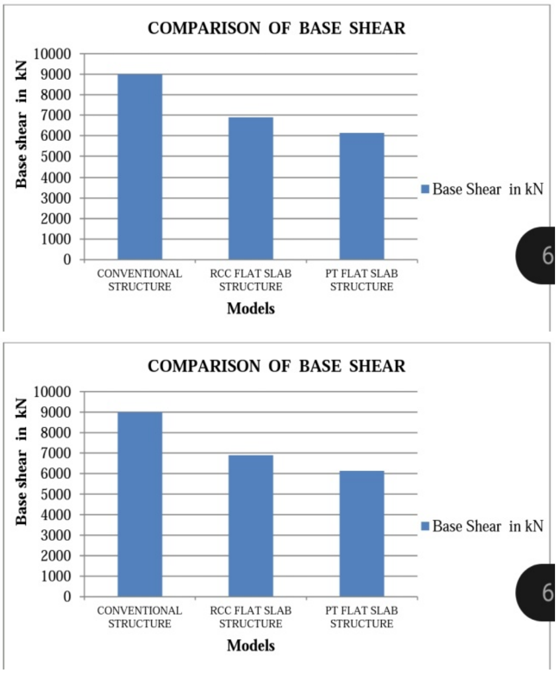

Fig 5 Graphical Representation ofBase Shear

TABLE III. COMPARISON OFRESULTS OBTAINED FROM VALIDATION

RCC PTFLAT SLAB	Storey Displacem ent	StoreyDrift	Base she ar
	mm		KN
ETABS	173.5	0.004 25	610 0
Validating Paper	173.5	0.004 25	610 0
% Difference	0%	0%	0%

VI MODELLING

In this section various models of RCC PT Flat slab and Steel RCC composite PT Flat slabs are modeled using Etabs to check the performance of building against seismic force. For this purpose a building with below described properties is considered.

Table IV: BUILDING DIMENSION

Plan Dimensions	27.5mx27.5 m
Total Height of building	54 m
Height of each storey	3.6 m
Total no. of storey's	15

Table V: POST TENSION STRAND DETAILS

Ultimate Strength	1860 KN/M2
Strand Dia	12.7mm

Table VI: MATERIAL PROPERTIES

Grade of concrete	M40
Grade of steel	FE 500
Grade of steel column	FE 345

A. SECTIONAL PROPERTIES OF BUILDING

Thickness of slab for RCC post tensionedflat slab structure – 200mm
Column dimensions storey 1 to 5 –850mmx850mm
Column Dimension Storey 6 to 10 –750mmx750mm
Column Dimensions from storey 11 to 15 – 600mmx600mm

B. LOADS APPLIEDLive load – 4 KN/M2

Earth Quake Data- Non linear time historyanalysis LOMAP

C. MODELS CONSIDERED

RCC PT Flat Slab is compared against the 2 models detailed below
Model 1 - Exterior RCC Columns Replaced by Steel Column
Model 2- Interior diagonal columns and middle 2 columns on all exterior face is replaced by steel columns

VII ANALYSIS

Dynamic analysis is considered for the evaluation performance in ETabs .The structure is modeled and analyzed using ETabs and Tabulated using MS Excel Model analysis is carried out to evaluate Storey displacement, storey drift and storey stiffness. Time history analysis with PGA earth quake data LOMAP is applied for seismic performance. To improve the performance of building Steel columns are introduced. The RCC PT Flat slab is then compared against two models of RCC – Steel composite PT flat slab

TABLE VII: STOREY DISPLACEMENTAND STOREY DRIFT OF RCC PT FLATSLAB

STOREY NO	DISPLACEMENT mm	DRIFT
15	261.776	0.00429
14	249.634	0.004951
13	238.761	0.005786
12	221.518	0.006798
11	197.057	0.008453
10	167.914	0.008883
9	144.639	0.008734
8	123.555	0.007997
7	105.064	0.006596
6	84.627	0.005828
5	63.656	0.005482
4	45.696	0.004835
3	31.16	0.004013
2	16.712	0.003248
1	5.02	0.001394
0	0	0

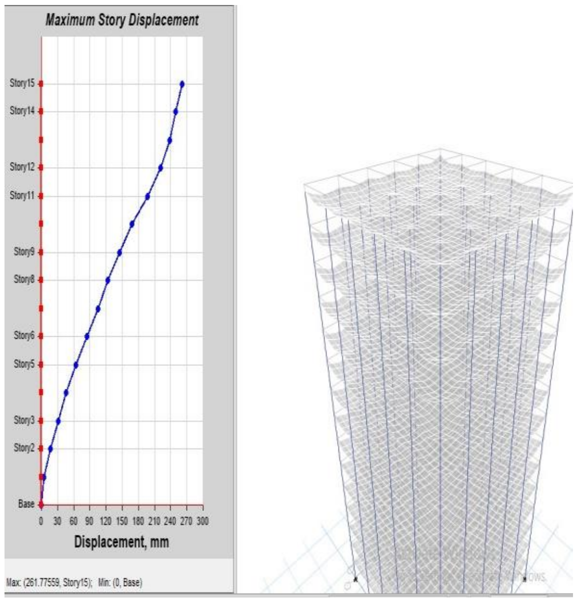

Fig 6: Graphical Representation of StoreyDisplacement

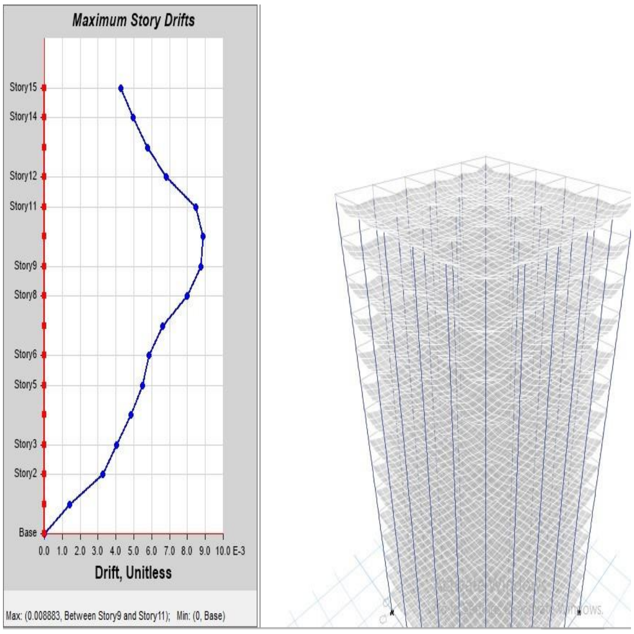

Fig 7: Graphical Representation of StoreyDrift

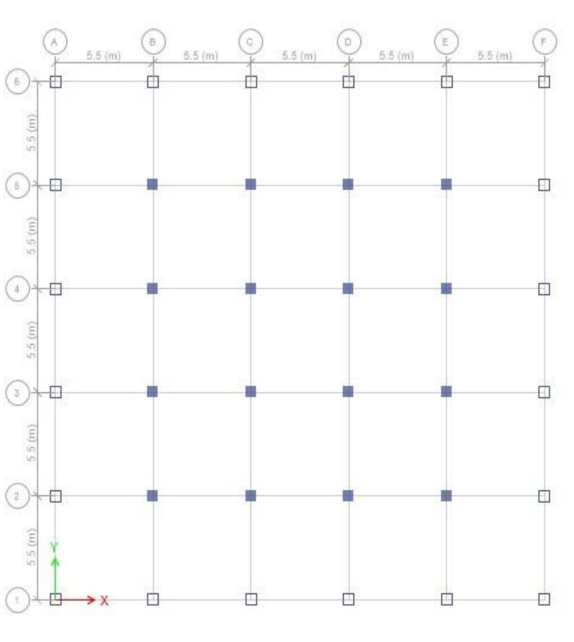

FIG 8: Plan of Model 1

TABLE VIII: STOREY DISPLACEMENTAND STOREY DRIFT OF MODEL 1

STOREY NO	DISPLACEMENT mm	DRIFT
15	171.124	0.002874
14	163.22	0.003258
13	159.943	0.003662
12	155.553	0.003909
11	149.657	0.003853
10	141.924	0.003819
9	132.145	0.004727
8	120.304	0.005185
7	111.908	0.005159
6	102.199	0.004737
5	89.472	0.004398
4	74.133	0.004757
3	57.359	0.005034
2	40.86	0.005337
1	21.69	0.006025
0	0	0

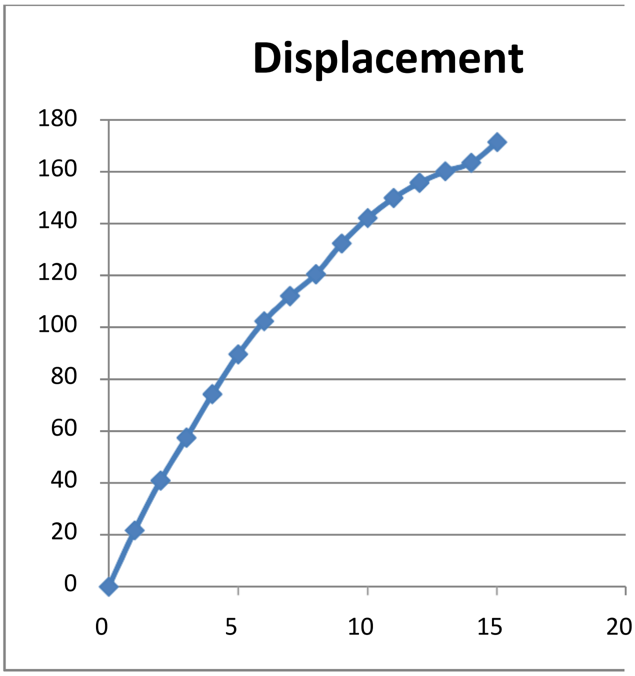

Fig 9: Graphical representation of StoreyDisplacement of Model 1

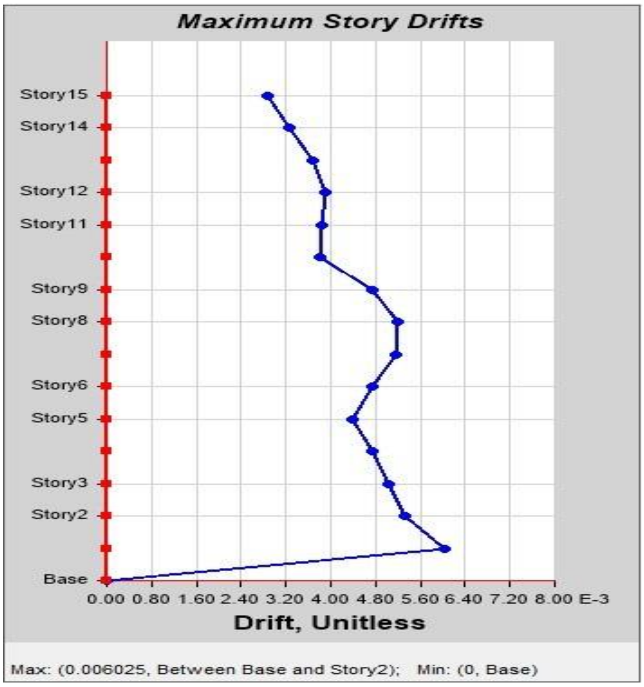

Fig 10: Graphical representation of StoreyDrift of Model 1

TABLE IX: STOREY DISPLACEMENTAND STOREY DRIFT OF MODEL 2

STOREY NO	DISPLACEMENT mm	DRIFT
15	165.904	0.003087
14	156.363	0.003623
13	153.748	0.003912
12	149.924	0.004114
11	144.697	0.003851
10	136.404	0.00422
9	126.264	0.004872
8	114.283	0.005089
7	106.609	0.004863
6	96.314	0.004287
5	82.963	0.00427
4	67.592	0.004547
3	51.243	0.004658
2	35.844	0.004771
1	18.708	0.005197
0	0	0

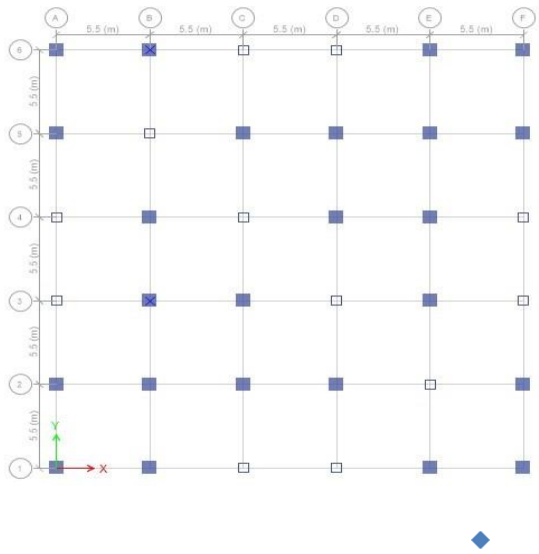

FIG 11: Plan of Model 2

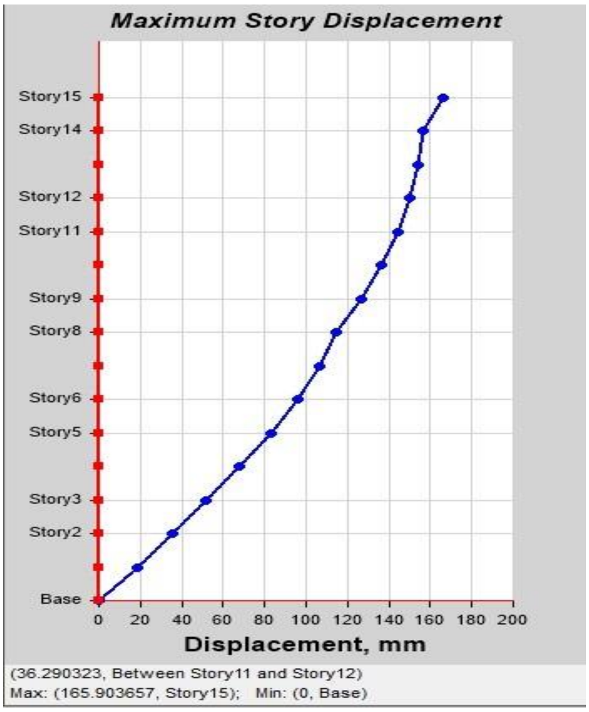

Fig 12: Graphical representation of StoreyDisplacement of Model 2

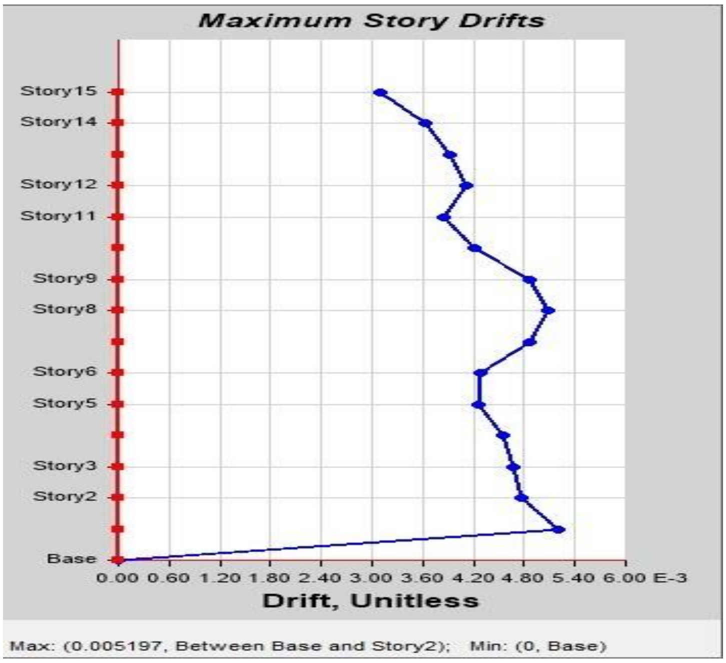

Fig 13: Graphical representation of StoreyDrift of Model 2

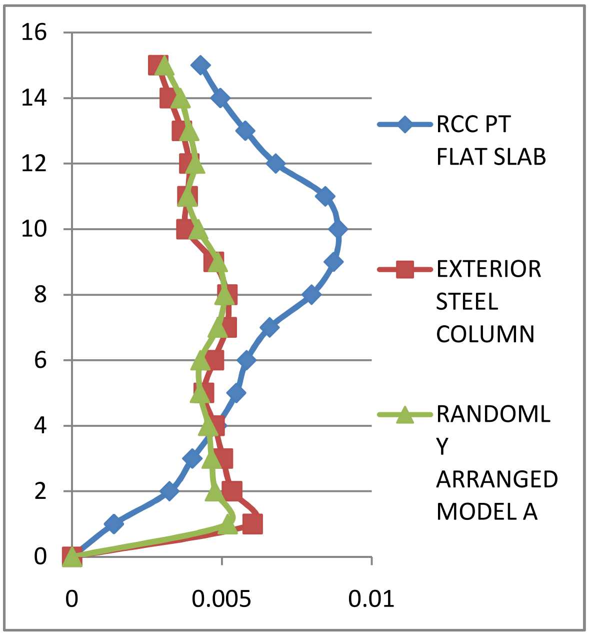

Fig 15: Storey Drift Graph of all Models

Fig 15: Storey Drift Graph of all Models [11]

VIII RESULTS AND DISCUSSION

The outcomes obtained from ETabs software after evaluating the models have been specified in the models. Fig 14 shows amonth the 3 models compared, the value of storey displacement for RCC PT Flat slab is higher and not within the acceptable limit, further considerable decrease in storey displacement can be seen in model 1 and model 2 which is wihin the acceptable limit.

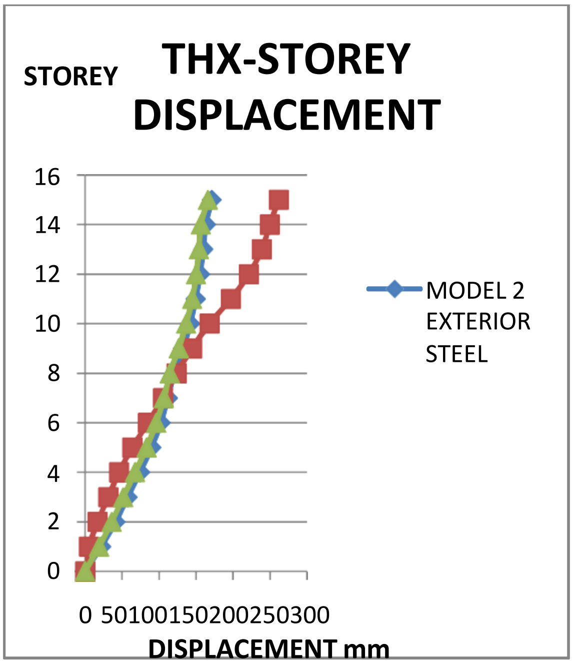

Fig 14: Displacement Graph of all models

IX CONCLUSION

The Etabs software is used for the modeling of PT RCC Flat slab and PT Steel-RCC composite Flat slab then to analyze the model for Non linear Time history analysis with real time PGA data. MS Excel is used for tabulating the results. The following Results are obtained.

- RCC post tensioned flat slab is modeled and analysed and found that the structure shows week performance against seismic force.
- Steel columns are introduced and to models with steel columns are analysed against seismic force which shows better performance.
- From the table it is observed that Model 2 of Steel composite PT flat slab has higher performance since it has less displacement against seismic force and makes structure stiff.
- Model 1 has considerably lesser value for storey drift since all theexterior columns are steel columns.
- 36% decrease in displacement was observed for model 2.

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