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Post Tensioning Building Analysis Considering Seismic Zone V using Analysis Tools ETABS

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ABSTRACT

In this fast-paced and competitive world, building sector is at the apex of the growth of any country. High-rise buildings are admired by every human being. Traditionally the construction of a building is done by RCC but inpresent world, construction of high rise buildings should be done by Post-Tensioning to resist lateral forces and enhancing structure strength. In RCC, the economic expenditure is very high in commercial and institutional buildings because of more material required in construction and hence, Post Tensioned building proves to be more economic and durable. Post-Tensioned building saves quantity of steel and concrete as compared to RCC and increases clear span in rooms. Through this study, the emphasis is to design a post-tensioned building using ETABS. ETABS stand for Extended Three-Dimensional Analysis of a building systems. The main purpose of this software is to design multistoried building in a systematic process which will be in accordance with Indian Standard design codes. In this comparative study we have consider a unsymmetrical plan of G+9 floors considering Wind load as per I.S. 1983-I:2016 & Black cotton soil. In this study comparative study is done with bare frame building structure considering same loading data to determine maximum storey displacement, axial forces, shear forces, maximum bending, storey drift, stiffness, overturning moment, displacement in x and z direction and cost analysis as per S.O.R.

Keywords : Etabs, High rise building, analysis, post tensioning, cost analysis, S.O.R, SAFE, Drift.

I. INTRODUCTION

Dynamic actions are caused on buildings by both wind and earthquakes. But, design for wind forces and for earthquake effects are distinctly different. The intuitive philosophy of structural design uses force as the basis, which is consistent in wind design, wherein the building is subjected to a pressure on its exposed surface area; this is force-type loading. However, in earthquake design, the building is subjected to random motion of the ground at its base, which induces inertia forces in the building that in turn cause stresses; this is displacement-type loading. Another way of expressing this difference is through the load-deformation curve of the building – the demand on the building is force (i.e., vertical axis) in force-type loading imposed by wind pressure, and displacement (i.e., horizontal axis) in displacement-type loading imposed by earthquake shaking. Wind force on the building has a non-zero mean component superposed with a relatively small oscillating component. Thus, under wind forces, the building may experience small fluctuations in the stress field, but reversal of stresses occurs only when the direction of wind reverses, which happens only over a large duration of time. On the other hand, the motion of the ground during the earthquake is cyclic about the neutral position of the structure. Thus, the stresses in the building due to seismic actions undergo many complete reversals and that too over the small duration of earthquake.

The primary reasons for the strengthening of concrete structures are typically to increase existing elements' capacity to carry new loads or to resolve an existing deficiency. Several strengthening techniques such as section enlargement, externally bonded fiber reinforced polymer (FRP) reinforcement, supplemental steel elements, and post-tensioning can be employed to increase the load carrying capacity and improve serviceability of existing structures. However, there are many technical factors that should be considered when selecting a strengthening system. In addition to technical concerns such as serviceability, strength, durability, appearance, and fire rating, one should consider non-technical factors such as constructability, aesthetics and cost.

In this comparative study we have consider a unsymmetrical plan of G+9 floors considering Seismic zones V and soft type soil as per I.S. 1893 part 1 2016. for analyzing and modeling purpose ETABS 17 programming is utilized and study is done on the premise of maximum storey displacement, axial forces, shear forces, maximum bending, storey drift, stiffness, overturning moment, displacement in x and z direction and cost analysis as per S.O.R. (C.P.W.D.)

Need of Study:

As due to drastic increment in population in our country, need of tall structures are rapidly growing around all the metro cities and towns, thus to settle such drastic increased population tall structures are increasing. We know that tall structures are very much affected by lateral forces which can cause there failure and loss of life. To prevent such tremors Here in this research work our main motive is to state a benchmark for the future work using post tensioning members in India as per 1893:2016 codal provision for construction of tall structures even in severe zone areas.

Objectives:

The objectives of the study are as follows:

a) Determination of the effect of External Post Tensioning members on a High rise building
b) Evaluation of cost effectiveness and variation in cost as per S.O.R.
c) Seismic strengthening of the building due to post tensioning members at exterior region.
d) Utilization of Advance analysis tool ETABS'17 for post tensioning method.
e) To prepare a reference study for implementation of post tensioning members in Indian region as per seismic code 1893-part-1:2016.

K Bednarz (2018) Analyzed the method for correct construction of large span, slim post-tensioned concrete slabs is conditioned by an appropriate cross-section selection. It is generally accepted that the thinnest slab can be constructed using the full cross-section as the largest compression stress storage. However, completely different cross-sections may help to overcome large spans. The paper presents the results of the computational analysis of several types of cross-sections (full, with internal relieving inserts and ribbed) in the application to a post-tensioned slab with a span of 15.0m. Based on the results presented, appropriate conclusions were drawn.

Rahul singh et. al. (2018) studied that In this fast-paced and competitive world, building sector is at the apex of the growth of any country. High-rise buildings are admired by every human being. Traditionally the construction of a building is done by RCC but in present world, construction of high rise buildings is done by Post-Tensioning. In RCC, the economic expenditure is very high in commercial and institutional buildings because of more material required in construction and hence, Post Tensioned building proves to be more economic and durable. Post-Tensioned building saves quantity of steel and concrete as compared to RCC and increases clear span in rooms. Through this paper, the emphasis is to design a posttensioned building using ETABS and SAFE. ETABS stand for Extended Three-Dimensional Analysis of a building systems. The main purpose of this software is to design multistoried building in a systematic process which will be in accordance with Indian Standard design codes.

Abbas abdul majeed allawi et. al. (2018) studied The structural behavior of Segmental Precast Post-tensioned Reinforced Concrete (SPPRC) beams largely depends on the behavior of the joints that connect between the segments. In this research, series of static tests were carried out to investigate the behavior of full-scale SPPRC beams with different types of epoxy-glued joint configurations; multi-key joint, single key, and plain key joint. The reference specimen was monolithically casted beam and the other specimens were segmental beams with five segments for each one. The general theme from the experimental results reflects an approximate similarity in the behavior of the four beams with slight differences. Due to the high tensile strength of the used epoxy in comparison to concrete, cracks at joints occurred in the concrete cover which was attached to the epoxy mortar.

Table 1 : Geometrical data

Design data of building	**Dimension**
Plan dimension	12 x 15 m
No. of bay in X direction	3 Bay
No. of bay in Y direction	3 Bay
No. of storey	G+9
Typical storey height	3.0 m
Bottom storey height	2.5 m
Column size	450 x 450
Beam size	450x 300
Thickness of slab	150 mm
Grade of concrete	M-25
Grade of steel	Fe-415
Wall thickness	230 mm for external wall
Post tensioning wire	230 mm diameter cable

II. METHODS AND MATERIAL

Step-1 Modelling of building frames
Step-2 Assigning section properties and material
Step-3 Assigning supports
Step-4 Assigning Post Tensioning Hinge
Step-5 Application of Load
Step-6 Selection of parameters of seismic Definition of various soil conditions
Step-7 Application of response Spectrum
Step-8 Formation of load combination (8 load combination)
Step-9 Design of RCC structure

III. RESULTS AND DISCUSSION

Analysis Result:

Max. Bending Moment:

Table 2 : Bending moment

Storey	**Max. Bending moment kN-m**	
	Bare Frame	**Post-tensioning frame**
9th	144.8	69.18
8th	129.67	62.79
7th	114.54	56.4
6th	99.41	50.01
5th	84.28	43.62

4th	69.15	37.23
3rd	54.02	30.84
2nd	38.89	24.45
1st	23.76	18.06
0	0	0

Shear Force:

Table 3 : Shear Force

Storey	Max. Shear Force kN	
	Bare Frame	Post-tensioning frame
9th	254.05	197.93
8th	228.55	177.62
7th	203.05	157.31
6th	177.55	137
5th	152.05	116.69
4th	126.55	96.38
3rd	101.05	76.07
2nd	75.55	55.76
1st	50.05	35.45
0	0	0

Axial Force:

Table 4 : Axial Force

Storey	Max. Axial force kN	
	Bare Frame	Post-tensioning frame
9th	54.334	39.04
8th	53.21	37.87
7th	52.086	36.7
6th	50.962	35.53
5th	49.838	34.36
4th	48.714	33.19
3rd	47.59	32.02
2nd	46.466	30.85
1st	45.342	29.68
0	0	0

Displacement:

Table 5: Storey Displacement

Storey	Max. Displacement in mm	
	Bare Frame	Post-tensioning frame
9th	17.402	8.5501254
8th	15.227	7.4813932
7th	13.052	6.412661
6th	10.877	5.3439288
5th	8.702	4.2751966
4th	6.527	3.2064644
3rd	4.352	2.1377322
2nd	2.177	1.069
1st	0.002	0.0002678
0	0	0

Drift:

Table 6 : Storey Drift

Storey	Max. Storey Drift in mm	
	Bare Frame	Post-tensioning frame
9th	23.928	11.7564559
8th	20.6655	10.1533576
7th	17.403	8.5502593
6th	14.1405	6.947161
5th	10.878	5.3440627
4th	7.6155	3.7409644
3rd	4.353	2.1378661
2nd	1.0905	0.5347678
1st	0.001	0.0001339
0	0	0

IV.CONCLUSION

The Study presents results of implement post-tensioning method in the building. High-rise structure is modelled and analyzed in this study using ETABS software. Presented project is a first venture of this type in project. Results of measurements of deflection during construction of the building indicate Stability of the structure due to post tensioning members which shows deviations from predicted values.

In this study following results are observed as follows:

- Bending moment in each storey decreased due to introduction of post-tensioning members, this results in economical sections. In this study it is observed that 47.7% decrement in moment is resulted in Post tensioning frame comparing to bare frame.
- Storey shear is decreasing causing minimize risk of unbalanced forces in post tensioning structure. It is observed in above chapter that unbalanced force are observed 13.87% less in post tensioning building frame comparing to bare frame.
- Lateral force resistivity results in less deflection and stability of a structure to resist lateral forces thus assigned wind pressure can be resist easily. Displacement in post tensioning member is resist by 50.09% which make the structure more stable and lateral load resistable.
- Axial force in Post tensioning building frame is observed minimum compared to Bare frame. It is observed in above chapter that distributing forces in vertical members are 28.20% less in post tensioning member frame in comparison.
- Storey Drift is the relative displacement of two adjoining stories, In the chapter above it is observed that post tensioning member results in 49% reduction in relative displacement compared to bare frame structure.

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