Study of P-Delta effects on Tall Building

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***Abstract* - As the urbanization increases worldwide , the available land for building is becoming scarer and scarer, and the cost of land is becoming higher and higher. Thus the popularity of tall structure are increasing day by day to accommodate growing population in metropolitan cities. As number of stories increases, P-Delta effect becomes more important. In this study the P-Delta effects on tall structure is studied. For the analysis three different types of structural systems will be carried out. In these structural systems 1) Moment frame structure 2) Moment frame with structural wall and 3) Tube structure with structural wall. Earthquake load is applied and the P-Delta analysis is consider for the analyse the structure. This analysis of multistoried RC building has been done using ETABS 2016 structural analysis software. The results of Base shear, Storey drift and storey displacement is compared and it will demonstrate the effectiveness of the above stated analysis methods on variation of storey height. The analysis of the tall structure will be carried out by considering the P-Delta effect in ETABS software using the criteria of IS 16700-2017.**

***keywords* - Tall buildings , P-Delta effect, Seismic loads , IS 16700:2017, ETABS 2016.**

I. INTRODUCTION

The tall structures are used as Residential, Commercial and more-over as a modern trend among the people which is growing towards the development of tall structure. Seismic analysis is carried out in this study. Earthquake ranges in size from those that areas so weak that they cannot be felt to those violent enough for people around and destroy whole cities. Buildings are susceptible to earthquake forces because of the fact that during earthquake the very ground on which building stands starts shaking. The ground motion is characterized by displacement, velocities and acceleration that are erratic in direction, magnitude, duration and sequence. The static analysis may be used to design buildings, extreme caution must be taken to render them disaster proof. This is where the dynamic analysis comes into play , modelling the seismic loads accurately and thereby providing economical design. By carrying out dynamic analysis, one obtains the design forces of the building and additionally, height wise distribution of those forces. In the traditional first order analysis of structures, the effects of change in the structure actions due to structure deformations are neglected. However, when a structure deforms, the applied loads may cause additional actions in the structure that are called second order or P-Delta effects.

The P-Delta effect is dependent on the applied load and building characteristics. In addition to parameters such as height and stiffness of a building, the degree of its asymmetry may also be of importance. The building asymmetry is often due to unbalanced distribution of its mass, stiffness or strength. The induced torsional deformations usually cause uneven displacements among lateral load resisting elements and therefore concentration of damage in some of them. Therefore, torsionally unbalanced buildings are normally more susceptible to earthquake damages. The deformations caused by torsion can affect the P-Delta consequences. As a result, it is expected that torsion and P-Delta have interaction in the seismic behavior of some buildings. A long list of parameters is likely to be effective in this interaction. Lateral and torsional stiffness of building, the level of its eccentricity, mass moment of inertia, height, the properties of loading and ground motions are some of these parameters.

P-Delta analysis:

It is also known as geometric nonlinearity, involves the equilibrium and compatibility relationships of a structural system loaded about its deflected configuration. Of particular concern is the application of gravity load on laterally displaced multi-story building structures. This condition magnifies story drift and certain mechanical behaviors while reducing deformation capacity. When an initial P-Delta analysis is requested on the P-Delta Options form, it is performed before all linear-static, modal, response-spectrum, and time-history analyses in the same analysis run. The initial P-Delta analysis essentially modifies the characteristics of the structure, affecting the results of all subsequent analyses performed.

There are two P-Delta effects:

- P-BIG delta (P-Δ) - a structure effect
- P-little delta (P-δ) - a member effect

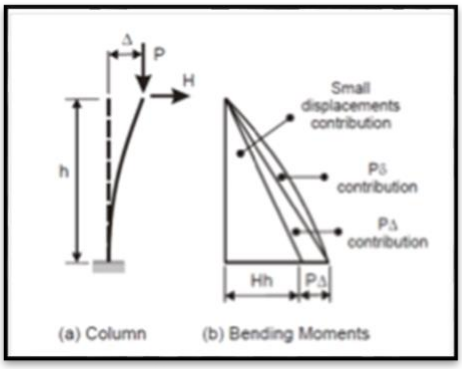

Fig. 1 P-Delta Effect on Column

II. Review of Literature

A.S.Moghadam,A.Aziminejad,[1] The importance of asymmetry of building on the P-Delta effects in elastic and inelastic ranges of behaviour are evaluated. Four buildings with 7, 14, 20 and 30story are designed based on typical design procedures, and then their elastic and inelastic static and dynamic behaviour, with and without considering P-Delta effects, are investigated. Each building is considered for 0%, 10%, 20% and 30% eccentricity levels. The results indicate that the type of lateral load resisting systems plays an important role in degree that torsion modifies the P-Delta effects. It is also shown that although in the elastic static analyses, torsion always magnifies the P-Delta effects, but the same is not always true for the dynamic analyses. The result of dynamic analyses show the high level of sensitivity to ground motion characteristics.

Deepak G, Arunkumar B.N, [2] In this study they have performed static linear analysis on Tall structure using E-TABS 2013. They studied 10, 20, 30, 40 and 50 story buildings by changing the size of the column respectively. In this study they concluded that the displacement obtained is quite large but the drift ratios nearly matches the safety limit. As per the obtained results it is necessary to consider P-Delta effects in greater than 20 story.

Pushparaj J. Dhawale, Prof. G. N. Narule,[3] Large displacement theory is that the results force and moments take full account of the effects due to the deformed shape of both the structure and its member. Two types of P-Delta effects 1) Big Delta (P-Δ)- a structure effect 2) Little Delta (P-Δ)- a member effect. The 20, 25, and 30 story buildings are considering in analysis with and without P-Delta effects in SAP-2000. The iterative P-Delta analysis method is used. As the number of stories are increasing the P-Delta effects becomes very important and for minimum 25 story P-delta analysis should be performed.

Rajat Sharma, Raghvendra Singh,[4] In the present study of seismic analysis and wind load analysis of multistory RC building with and without P-Delta effects is analysed by E-TABS software. Generally analysis of buildings is done bsy using linear elastic methods, which is first order structural analysis in which the displacement and internal force are evaluated, but in some cases deflection of the structure can have a geometric second order effects on behaviour of the structure. The P-Delta effects found to decreases the story displacement by Earthquake using Shear wall and also decrease by wind loading. Story displacement values for all the load cases are within permissible limit.

Mr. Dhruvil Y Patel , Mr. Piyush Jain, Dr. V. R. Patel [5] In this project three major systems used for the tall buildings are: 1. Shear wall system.2. Shear wall combined bracing system. 3. Tube in tube system. Tall building almost always require additional structural material in order to limit the displacement and storey height. The results of three models of analysis are compared between the three sets of models to study the storey wise efficient structural system for adopted structure on the basis of displacement and storey drift. During the study it's known that time history analysis predicts the structural response more accurately than the response spectrum analysis so the conclusion of the project is based on the result of time history analysis of displacement and storey height. They conclude that the Shear Wall building is suggested for 35 Stories(105m), for Shear wall & Bracing combined building 45 stories (135 m) and for Tube in tube building 55 stories (165m) are suggested.

A.M. Pattar, S.M. Muranal [6] They have analysed three models with different story : 1) Bare frame structure, 2) Braced frame structure and 3) Masonry infill frame structure.The P-Delta analysis is not necessary for infill masonry structures up to 40 storey building structures. From 30 storey onwards it has been observed that there is a sudden increase in lateral displacements and overturning moments in infill masonry structures.The rectangular bare frame RC structures are more vulnerable to P-Delta effect than the masonry infill structures and braced structures. However, bare frame RC structures more than 40 stories has very much larger displacements and even design for P-Delta effect will not be economical. So, for more than 40 stories the braced systems can be adopted to reduce P-Delta effects.

III. Summary

Now a days very much increasing in the population, population of rural areas attracts towards urban areas, creates an increasing demand for tall buildings. The achievement of structural system for tall buildings is not an easy task. As an engineer we not only have to depend on the strength of the building but also on the economy of the structure should be considered. So, if the geometric non linearity considered by P-Delta effect , it modifies the response of the structure.

IV. Conclusion

The P-Delta effect from the above results shows that it is necessary for stories greater than 20. As the number of stories increases the P-Delta effects becomes more important. In inelastic analyses, sensitivity is still important but less than the elastic dynamic case. In general the sensitivity to ground motion increases, as the eccentricity increases. Moreover if the P-Delta effect should be considered for the long term performance of the structure. P-Delta effect is necessary for the analysis of the tall structure as it creates additional moment in the tall structure.

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