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Analysis of a High-Rise Building Frame Considering Lateral Load Using Analysis Tools A Review

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ABSTRACT

Buildings must be able to safely withstand any significant ground motions that could happen during construction or regular operation in order to be considered earthquake resistant. The impacts that ground motions have on structural reactions, however, are special. The time-history analysis is the analytical method that is most accurate for structures that are subjected to severe ground vibrations. For this analysis, a stepwise solution is used to integrate the pushover analysis of a multi-degree-of-freedom system, or MDOF, in the time domain in order to depict the real reaction of a structure. Although it can be applied to all practical uses, this method takes time. The pushover analysis was developed because it was necessary to develop quicker techniques that would nevertheless provide a trustworthy structural assessment or design of structures subjected to seismic loading.
In this paper presenting review of literature related to analysis of tall structure.

Keywords: RCC Frame, Irregular Building, FEMA Hinge, Capacity Spectrum, Pushover Analysis, Seismic Reaction.

I. INTRODUCTION

Modern high rise building construction began to address a variety of objectives, including the need to accommodate a growing population, the high cost of land, and even to demonstrate the state of the economy in the case of corporate structures. Earlier, these structures were regular in shape, but with modern technology and materials, it is now feasible to build structures with a variety of plans, shapes, and sizes. Due to their practical and aesthetically pleasing qualities, these atypical structures are quite prevalent all over the world. Different story heights, excess mass in one or more storeys that may be caused by the presence of public meeting areas like gyms, halls, etc., abrupt changes in stiffness made in accordance with architectural considerations, and other factors can all contribute to irregularity. The majority of apartments favour soft-storey structures with sizable parking areas. Irregular buildings are those that have discontinuities in their bulk and rigidity in their layout or elevation. Performance level describes the state of the building's damage, providing information on whether it is safe for occupants to occupy it or how much repair work will be required, as well as its serviceability following an earthquake. Different design requirements are needed at various performance levels. Therefore, it is impossible for a single design parameter to achieve all performance goals. Even though these performance goals could place competing demands on stiffness and strength, one shouldn't sacrifice life safety.

II. Literature Survey

D J Zavala et.al (2022) author analyzed the influence of the stiffness irregularity and the p-delta effect on the structural behavior of a reinforced concrete building. The main objective was to determine the impact of the stiffness irregularity and the p-delta effect on the structural behavior in regular and irregular buildings. The linear dynamic analysis procedure was performed in order to determine the structural response in terms of drifts, shear force and moments per floor. A comparative analysis of the responses from the linear and nonlinear analysis was carried out to determine the percentage variation of the results.

When analyzing the structures that consider the stiffness irregularity and the p-delta effect, variations of up to 16.50%, 11.00% and 14.00% was obtained in drifts, shear force and moments per floor respectively, which are considerable values. When the p-delta effect was considered in structures with the presence of stiffness irregularity, there was a variation in stiffness of up to 59.85%. Conclusion stated that p-delta effect produces a greater degradation of the overall stiffness of the structure.

Thokala Brahmendra Rao et.al (2022) in the research paper, p- delta (P-Δ) effect on high- rise building was investigated for the analysis of G+29 RCC framed building and models were done by ETABS2016. Seismic and wind loads were applied to model as per IS-1893 (2002) and IS-875 (PART-III). The displacements, storey drifts, Bending Moments and Shear Forces are compared to the different models by considering with and without P-delta effect and by providing shear walls at different locations.

Results stated that displacements of conventional building models (without p-delta) is less when compare to building with p- delta. The storey drifts in building models with p-delta effect are more when comparing with models analysed using equivalent static analysis method(without p-delta effect). The bending moment (BM) in shearwall 18% increases after p-delta effect. Shearwall placed at centre of frame shows more effectiveness when comparing with shear wall placed at corner and without shear wall of the structure.

A. Seyedkazemi and F. Rahimzadeh Rofooei (2021) research paper aimed to reliably quantify the seismic response parameters of steel diagrid structural systems and further proposed a simpler framework for estimating and validating SPFs while applying the concepts of FEMA P-695 guideline.

The results showed that the R factors obtained through SPA procedure for steel diagrid systems were conservative and the IDAbased probabilistic method ensured a more rational value for the R coecient. Furthermore, the proposed simplied method was in agreement with FEMA P-695 in predicting the collapse capacity of diagrid models.

Dharanedharan K S and Sivakumar C G (2021) In the research paper, a G+50 storey RC structure with vertical irregularity is considered in such a way that P-delta effect is significant and the structure is analyzed by Linear Dynamic analysis as per IS codes and P-delta effects are included and analyzed as per ASCE code. The results such as displacement, storey drift, storey shear are compared and the significance of P Delta effects in high rise structure was investigated.

Results stated that peak value of displacement at zone III obtained by Linear dynamic method is 204.82 mm and by P- Delta method is 287.92 mm which is 41% more than that of linear dynamic analysis. The peak value of displacement at zone IV obtained by Linear dynamic method is 307.23 mm and by P-Delta method is 443.19 mm which is 44% more than that of linear dynamic analysis. The peak value of displacement at zone V obtained by Linear dynamic method is 460.85 mm and by P-Delta method is 287.92 mm which is 41% more than that of linear dynamic analysis. The P-delta effect is significant in a structure as per ASCE code, even though it is analysed by IS methods considering geometric irregularity, non-linear static analysis has to be performed so that the structure can be made more sustainable under seismic actions irrespective of the seismic zones.

Pavithra.S and Jegidha.K.J (2021) in the research paper, p-delta (P-Δ) effect on high-rise building was investigated for the analysis of G+10 building and models were done by ETABS. Seismic and wind loads are applied to model and the displacements, storey drifts, Bending Moments and Shear Forces was compared for the structure by considering with and without P-delta effect and by providing shear walls at different locations.

The results revealed that the seismic response becomes very sensitive to building models if P-Delta effect was considered.

Drisya S Kumar and Margaret Abraham (2019) objective of the research paper was to investigate seismic analysis of multi - story RC building with and without P Delta effects using ETABS structural analysis software.

Results concluded that the P delta effect is very important in the case of high-rise building. So, designing without considering this effect will leads to the collapse of buildings in earthquake or heavy wind. Since there is a change of base shear overturning moment and story displacement with and without considering the P delta effect with a maximum of 187%. There is variation in % values for different models. If the variation is more than 10% P delta effect should be considered in analysis. P delta effect have importance in designing of high -rise building than 1st order analysis. For regular building the p delta effect will increase the displacement, shear, moment. For irregular buildings the effect may increase or decrease the displacement, shear, moment. The effect of p delta effect on irregular buildings is unpredictable.

PhaniKumar.V et.al (2019) in the research paper, p delta (P-Δ) effect on high-rise building was investigated for the analysis of G+29 RCC framed building and models were done by ETABS2016. Seismic and wind loads was applied to model as per IS-1893 (2002) and IS-875 (PART-III). The displacements, storey drifts, Bending Moments and Shear Forces were compared to the different models by considering with and without P-delta effect and by providing shear walls at different locations.

Results stated that storey drifts in building models with p-delta effect was more when compared with models analysed using equivalent static analysis method(without p-delta effect). Shearwall placed at centre of frame shows more effectiveness when compared with shear wall placed at corner and without shear wall of the structure. Bending moment (BM) in column at fifth floor found75% increase after the investigation of p-delta analysis. The results show the bending moment (BM) in shear wall 18% increases after p-delta effect.

Sajad Ahmad Bhat et.al (2019) in the research paper, seismic performances of reinforced-concrete buildings was evaluated by nonlinear static analysis (pushover analysis) and nonlinear time history analysis considering 20-story reinforced concrete building in ZONE V. The global and local responses obtained from the pushover analysis were compared with those obtained from the nonlinear dynamic analysis of MDOF system.

Results stated that first mode pushover analysis was unable to identify the plastic hinges in upper stories where higher contribution of response is known to be more significant. The 20 storey Reinforced concrete building deforms into the inelastic range which leads to yielding of some of the beams and columns for seismic intensity of 0.36 peak ground acceleration. Hence, the PA was accurate enough for practical applications in seismic performance evaluation when compared with the nonlinear dynamic analysis of MDOF system.

D. L. Balappa and V. Malagavelli (2018) in the research paper, G+10 structure with and without bracings of 4 models has been analyzed using the SAP2000 software. Nonlinear static (pushover analysis) analysis was carried out to understand the behavior of two models. The results in terms of Base Shear, Displacements, Time Period, Location of Hinges and Pushover curve was compared.

The results showed that structure with bracings placed in the center has shown improved performance than other bracing arrangements. Model when compared to RC Frame model (without bracings) and also displacement at roof was lesser in bracings model i.e., displacement decreases when stiffness increases. Therefore presence of bracings concrete Frame has a positive effect on the buildings. Hence RC frame building (without bracings) can reach a collapse state and building with bracings can sustain with less damages because of the stiffness of bracings.

Parsa Heydarpour et.al (2018) Columns with low and medium axial load which were redesigned using both Paulay and MacRae method for compensating for P-Delta effects showed promising results in terms that nonlinear time-history analysis on redesigned columns with inclusion of P-Delta effects achieved damage ductility very close to target damage ductility. For single column bents supported on fixed foundation Caltrans recommends design target ductility of four which is used in this research.

Obtained results for columns with high axial load ratio and high column aspect ratio showed that the redesigned columns collapsed under nonlinear time-history analysis. For columns with high axial load ratio and high column aspect ratio, which suffer the most from P-Delta effects it is suggested to perform time-history analysis with multiple earthquake records to study the instability effects of P-Delta effects instead of using static nonlinear analysis which is unable to fully capture the dynamic nature of P-Delta effects under dynamic loading. The stability problem under seismic loading is dynamic by nature, and using static procedures such as pushover analysis especially for cases with high P-Delta effects is discouraged.

T. Nagarjuna and R. B. N. Santhosh (2018) in the research paper, the plan with dimensions 15 x 40m was considered and varied the stories of the building 15, 20 and 25 was modeled and earthquake load is applied on model of structure as per IS-18939(2002) for zone III. Then by trial and error method suitable cross-section are provided for unsafe building to bring within acceptable limit by increasing stiffness of a building. Bending moment and story displacement with P-Delta effect was considered and compared for all the models.

Results stated that P-Delta effects have more effect in designing of a structure rather than firstorder effect. As the number of storey increases the P-Delta effect becomes more important. P-Delta effect is only observed in some of the beams and columns in some load cases. If these load cases are governing load cases for design of member, then only we can say that it is considerable. This condition is observed in 20 and 25 storey buildings and mostly in 25 storey building. Out of that ETABS show the accurate results.

Vijayalakshmi R et.al (2017) in the research paper, the Non-Linear static analysis was carried out using ETABS 9.7 with identification of P-Delta effects in multi-storey buildings based on its behavior. The drift ratio is found for both, earthquake and wind loading, considering with and without P-Delta effect for different number of stories such as G+10, G+20, G+30 and G+40 stories. The load deflection curves and drift ratios have been obtained for different cases and results so obtained have been compared to identify the drift ratios for different stories of the structure.

For G+10 storey Shear wall structure, the top storey displacement with P Delta effect is P Delta analysis has more value of displacement varying from 2% to 3% when compared to structure without P-Delta analysis. For G+20 storey Shear wall structure, the top storey displacement with P Delta effect is P Delta analysis has more value of displacement varying from 2.5% to 3.5% when compared to structure without P-Delta analysis. For G+30 storey Shear wall structure, the top storey displacement with P Delta effect is P Delta analysis has more value of displacement varying from 8% to 9% in Lateral EQX Direction and 10 to 11% in Lateral Y Direction when compared to structure without PDelta analysis. As the number of Storey increased, mass of the structure increases and hence the structure with PDelta analysis attracted larger inter-storey drifts when compared to structure without P-Delta analysis. Structure with dual configuration (Column-Shear wall) is less vulnerable to seismic forces as compared to structure with beam-column system.

ManikRao and Rajendrakumar S Harsoor (2016) in the research paper, the effect of lateral load on the structural system was considered for the P-Delta effect. The drift ratio is found for both, earthquake and wind loading, considering with and without P-Delta effect for different number of stories such as G+10, G+20, G+30 and G+40 stories. The load deflection curves and drift ratios were obtained for different cases and results obtained were compared to identify the drift ratios for different stories of the structure.

The results of bending moments obtained from 20 storey and 15 storey model, when analysed for P-delta effect shows respectively 30.305 % and 12.31% more than that obtained from linear static analysis. Hence, it was concluded that the P-delta effect should be considered in analysis of multistoried buildings.

Nikunj Mangukiya et.al (2016) in the research paper, G + 24 story structure, was analyzed with static linear and static non-liner analysis, here Geometric non linearity is considered by accounting, p-delta effect it was shown from displacement comparison that there is about 12% to 20% variation in the result. Similarly, the bending moment for the load combination (EQ Y-) showed 5% to 20% variation, value of modal period, in the different mode shapes are also variable. It is advisable to account such effect in tall structures.

Pushparaj J. Dhawale and G. N. Narule (2016) author analyzed the P-delta effect on high rise buildings. Linear static analysis (without P-delta effect) and nonlinear static analysis (with P-delta effect) on high rise buildings having different number of storey was carried out. For the analysis G+19, G+24, G+29 (i.e. 20, 25, 30 storey) R.C.C. framed buildings was modelled. Earthquake load is applied on model of structure as per IS-1893(2002) for zone III in SAP2000-12 software. Load combinations for analysis are set as per IS-456(2000). All analysis is carried out in software SAP 2000-12. Bending moment, story displacement with and without P-delta effect was calculated and compared for all models.

Results stated that it was essential to consider the P-delta effect for 25 storey building. So buildings having height more than or equal to 75m, should be designed considering P-delta effect. Up to 25 storey building, it is not necessary to consider P-delta effect in design and first order analysis is sufficient for design.

Prashant Dhadve et.al (2015) in the research paper, P-delta effect on high rise building was investigated and Linear static analysis (without P-delta effect) on high rise building having different number of stories was carried out. For the analysis G+14, G+19, G+24, (i.e 15, 20, and 25storey) R.C.C. framed building was modeled. Earthquake load was applied on model of structure as per IS18939 (2002) for zone III in E-Tab software. Load combination for analysis is set as per IS-456 (2000). All analysis was carried out in software ETAB. Bending moment, story displacement with and without p-delta effect was calculated and compared for all the models.

The results showed that it was essential to consider the P-delta effect for 25storey building. So buildings having height more than or equal to 75m, should be designed considering P-delta effect.

Conclusion:

This paper represents the utilization of analysis software in modelling and designing of tal structure,

III. REFERENCES

[1]. Pushparaj J. Dhawale and G. N. Narule, [Analysis of P-Delta Effect on High Rise Buildings], InternatiTonal Journal of Engineering Research and General Science Volume 4, Issue 4, July-August, 2016 ISSN 2091-2730.

[2]. PhaniKumar.V, M.Deepthi, Saikiran K and R.B.N. Santhosh, [Behavior of P-Delta Effect in High- Rise Buildings With and Without Shear Wall], International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878 (Online), Volume-8 Issue-2, July 2019.

[3]. Drisya S Kumar and Margaret Abraham, [Analysis of High Rise Building for P-Delta Effect using ETABS], International Journal of Applied Engineering Research ISSN 0973-4562 Volume 14, Number 12, 2019 (Special Issue).

[4]. Dharanedharan K S and Sivakumar C G, [Significance Of P-Delta Effects In High Rise RC Structure In Various Seismic Zones], International Journal of Aquatic Science ISSN: 2008-8019 Vol 12, Issue 02, 2021.

[5]. T. Nagarjuna and R. B. N. Santhosh, [An Evaluation of P-Delta Effect in High-Rise Building], International Journal of Science and Research (IJSR), Volume 7 Issue 6, June 2018.

[6]. Parsa Heydarpour, Pedro F. Silva and Rigoberto Burgueño, [An Investigation on the Pushover Analysis Based Methods for Compensating the P-Delta Effects], International Journal of Structural and Civil Engineering Research Vol. 7, No. 1, February 2018.

[7]. Thokala Brahmendra Rao, Dr M Janardhan and M.Venkata Narasaiah, [Study of P-Delta Effect in High- Rise Buildings with and without Shear Wall], INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH IN TECHNOLOGY, September 2022| IJIRT | Volume 9 Issue 4 | ISSN: 2349-6002.

[8]. Dhangar Laxmi Balappa and Venu Malagavelli, [Pushover Analysis of High Rise Buildings with and without Bracings], International Journal of Civil Engineering and Technology (IJCIET) Volume 9, Issue 9, September 2018, pp. 759–767.

[9]. Pavithra.S and Jegidha.K.J, [Analysis and Design of Tall Buildings using ETABS with P-Delta Analysis], International Journal of Engineering and Techniques - Volume 7 Issue 6, November 2021.

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