International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 11 Issue: 03 | Mar 2024 www.irjet.net p-ISSN: 2395-0072

Implementing P-Delta Analysis in RCC Column Design: A STAAD.Pro Approach

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***Abstract* - The P-delta effect, also known as the geometric nonlinearity effect, emerges as a significant component in structural analysis, particularly in tall structures. This study looks into the effects of the P-delta effect on high-rise buildings, with a focus on linear static analysis performed without P-delta considerations. Employing STAAD.Using Pro software, several RCC-framed edifices of varying heights are digitally drawn, and seismic loads are applied in compliance with IS-1893(2016) criteria for Zone III. The analytical path is guided by the load combinations specified in IS-456(2000). Following that, rigorous calculations are performed to determine bending moments and narrative displacements, comparing results obtained with and without factoring in the P-delta effect across all models.**

Furthermore, iterative experimentation is used to investigate approaches for improving hazardous structures by increasing their rigidity. This includes fine-tuning the building's cross-sectional properties to meet acceptable levels. Our findings highlight the need of acknowledging the P-delta effect, particularly for 5-story and larger structures. Thus, buildings with altitudes equal to or more than 20m require careful consideration of the P-delta impact during the design process. However, our findings suggest that for structures up to 25 storeys, primary assessments are sufficient, eliminating the compelling need to consider the P-delta effect. Measures such as increasing structural rigidity by careful cross-sectional alterations or structural reinforcements are effective ways to assure adherence to safety procedures.

Index Terms – P-delta effect, RCC building design, Structural analysis, STAAD.Pro software, Linear static analysis, Geometric nonlinearity.

I INTRODUCTION

In the next step of our P-delta analysis research, we transition from theory to practice, applying what we've learned to real-world structural engineering. We are putting the findings from our survey paper into action. Our primary focus is on how non-linear elements of structural geometry affect RCC structures under wind, seismic, and temperature loads. We strive to bridge the gap between theoretical and real-world design issues. We want to understand how structural shape, materials, and external pressures interact by carefully modeling, analyzing, and refining them. Our mission is to provide engineers and architects with practical assistance for designing safer, stronger structures that can withstand a variety of environmental conditions

As we begin the implementation phase, we are fully aware of the scale and importance of our task. We're looking at RCC buildings of varying heights to ensure that our findings are applicable in the actual world. We anticipate hurdles, such as coping with diverse materials and construction methods, as well as changing environmental circumstances. However, we consider these problems as opportunities to learn and improve. By attacking issues head on, we seek to push the bounds of structural engineering. Our ultimate goal is to contribute to a society in which buildings are not just functional, but also robust and sustainable, prepared to meet whatever the future brings.

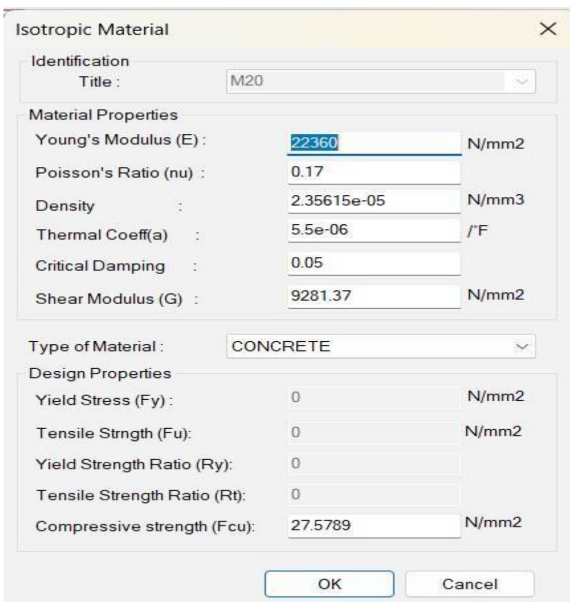
II. OBJECTIVES

During this implementation phase, our goals focus around two key objectives. First, we want to validate the theoretical insights gained from the survey study by applying them to real-world structural design scenarios. Our goal with hands-on tests and analysis is to validate the practicality and applicability of the theoretical discoveries made during the survey stage. Second, we aim to transform this theoretical understanding into practical recommendations and guidelines for engineers and architects working on RCC building design. Our goal in giving practical demonstrations and case studies is to provide straightforward and useful insights that can be directly adopted in real-world scenarios, hence improving the safety and resilience of RCC structures.

Furthermore, this phase of implementation will focus on specific practical aspects and real-world scenarios in which theoretical insights can be effectively used. This includes carrying out structural evaluations using software tools such as STAAD.Pro and RCDC to simulate real-world situations and assess the impact of geometric nonlinearity on RCC buildings. In addition, we will develop design principles and recommendations based on the analytical results, with an emphasis on increasing structural efficiency and strengthening resilience to environmental pressures such as wind, earthquake, and temperature-induced loads. Collaborative efforts with industry experts and stakeholders will be critical in demonstrating the practical applicability of the suggested principles and recommendations using real-world scenarios and applications. Finally, providing training and instructional resources to engineers and architects would help them integrate the recommended principles and recommendations into their projects. Overall, the goals of this implementation phase are to bridge the gap between theoretical understanding and actual application, resulting in safer, more resilient RCC structures in real-world environments.

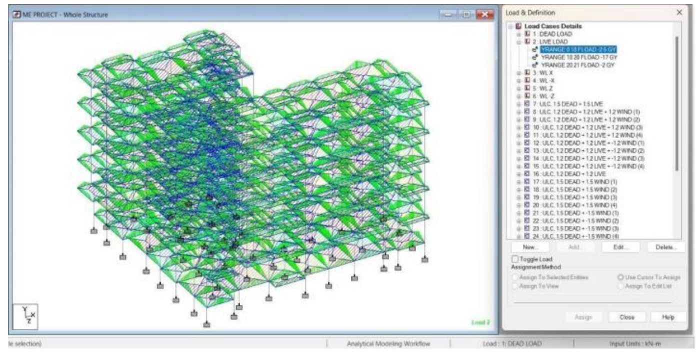
III. METHODOLOGY

The implementation part of our research entails a systematic method to apply the insights gathered from our survey paper to real-world structural design problems. We will validate and operationalize the theoretical findings through a series of meticulous processes.

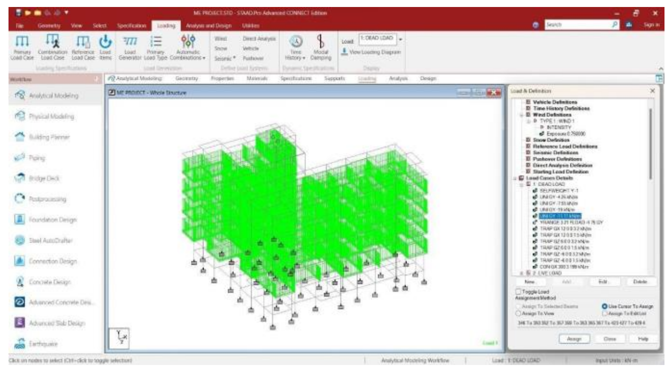


Materials Properties

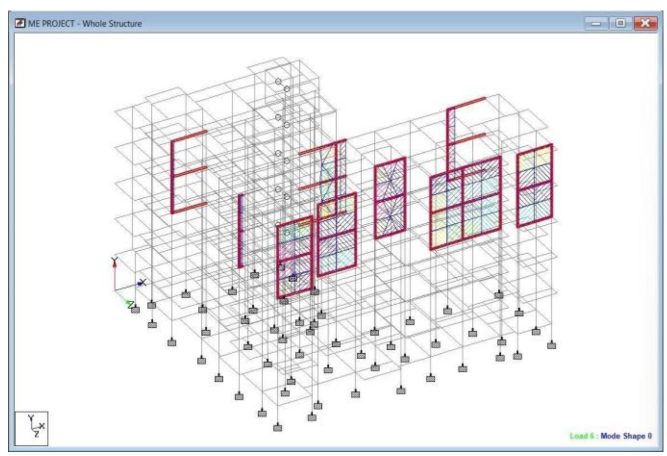
To begin, we will define the structural geometry of RCC buildings, including dimensions, member sizes, and material parameters such as modulus of elasticity and Poisson's ratio that appropriately reflect real-world situations. We will then use sophisticated structural analysis software like STAAD.Pro and RCDC to generate finite element models of the structures, including all necessary components including beams, columns, slabs, and braces.



Live Load Acting On Floor



Dead Load



Wind Load Acting On Building

Once the models are established, we will apply loads in accordance with existing building norms and standards, including dead loads, live loads, wind loads, and seismic.

Furthermore, sensitivity analyses will be undertaken to determine the effect of changes in parameters such as material qualities and loading circumstances on the P-delta results, offering significant insights into the design's robustness.

COLUMN	LOADING	DISTANCE	X	Y	Z	RESULTANT
814	1 EQ X	0	0	0	0	0
		0.8	0	0.007	0	0.007
		1.6	0	-0.004	0	0.004
		2.4	0	-0.012	0.001	0.012
		3.2	0	0	0	0
	2 EQ Z	0	0	0	0	0
		0.8	0	0.001	0.002	0.002
		1.6	0	0	0.006	0.006
		2.4	0	-0.001	0.008	0.008
		3.2	0	0	0	0
	3 EQ-X	0	0	0	0	0
		0.8	0	-0.007	0	0.007
		1.6	0	0.004	0	0.004
		2.4	0	0.012	-0.001	0.012
		3.2	0	0	0	0
	4 EQ-Z	0	0	0	0	0
		0.8	0	-0.001	-0.002	0.002
		1.6	0	0	-0.006	0.006
		2.4	0	0.001	-0.008	0.008
		3.2	0	0	0	0
	5 DEAD LOAD	0	0	0	0	0
		0.8	0	-0.002	0.001	0.002
		1.6	0	0.001	0.002	0.002
		2.4	0	0.003	0.002	0.004
		3.2	0	0	0	0

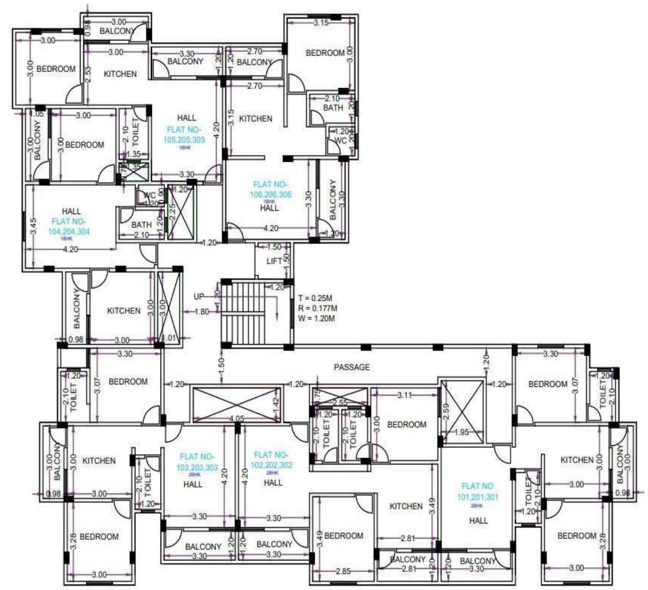
P-delta Analysis

Finally, a complete final P-delta analysis will be performed to ensure that the redesigned structure meets the necessary safety and performance criteria, validating the practical application of the implemented findings. Our goal with this rigorous methodology is to bridge the gap between theory and practice, promoting the development of safer and more resilient RCC structures for real-world applications.

IV. Practical Applications

In the practical application phase, we focus on applying the methodology developed in our P-delta analysis to real-world structural design difficulties. Through case studies and examples, we demonstrate how our research leads to actionable ideas for improving structural stability and resilience.

Case Studies:



Residential Building Plan.

One example is applying our methods to the design of a residential structure with STAAD.Pro. We evaluate its performance under various scenarios by modeling and applying necessary loads in accordance with building codes, identifying areas for improvement.

Another possibility is modifying a commercial structure to increase its seismic resilience. We use STAAD.Pro to do iterative refinement and sensitivity assessments to assess the consequences of structural adjustments while assuring compliance with safety regulations.

Real-world Data and Observations:

Throughout the implementation phase, we gather empirical data and observations to validate our method. Field tests and structural assessments provide actual proof that P-delta analysis improves structural performance. This data serves as a benchmark for evaluating our approach's accuracy and reliability.

Challenges and solutions:

Real-world initiatives inevitably present problems. Discrepancies between theoretical predictions and actual structural behavior, combined with budget and resource limits, pose considerable challenges. To address these problems, we take a systematic approach, constantly refining our analysis methodologies to provide best solutions. By overcoming these challenges, we ensure that our findings are successfully used in actual contexts.

V. Results and Analysis

The findings and analysis of our research into P-delta analysis in the design of tall buildings provide important insights into how these structures respond under various loading scenarios. Our modeling and analytical efforts, which used advanced tools such as STAAD.Pro, resulted in several notable results. Initially, we observed a clear relationship between a building's height and the severity of the P-delta effect, emphasizing the importance of accounting for geometric nonlinearity in tall structures to avoid underestimating displacements and internal forces. In a comparison of P-delta and traditional stability analysis, we regularly observed larger displacements predicted by P-delta, indicating its significant influence on structural deformations.Furthermore, our findings revealed that P-delta impacts extend beyond gravity loads to include lateral forces such as wind and seismic loads, demanding a comprehensive design approach. Furthermore, through parametric investigations, we found X-bracing as a powerful technique for mitigating P-delta effects, with the potential to reduce them by up to 95%, hence improving structural stability. In essence, our findings underline the crucial function of P-delta analysis in creating durable tall buildings capable of sustaining dynamic loading situations.

VI. Conclusion

In conclusion, the use of P-delta analysis becomes increasingly important, particularly in tall buildings where its influence grows with height. Our findings emphasize the need of prioritizing P-delta analysis above standard stability assessments in order to appropriately predict structural behavior. Our findings show that displacements in P-delta analysis are approximately 10% higher than those in regular building analyses, stressing the importance of carefully considering geometric nonlinearity. It is worth emphasizing that P-delta effects are influenced not just by gravity loads, but also by lateral forces, demanding a thorough structural analysis approach. Integrating X-bracing into the structure is a successful technique for mitigating P-delta effects, with reductions of up to 95% reported. By incorporating these insights into structural design approaches, we may improve building safety and resilience, guaranteeing that they can withstand the various stresses encountered in real-world scenarios.

VII. References

1. Dr Ruaa Abdulateef Abdulhameed (Author) P-Delta Effect on The Dynamic Seismic Response of High Rise Buildings Paperback – Import, 22 April 2019
2. Amrul Kaish .A.B.M, Jamil.M,. Raman.S.N, Zain. M.F.M (2015) Axial behavior of ferrocement confined cylindrical concrete specimens with different sizes, Journal of Construction and Building Materials
3. Mallikarjuna B.N1 , Ranjith A STABILITY ANALYSIS OF STEEL FRAME STRUCTURES: P-DELTA ANALYSIS (2014)
4. Kanchan Gupta, Md. Tasleem Performance of P-Delta Analysis of Flat Slab and R C Framed Buildings (2020)
5. Prashant Dhadve “Assessment of P-Delta Effect on High Rise Buildings” (2015)
6. Atul Rupanvar, Deokate K “Assessment of P-Delta Effect on High Rise Buildings” (2016)
7. S.Sudheer, Analysis & design of g+5 residential building using STAAD Pro.
8. Mr. A. P. Patil, Mr. A. A. Choudhari, Mr. P. A. Mudhole, Mr. V. V. Patole, Ms. A. D. Dange.