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Correction Factor Method As A Substitute For Sequential Construction Analysis Of Buildings

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Abstract: Within the sphere of structural analysis, a method of paramount importance emerges - the Correction Factor Method. Unlike conventional approaches, this method stands as a stalwart against the complexities of non-linear structural behavior. It pioneers a path that diverges from the linear norm, offering precision and insight where others falter. The structural parts of the building are analyzed in one step using linear static analysis method by assuming that the structure will be subjected to full load after the finishing of the construction completely. In reality things work in other way the dead load from each structural members and finishing materials are imposed in different stages as the structure is constructed storey by storey. Similarly the stability of frame changes at every stage of construction. Because of this changes the loads assumed in conventional analysis vary in the construction process and the results obtained in the traditional analysis will be unstable.

Thus the structural frame should be analyzed in every structural construction stage by keeping variation of loads. This process is called as Construction Stage Analysis this process considers all the uncertainties precisely. This process is a time consuming process as the analysis is a complex process. Thus Correction factor method can be introduced where the analysis time can be reduced and the results will be accurate to Construction Stage Analysis.

In this project multistoried reinforced concrete building frames with different number of floors are analyzed using ETABS, and then Construction Stage Analysis of each building model is done. A comparative study of Bending moments, axial forces, twisting moments and shear forces are carried out at every stage of the structural frame. These values are compared with linear static analysis and Construction Stage Analysis. From the values obtained correction factors are derived.

From this method we can get results which has a maximum error of 2% and this proves that correction factor can be used as a substitute for sequential construction analysis.

Keywords: Construction Stage Analysis, correction factor Method, ETABS.

I. INTRODUCTION

The most structural failures that occur are due to lack of stability in the structural elements. The designer should take into consideration of all the probabilities and design the structure to withstand different types of loads. The stability of the structure which is

Structural failures often occur primarily due to a lack of stability in the structural elements. It is crucial for designers to carefully consider all potential scenarios and ensure that the structure can withstand various types of loads. The overall stability of a completed structure hinges on the presence and stability of all its structural members.

During the construction phase, a structure is inherently incomplete, and it undergoes changes over time as loads shift. Temporary bracing plays a pivotal role in maintaining stability during this phase. It is essential to prioritize construction sequencing during the analysis and design process to enhance the stability of the structure during construction.

Excessive construction loading is another common reason for structural failures during construction. Typically, the loads applied to structural members during construction exceed the service loads anticipated by the designer. This occurs because newly constructed floors are supported by previously cast floors.

Analyzing a structure for stability when it is irregular, incomplete, and constantly changing poses a significant challenge for structural engineers. To ensure stability at all times, engineers must account for potential variations in loads during construction, temporary support measures, and repair scenarios.

The concept of "Sequential Construction Analysis" proves highly beneficial in achieving stability during the step-by-step construction of multistoried structures. This approach should be employed for analyzing and designing buildings. Although the analysis part may be complex and time-consuming, the use of correction factor methods simplifies the process, ensuring that the design of the structure is carried out safely.

II. LITERATURE REVIEW

Considering the sequential nature of construction, the impact of sequentially applying dead loads significantly influences the analysis of multistory frames. Regrettably, many engineers have historically disregarded this factor in practical applications. One approach to address this matter effectively involves conducting step-by-step procedures that align with the gradual application of dead loads during construction. However, these procedures often entail intricate calculations and extended solution times.

To tackle this challenge, this paper introduces a simplified method called the Correction Factor Method (CFM). The CFM offers a solution that doesn't necessitate elaborate step-by-step analyses. Instead, it relies on correction factors, derived through regression analysis of data collected from existing buildings, to adjust the outcomes obtained from conventional analytical methods. Through the application of these correction factors, the CFM aims to produce more precise results.

To illustrate the credibility and efficacy of the CFM, the paper presents numerical tests. These tests serve as a demonstration of the method's capability to deliver accurate outcomes.

III. PROBLEM DEFINITION

1) The literature review conducted gives us the insight into the research gaps.
2) These papers focuses on the sequential construction analysis and provides a scope for further research in using different methods for the analysis of buildings.
3) An efficient way of analyzing the structure is to be found out.

IV. METHODOLOGY

These models are analyzed by both conventional method and by Construction Stage Analysis. And similar building models were analyzed for both the methods considering floating columns on face center and face side bays of the structure. These 12 models were used for the comparison of responses of various forces in terms of axial forces, bending moments, shear forces and twisting moments.

Study Conducted For Number Floors = 5, 10, 15, 20, 25, 30

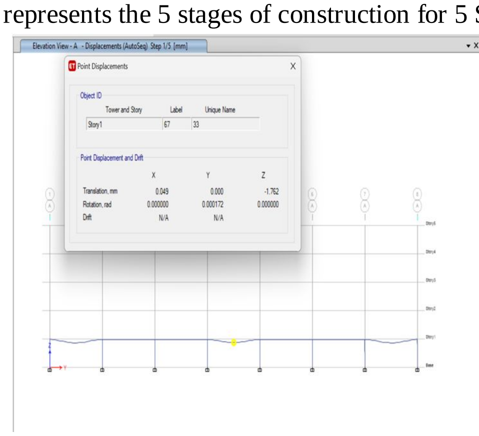
Table 1: Parameters used for the present study.

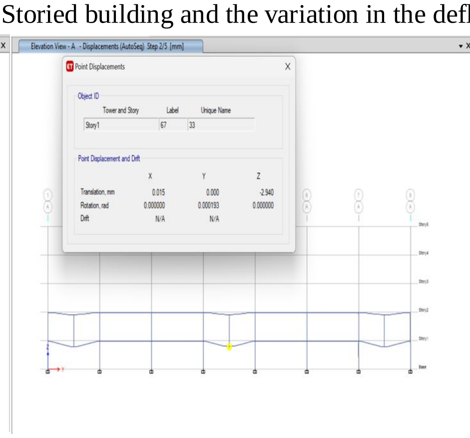
Beam section	Column section	Slab thickness	Wall thickness	Bay width in X-direction	Bay width in Y-direction	Storey-to-storey height
300X450mm	750*750mm	0.15m	0.2m	8m	8m	3m

Table 2: Loads assigned

Live load	3 kN/m^2
Floor finish load	2 kN/m^2
Wall load	11.4 kN/m

The Below 5 Figures represents the 5 stages of construction for 5 Storied building and the variation in the deflection values





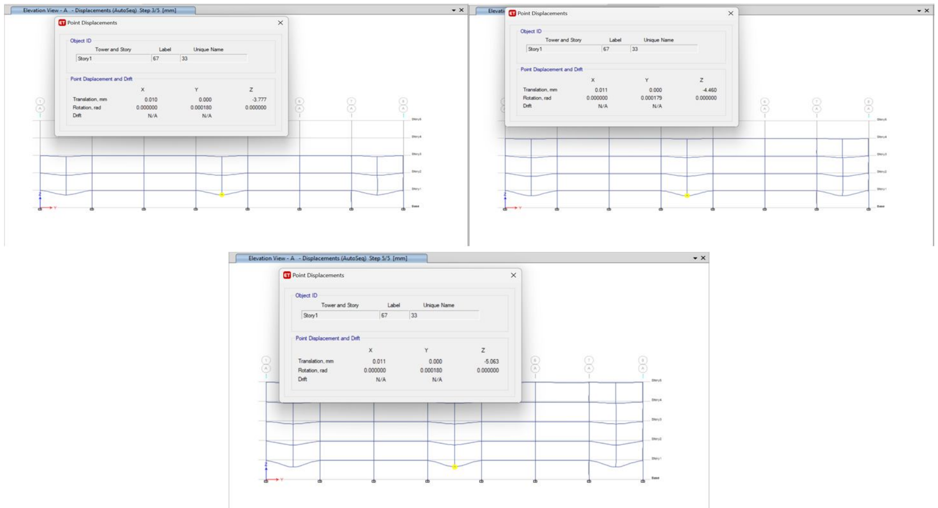
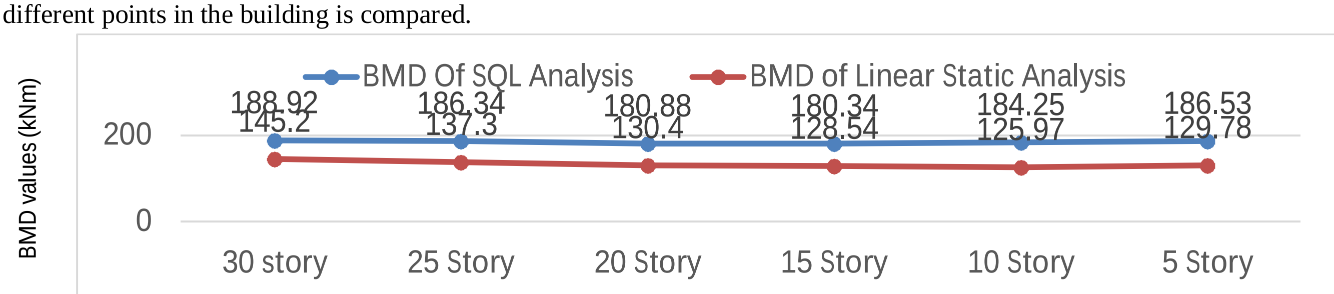


Figure 4.1: Displacement values in each steps

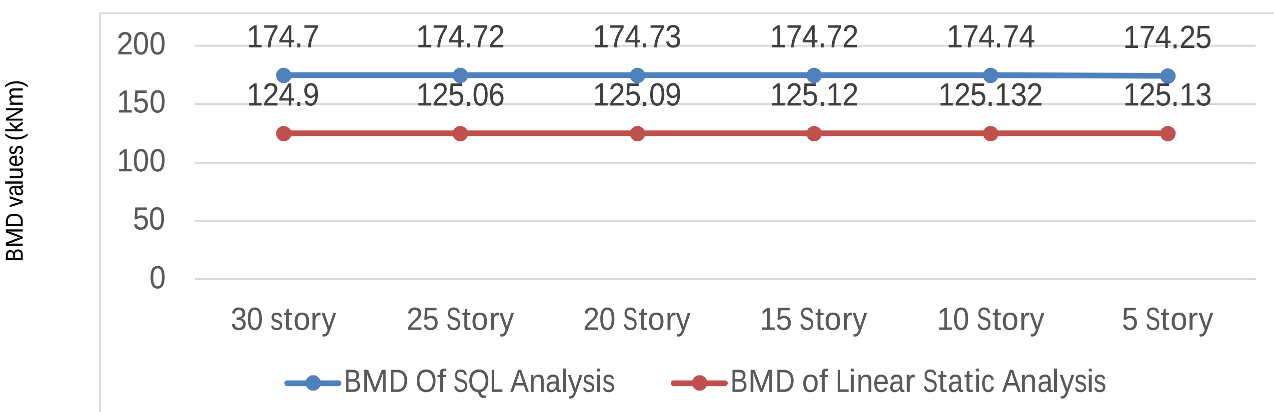
Table 3: Displacement Values

Step No.	Displacement Values
1	1.762
2	2.940
3	3.777
4	4.460
5	5.063

A comparison in the Bending Moment Diagram values between Sequential Construction analysis and Linear Static Analysis at different points in the building is compared.



Graph 4.1 : Comparison Of BMD With Respect to Top Corner Of building



Graph 4.2: Comparison Of BMD With Respect to Top Centre Of building

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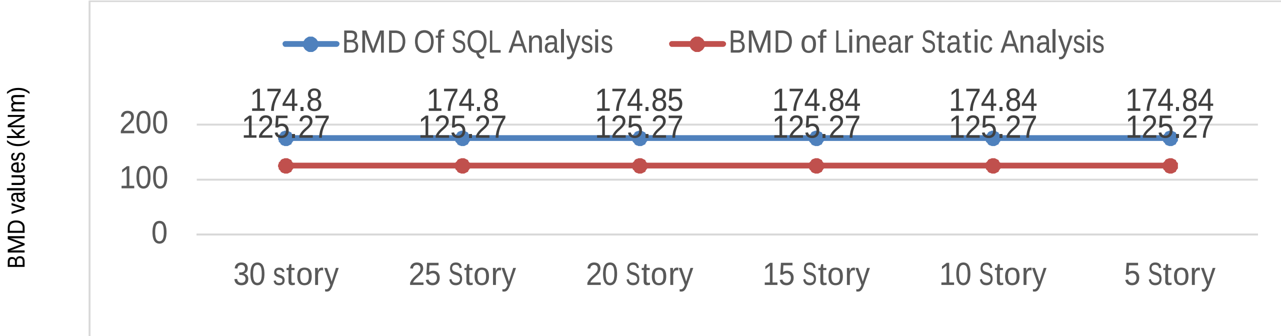
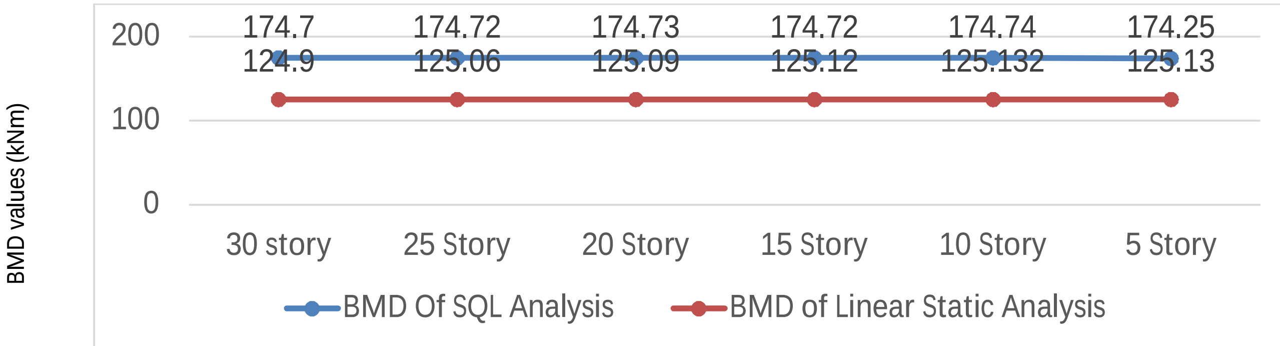


Graph 4.3: Comparison Of BMD With Respect to Bottom Centre Of building



Graph 4.4: Comparison Of BMD With Respect to Top Centre Of building

We can observe that there is a major difference in the Sequential analysis values and Linear static values this shows why sequential analysis should be used.

A. *Analysis details*

The methods discussed earlier for addressing issues related to the incremental application of dead loads yield accurate results but may require increased computational efforts once computer codes are developed. In practical applications, engineers may need to understand the nature of these problems, along with the associated algorithms and their computer implementations, to effectively utilize these techniques.

To encourage wider adoption of correction methods among practitioners, there is a need for the development of a simplified yet reasonably reliable approach. Incorrect stresses and displacements in conventional analyses arise from a combination of erroneous differential column shortenings and joint rotations. To rectify these inaccuracies and obtain accurate stress and displacement values in frame analysis, a step-by-step analysis for each construction stage is performed.

The correction factors can be derived statistically from the results of previous building analyses, akin to the concept of a design response spectrum used in seismic design.

Based on the methods Discussed previously, a practically applicable correction factor curve is Developed

1) *Correction Factor Determination*

$$C_f^i = \frac{(\delta_A^i - \delta_B^i)}{\delta_A^n} \dots\dots\dots\dots\dots \quad \text{(Choi, et al., 1992)}$$

2) *Determination of Amount Correction in Moment required at member ends*

$$M_c^i = \frac{6EI}{L^2(1+2\beta)} x\delta_e^i \dots\dots\dots\dots\dots \quad \text{(Choi, et al., 1992)}$$

3) *Determination of Amount Correction in Shear required at member ends*

$$S_c^i = \frac{12EI}{L^3(1+2\beta)} x\delta_e^i \dots\dots\dots\dots\dots \quad \text{(Choi, et al., 1992)}$$

4) Determination Of Correction Factor

$$C_f^i = \left(\frac{i}{n+1}\right) \propto \text{ (Choi, et al., 1992)}$$

Note:
□= Column displacements
i= i^{th} Floor
n= Top Floor
A and B = Methods of analysis
$\delta_e^i = \delta_A^i - \delta_B^i$
L= Length of the beam
E= Young's modulus
I= Moment of Inertia
β=Shear flexibility factor

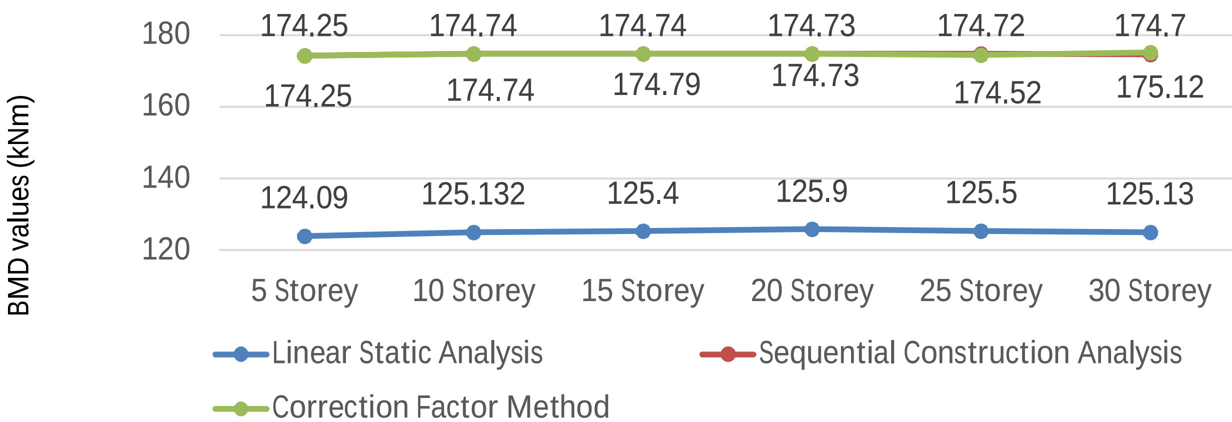
V. RESULTS AND DISCUSSION

From the Formulas the factors are derived and is tabulated below

Table 4: Correction Factor Values

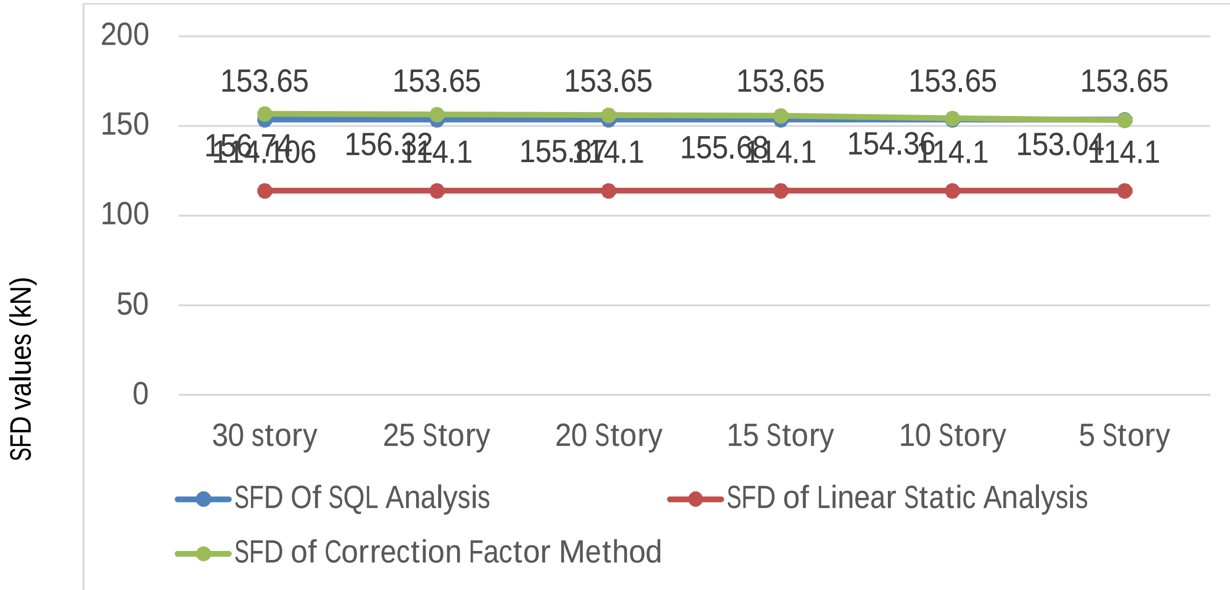
Correction Factor Values	
Number Of Floors	$\propto$
1-5	1.9
6-10	2.1
11-15	2.3
16-20	2.5
21-25	2.6
26-30	2.8

From the values obtained a comparison graph between all the three methods were drawn and this shows that the correction factor method is valid.



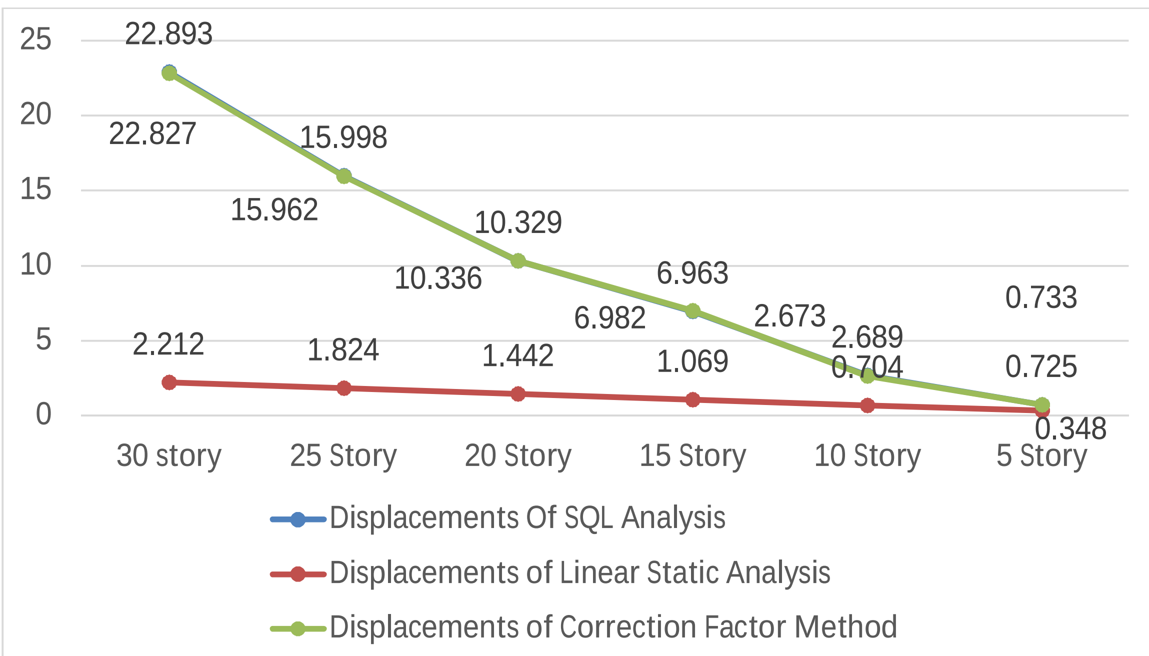
Graph 5.1 Comparison of BMD Values of all the three methods

From the above graph we can see that the values of Sequential analysis and Correction Factor method are almost similar and has a maximum difference of 0.24%.



Graph 5.2 Comparison of SFD Values of all the three methods

From the above graph we can see that the values of Sequential analysis and Correction Factor method are almost similar and has a maximum difference of 1.99%.



Graph 5.3 Comparison of Displacement Values of all the three methods

From the above graph we can see that the values of Sequential analysis and Correction Factor method are almost similar and has a maximum difference of 0.59%, hence it proves Correction factor method can be used as a substitute for Sequential construction analysis.

Discussions

1) Edge beams are found to be critical for all the responses except twisting moment and span moment if analyzed conventionally considering earthquake forces.
2) Whereas, interior beams are always critical during construction. Therefore, construction stage analysis is most suitable.

3) Corner columns are found to be critical during earthquake and not during construction. Whereas edge columns are critical if analyzed by construction stage analysis.
4) For interior columns all the responses are governed by earthquake forces. There is no effect of number of stories or storey height on the responses of the external forces.

VI. CONCLUSION

1) It has been noted that when analyzing the sequence of construction, there are significant differences in the design moments compared to traditional single-step analysis. Consequently, it is imperative for multistoried building frames to account for the influence of sequential construction. While achieving an exact simulation of the construction sequence may be challenging, it is always feasible to create an idealized representation of the construction sequence based on a simplified model. Additionally, it is advisable to establish approximate ratios between sequential analysis and single-step analysis, which can serve as useful design guidelines, considering the relative stiffness of beams and columns.
2) The shear force and bending moment values exhibit notable disparities between conventional analysis and construction sequence analysis. The findings unequivocally indicate that, particularly in high-rise buildings, considering construction sequence analysis is imperative due to the significant discrepancies in shear force, bending moment, and axial force values.
3) In traditional analysis, the construction staging is overlooked, resulting in values that deviate from real-world conditions. It is observed that beams are more susceptible to sequential loading when compared to columns. In construction sequence analysis, the axial force in exterior columns is lower than that in linear static analysis, while the axial force in interior columns is higher than that in linear static analysis.
4) In this study, a simplified solution called the Correction Factor Method (CFM) is introduced to address the issue of incorrect bending moments that arise in building members due to erroneous differential column shortening. This problem typically occurs in standard building analyses that do not adequately account for the sequential construction process and the gradual application of its weight. For tall buildings, the impact of incorrect rotation is negligible, and it can be appropriately addressed by selecting the appropriate alpha value.
5) The research findings highlight that the adjusted CFM yields results (such as member forces and column shortenings) that closely resemble those obtained through staged analysis.
6) Furthermore, the outcomes also demonstrated the proficiency of the modified CFM in handling dual structural systems, including both steel and concrete moment-resisting frames. It exhibited a greater accuracy in predicting analysis results that closely align with actual values derived from staged analysis, when compared to the standard CFM.
7) The correction factor method introduced in this current study, which takes into account the impact of construction sequence on structural analysis, can be efficiently employed in the initial design phase of structures, assuming a step-by-step construction approach.

VII. FUTURE SCOPE

1) Opportunities for research on steel structures of similar nature or character offer valuable insights and advancements.
2) Further research can be conducted to analyze precast materials, mirroring previous studies to gain valuable insights.
3) Continuing with a detailed sequential examination, further analysis can be conducted on structures incorporating shear walls, expanding our understanding.
4) Conducting empirical experiments is imperative to ascertain actual, real-world values and measurements essential for practical applications.

VIII. ACKNOWLEDGEMENTS

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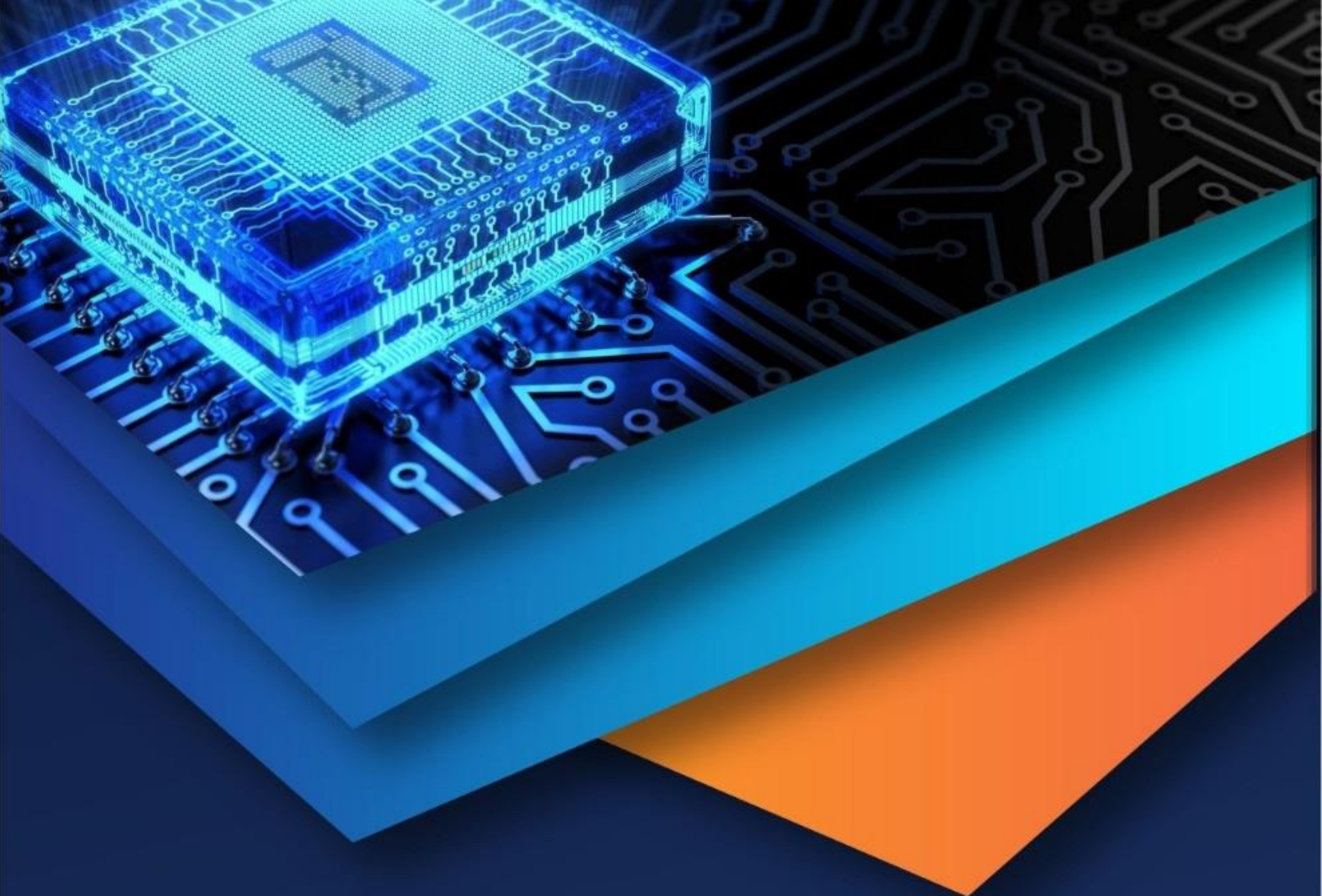

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