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Analysis of an RC Building Incorporating the Effects of Sequential Construction

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***Abstract*: Building structures usually analyzed in single step using conventional analysis based on assumption that full load is imposed on the structure once it is constructed completely. In reality loads are acted stage by stage as construction proceeds. Construction sequence analysis with time dependent parameters can cause redistribution of responses which is not taken into consideration in case of conventional analysis. In this present study sequential analysis of G+7 storey and G+10 storey buildings have been carried out with and without time dependent parameters for M20 and M25 grade concrete and the analysis results obtained are compared.**

***Keywords*: Sequential Construction, RC Building**

1. Introduction

Sequential construction analysis is a nonlinear static analysis which accounts the concept of incremental loading. It allows you to define the sequence of stages where you can selectively apply load to the portion of structure, also where you can add or remove the portion of structure and mainly time dependent material parameters such as creep, shrinkage and aging can be considered. So, the sequence of stages can be matched on how the buildings will be built. Sequential construction is important in the analysis of a high rise building, as the height increases the structural responses increasingly diverge from the actual behaviour.

2. Objectives

Bearing in mind the above discussion, main objective of this work is to reduce the potential for structural failure during construction phase.

The objectives of the present study are as listed below:

1. To study the behaviour and comparison between the conventional analysis and sequential construction analysis of an RC building.
2. To study the behaviour of RC building incorporating time dependent parameters such as creep and shrinkage.
3. To study the comparisons between geometric nonlinearity and material nonlinearity.
4. To study the effect on height of building and comparison between conventional and sequential construction analysis.
5. To study the effect on change in grade of concrete and comparison between them.

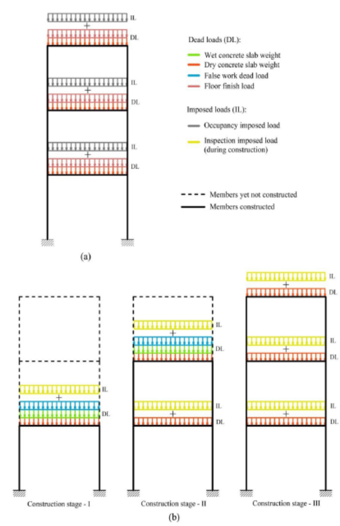


Fig. 1. (a) Conventional analysis (b) Construction stage analysis

3. Methodology

In order to understand the consequence of sequential construction analysis, several models of G+7 and G+10 story RC buildings with floating column, having story height 3m and bay width of 4m both along the length and width has been analyzed using ETABS. The various stiffness governing factors such as length, width, storey height, etc. are taken as basic parameters.

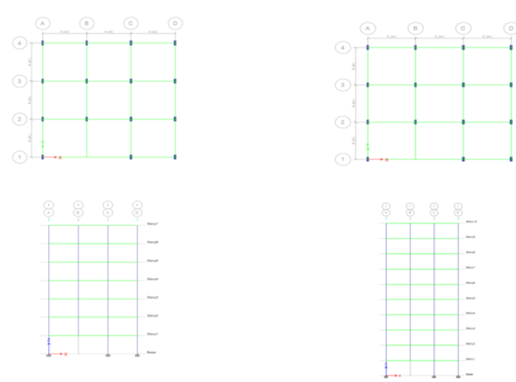


Fig. 2. G+7 and G+10 storey building plan and elevation

In G+7 storey and G+10 storey RC building totally 12 models have been done, Conventional analysis, Sequential analysis and sequential analysis with time dependent parameters respectively. 6 models for M20 grade concrete and 6 models for M25 grade concrete and Fe415 grade steel is used. Beam – 200x500 mm, column – 200x500mm and slab 125mm thick.

Table 1
Time dependent material properties
CEB FIP MODEL CODE 1990

Property	Value
% Relative humidity	75
Shrinkage coefficient	5
Shrinkage starts at	7 days
Notational size	142.9mm
Age at loading	7 days
Time range	0 to 10000 days

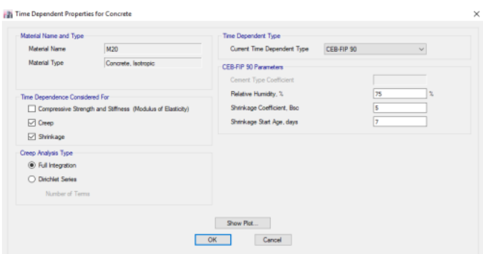


Fig. 3. Time dependent properties for concrete

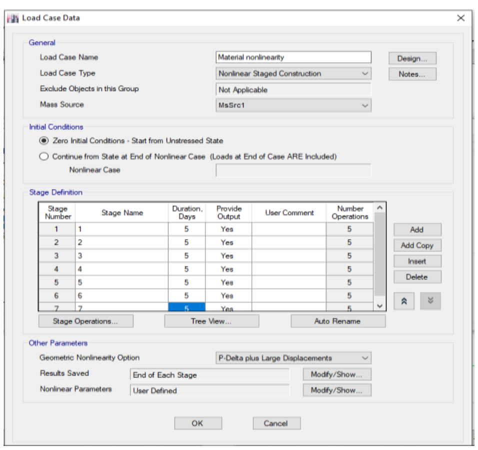


Fig. 4. Material non linearity load case data

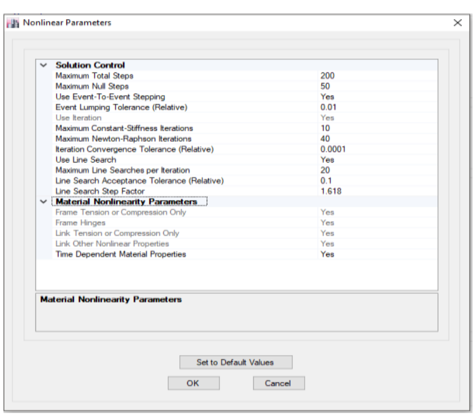


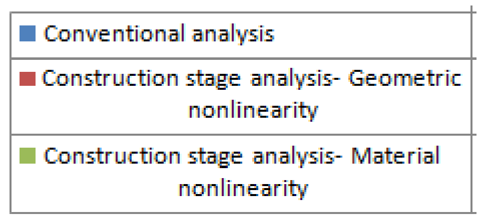
Fig. 5. Nonlinear parameter data

After the complete model is created the load patterns are defined and here we are considering the static load analysis for the present study. For both these cases analysis is performed and their corresponding results are compared.

The behaviour of the structure under linear static conventional analysis and nonlinear static sequential construction analysis is considered for the discussion. All the structural models are analysed for both linear static and nonlinear static analysis using ETABS 2016 software.

4. Results

A. G+7 storey building – M20 grade concrete



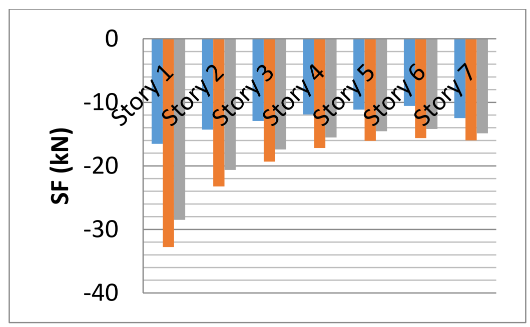


Fig. 6. Shear force variations for beam

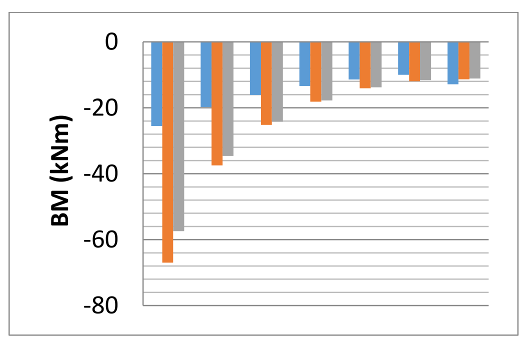


Fig. 7. Bending moment variations for beam

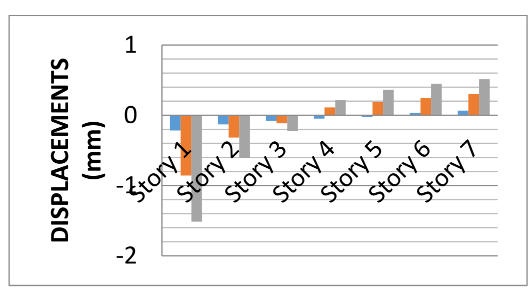


Fig. 8. Displacement variations for beam

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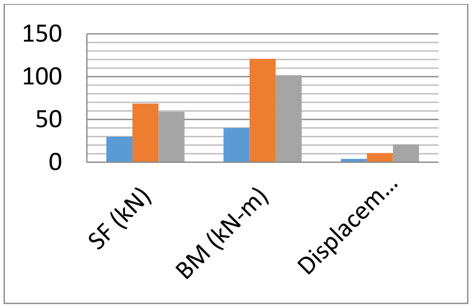

Fig. 9. Structural response variations for transfer beam

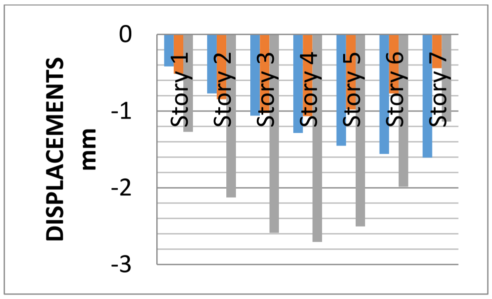

Fig. 10. Joint displacements variations for column

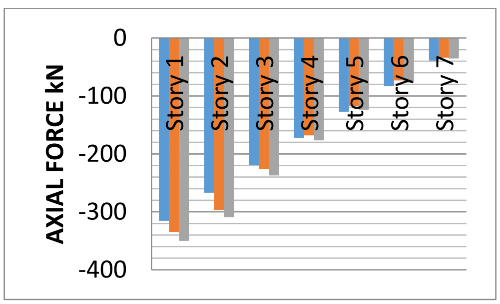

Fig. 11. Axial force variations for column

B. G+7 story building - M25 grade concrete

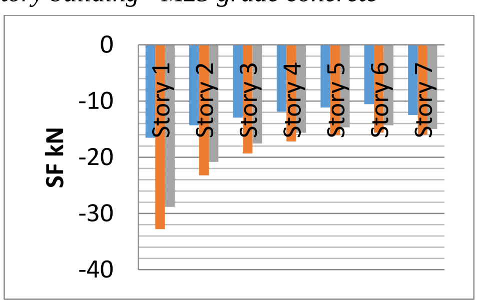

Fig. 12. Shear force variations for beam

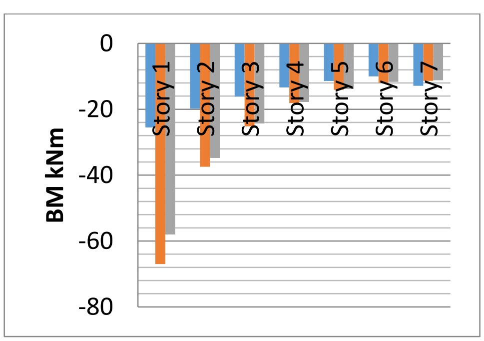

Fig. 13. Bending moment variations for beam

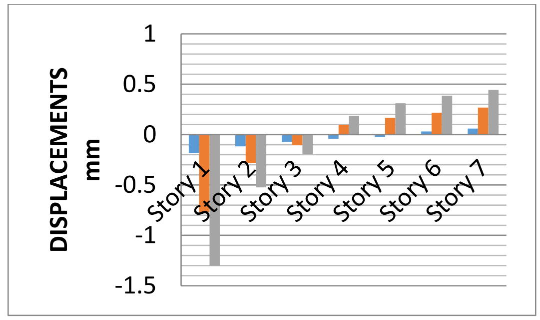

Fig. 14. Displacements variations for beam

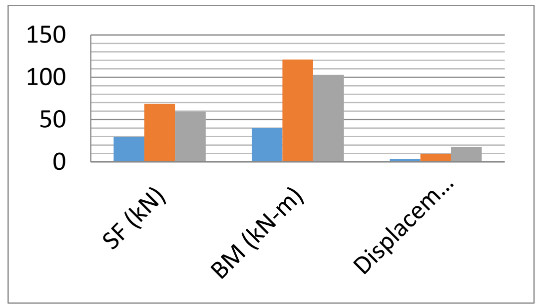

Fig. 15. Structural responses for transfer beam

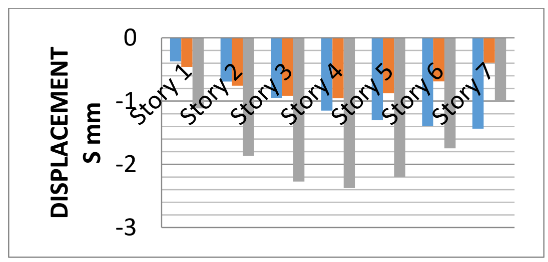

Fig. 16. Joint displacements for column

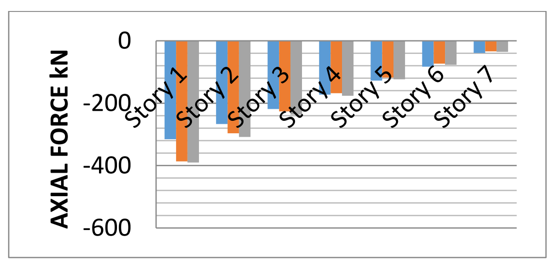

Fig. 17. Axial force for column

C. Structural responses for G+10 storey building - M20 grade concrete

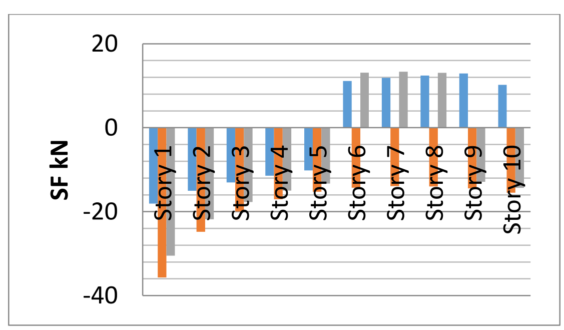

Fig. 18. Shear force variations for beam

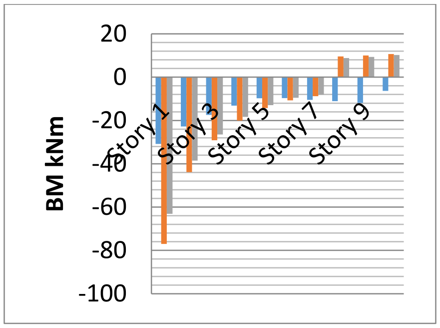

Fig. 19. Bending moment variations for beam

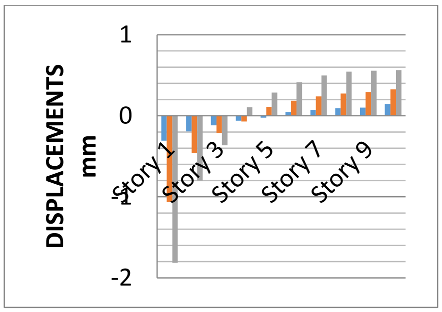

Fig. 20. Displacement variations for beam

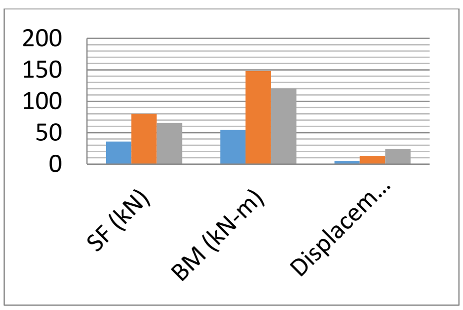

Fig. 21. Structural response variations for transfer beam

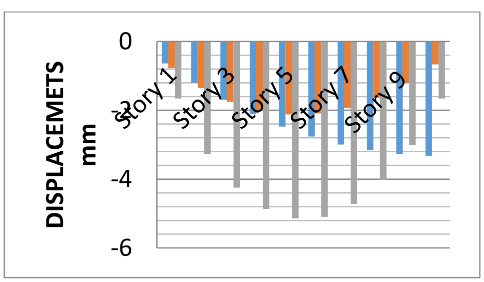

Fig. 22. Joint displacements for column

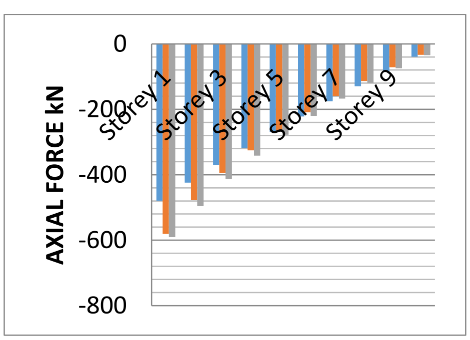

Fig. 23. Axial force for column

D. Structural responses for G+10 storey building - M25 grade concrete

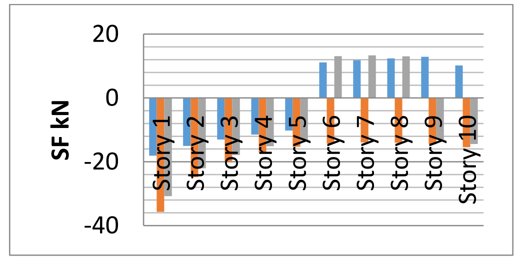

Fig. 24. Shear force variations for beam

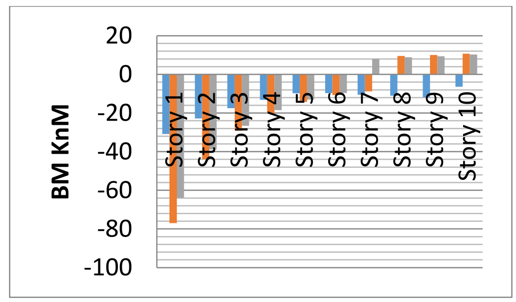

Fig. 25. Bending moment variations for beam

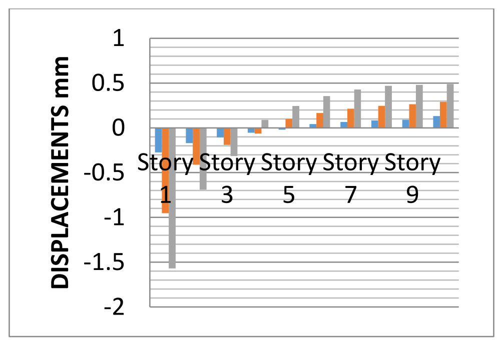

Fig. 26. Displacements variations for beam

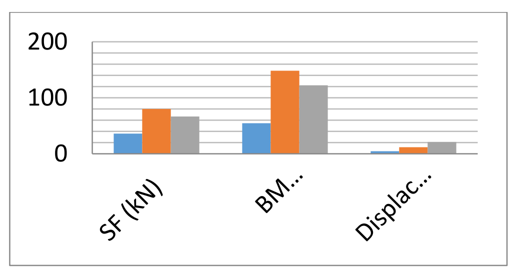

Fig. 27. Structural responses for transfer beam

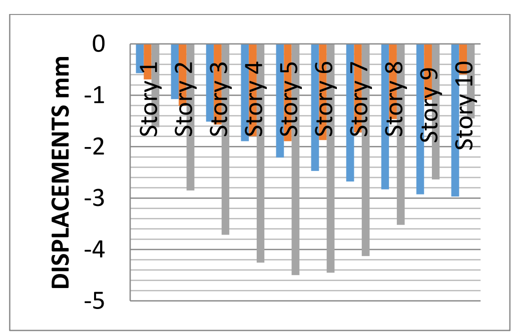

Fig. 28. Joint displacements for column

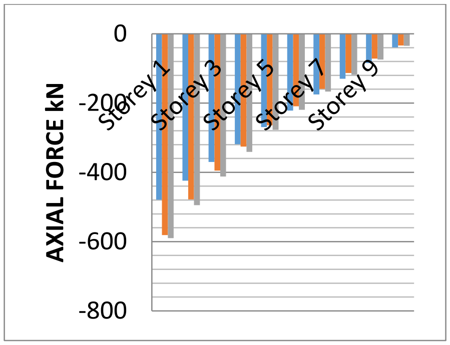

Fig. 29. Axial force for column

5. Discussions

A. G+7 storey building

- From fig. 6 it is observed that Shear force variation is higher for sequential construction analysis compared to conventional analysis, the variation is about 98% at lower stories and 28% at higher stories, with creep and shrinkage the variations is about 75% for beam element.
- From fig. 7 it is observed that bending moment variation is about 153 % at lower stories and about 13% at higher stories, with creep and shrinkage the variation is about 125% for beam element.
- From fig. 8 it is observed that displacement variation is about 300% at lower stories and about 350% at higher stories compared to that of sequential analysis, with creep and shrinkage the variation is about 600% for a beam element.
- From fig. 9 it was observed that the variations in structural responses are about 200%, with creep and shrinkage the variation is about 150% for transfer beam.
- From fig. 10 it was observed that Joint displacement variations is about 15% for column, with creep and shrinkage the variation is about 110% compared to that of conventional analysis.
- From fig. 11 it was observed that the variations in axial force are about 6% for sequential analysis, with creep and shrinkage the variation is about 10% compared to that of conventional analysis for column.
- From fig. 12 it was seen that shear force variations are about 100%, with creep and shrinkage the variations are about 75% for beam element compared to that of sequential analysis for M25 grade concrete.
- From fig. 13 it was seen that bending moment variations are about 160%, with creep and shrinkage the variations are about 130% for beam element for M25 grade concrete.
- From fig. 14 it was seen that displacement variations are about 310%, with creep and shrinkage the variations are about 600% for beam element for M25 grade concrete.
- From fig. 15 it was noted that variations in structural responses for transfer beam is about 160%, with creep and shrinkage the variations are about 150% for beam element for M25 grade concrete.
- From fig. 16 it was observed that joint displacement variations are about 20%, with creep and shrinkage the variation is about 98% compared to that of conventional analysis for column for M25 grade concrete.
- From fig. 17 it was observed that axial force variations are about 20%, with creep and shrinkage the variations are about 25% for column for M25 grade concrete.

B. G+10 storey building

- From fig. 18 it was observed that shear force variations are about 98%, with creep and shrinkage the variations are about 70% conventional analysis.
- From fig. 19 it was observed that bending moment variation are about 150%, with creep and shrinkage the variations are about 100% almost twice the value obtained from conventional analysis for beam element.
- From fig. 20 it was observed that displacement variations are about 250%, with creep and shrinkage the variations are about 500% for beam element.
- From fig. 21 it was seen that structural responses variations for transfer beam is about 180%, with creep and shrinkage the variations are about 120% for beam element.
- From fig. 22 it was noted that the joint displacement variations are about 15%, with creep and shrinkage the variations are about 120% for column, the values are higher at middle storey.
- From fig. 23 it was noted that axial force variations are about 35%, with creep and shrinkage the variations are about 35% for column compared to conventional analysis.
- From fig. 24 it was seen that shear force variations are about 95%, with creep and shrinkage the variations are about 70% for beam element for M25 grade concrete.
- From fig. 25 it was seen that bending moment variations are about 150%, with creep and shrinkage the variations are about 100% for beam element for M25 grade concrete. The values are higher at lower stories.
- From fig. 26 it was seen that displacement variations are about 250%, with creep and shrinkage the variations are about 480 %for beam element for M25 grade concrete.
- From fig. 27 it was observed that variations in structural responses for transfer beam is about 175%, with creep and shrinkage the variations are about 125% for beam element for M25 grade concrete.
- From fig. 28 it was seen that joint displacement

variations are about 15%, with creep and shrinkage the variations are about 100% for column for M25 grade concrete.

- From fig. 29 it was observed that axial force variations are about 20%, with creep and shrinkage the variations are about 25% for column for M25 grade concrete.

6. Conclusions

The structural behaviour of sequential construction analysis is unique when compared to that of conventional analysis.

With increase in slenderness the necessity to perform sequential construction analysis considering geometric nonlinearity and material nonlinearity becomes more significant.

With increase in grade of concrete the structural responses were decreased, it was found that higher the grade of concrete lesser is the creep.

- In transfer beam the shear force, bending moment and displacements increase when sequential construction analysis is performed compared to that of conventional analysis.
- When time dependent parameters are considered it induces additional moments and displacements in the transfer beam.
- In sequential construction analysis displacements at critical joints increases at lower stories, as the number of stories increases the displacement decreases. Where as in case of conventional analysis the joint displacements were found to be more at higher stories.
- Higher the grade of concrete lesser the joint displacements, in case of sequential construction analysis compared to that of conventional analysis.
- In general, it is pointed that creep and shrinkage in concrete construction greatly affects the behaviour of structure with sequential construction analysis.
- Finally, it can be concluded that the study reveals the necessity of performing sequential construction analysis becomes more significant with time dependent nonlinear parameters in case of high rise buildings.

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