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Creep and Shrinkage Effect in Multistory Building using Non Linear Staged Construction

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Abstract - *The phenomenon of column shortening and differential shortening in high rise buildings considering non linear staged construction have become very significant now a days. The effects of column shortening, both elastic and inelastic, need special consideration in design with increased height of structure. This paper does study on different parameters affecting creep and shrinkage in high rise building such as temperature variation, relative humidity percent, cement content in design mix, aggregate ratio and slump on concrete columns using ACI code as long term column shortening could affect the structural elements like beams, floors as well as nonstructural elements like partitions.*

Key Words: Creep, Shrinkage, Staged construction, Differential shortening, High rise buildings.

1.INTRODUCTION

High rise building presents extreme challenges in terms of their design and construction. Structure must hold its strength as well as serviceability throughout the designed life without any failure. Axial and differential axial deformations in high-rise buildings are extremely significant during construction. When properties of material changes with time then these nonlinear effects should be considered in the analysis and design at each construction stages of the structure.

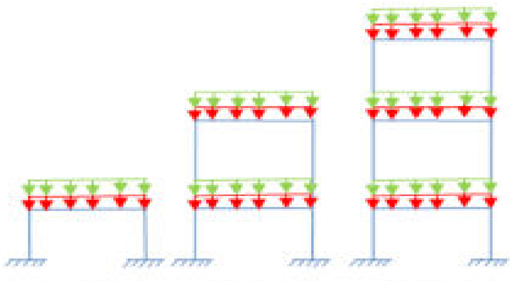
1.1 General

Prediction of long-term strains in high rise buildings, due to creep and shrinkage is important to ensure adequate safety and serviceability throughout the life of the structure. In the design of tall reinforced concrete (RC) buildings, creep and shrinkage deformations are critical and the same must be accounted for in the design. Axial shortening of columns due to time dependent phenomena of basic creep, shrinkage deformations is a challenge in high rise buildings. The magnitudes of this deformation in each member may differ due to the differences in load tributary areas and the geometry. As a consequence, the differential axial shortening between these members occurs. Differential axial shortening of vertical elements as a result of long-term strains often leads to additional deflections, cracks and stress re-distributions in the structural and nonstructural members of the building.

Several models have been developed for prediction of creep and shrinkage which are Eurocode 2, CEB-FIP MC90 and the ACI-209 model. For model verification a concrete column was modeled on Etabs 2017 subjected to concentrated load and the result was verified with ACI code empirical method used for calculating creep and shrinkage.

1.2 Nonlinear staged Construction

Construction sequence analysis is a nonlinear analysis approach in which the structure is analyzed at various stages corresponding to the construction sequence and the required loads are applied sequentially at every stage. In general, the structures are analyzed and designed using single step using gravity analysis on the basic assumption that the structure will be fully loaded at once but Practically, the structure is constructed story-wise hence dead load is applied story-wise and the finishing loads are also imposed as the structure is constructed in stage wise. This method is more accurate and practical as it considers the loads at their actual time of application. It is observed that the effect of construction sequence increases with the increase in stories. Therefore, the effect of construction sequence cannot be neglected and a precise analysis should be conducted.



(a) Stage 1 (b) Stage 2 (c) Stage 3

2. PROBLEM FORMULATION

In this study, G+25 and G+35 RCC symmetrical building (refer fig. 1) is modeled and analyzed in software named Etabs. In the selected model considered beam sizes are 300x600, columns sizes are as per design with reinforcement ratio nearly 3.5% with a height of 3.5m for each story. The shear walls are considered at the corners of the building with thickness 300mm each. The grade of concrete used is M35 in all structural members.

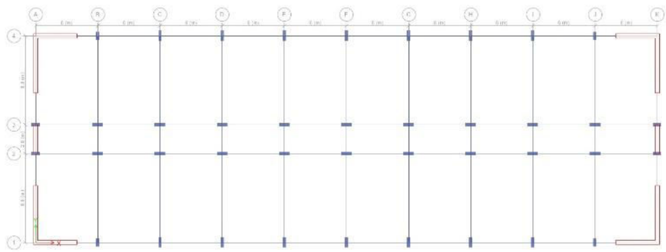


Fig 1- Plan

3. METHODOLOGY

3.1 Analytical Model-

The building analyzed and designed in is done on software ETABS.

The live load on each floor 3kN/m^2 and floor finish of 1kN/m^2 is considered also the wall load of 12kn/m2 is considered at the periphery of the building and inside the 6kn/m2 is considered.

The rate of construction of each story is taken as 14days.

For creep and shrinkage calculation ACI method is used.

According to ACI Committee

The creep coefficient of concrete C_t is given by

$$C_t=C_u K_1 K_2 K_3 K_4 K_5 K_6$$

Where C_u = Ultimate Creep coefficient

K_1 = Time under load coefficient

K_2 = Relative humidity coefficient

K_3 = Volume/surface ratio coefficient

K_4 = Slump of concrete coefficient

K_5 = Fines Coefficient

K_6 = Air Content Coefficient

The shrinkage strain at any time is given by.

$$\varepsilon sh = \varepsilon shu\ S_1 S_2 S_3 S_4 S_5 S_6$$

Where

εshu= Ultimate Shrinkage Strain

S_1 = Time period coefficient

S_2 = Relative humidity coefficient

S_3 = Volume/surface ratio coefficient

S_4 = Slump of concrete coefficient

S_5 = Fines Coefficient

S_6 = Air Content Coefficient

After analysis the deformed shape of building is shown in fig. 2 and 3.

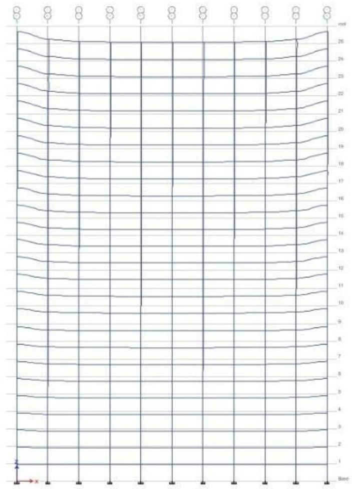


Fig 2- Deformed shape of 25 story building

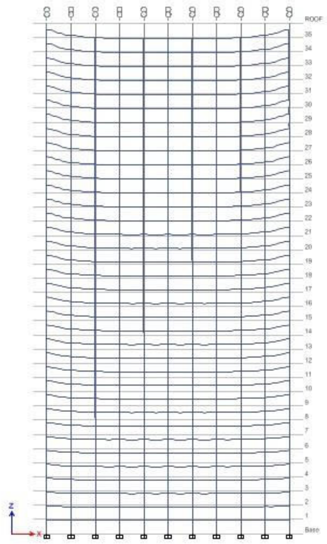


Fig 3- Deformed shape of 35 story building

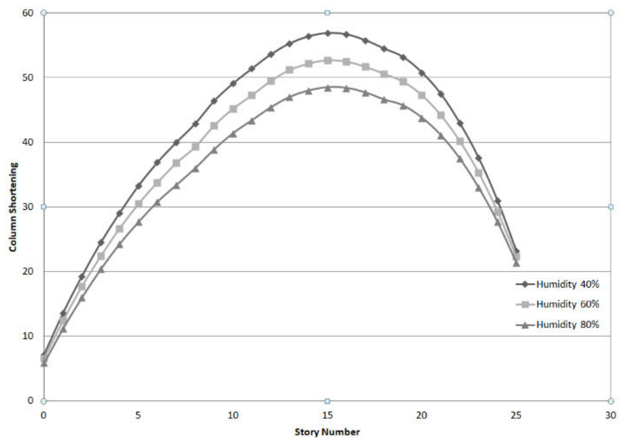
3.2 Analytical Model Results-

- **Relative humidity Effect**

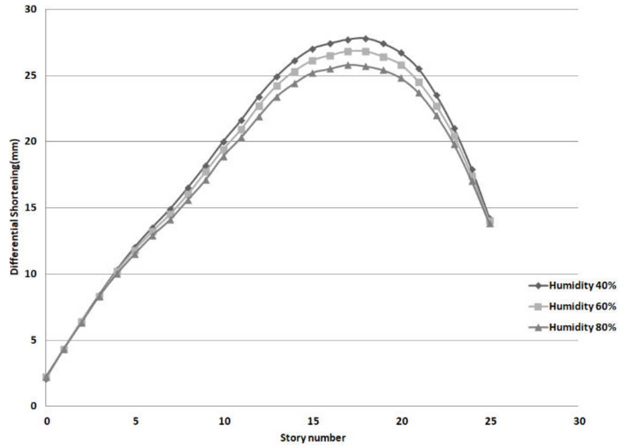
Creep and shrinkage both are affected by relative humidity, therefore this parameter is important to consider.

In this study, 40, 60, 80% humidity is considered.

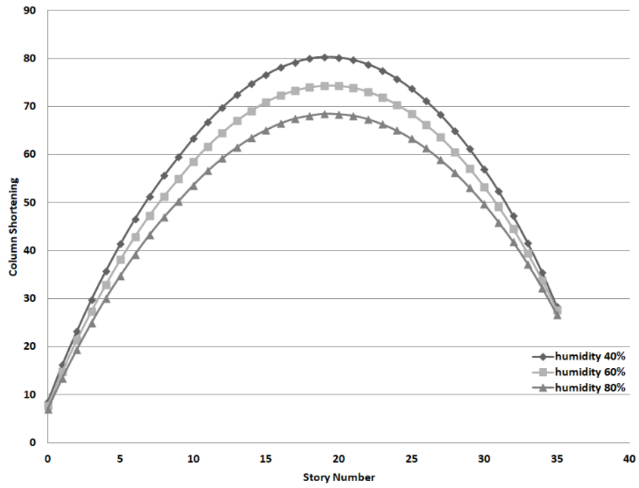
For both the buildings, creep and shrinkage is calculated separately to compare the differential and column shortening. The calculated column and differential shortening is shown in below graphs.



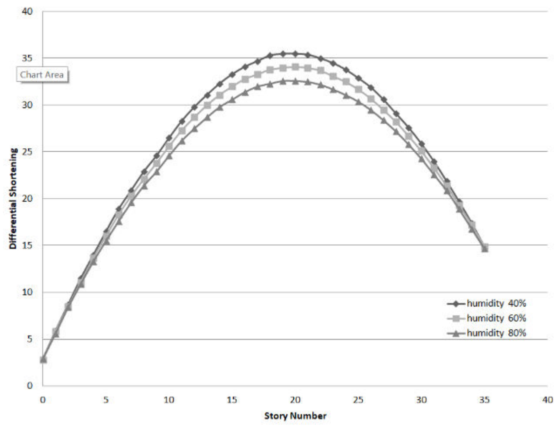
Graph- 1 Column Shortening of 25 story building for Different relative humidity



Graph- 2 Differential Shortening of 25 story building for Different relative humidity



Graph- 3 Column Shortening of 35 story building for Different relative humidity

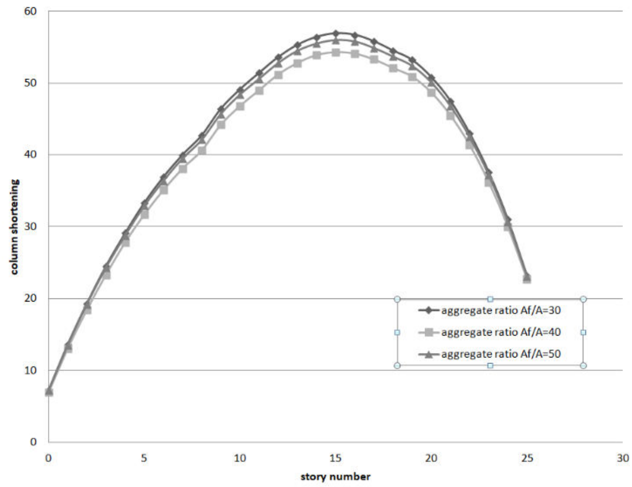


Graph- 4 Differential Shortening of 35 story building for Different relative humidity

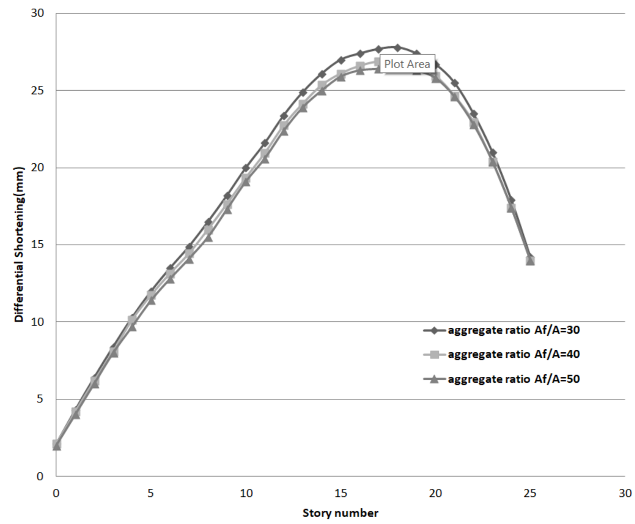
From the graphs it is clear that effect of relative humidity on creep and shrinkage is noticeable. It is important to give the attention to climate attention in each region, also it is clear that with increase in relative humidity, creep and shrinkage decreases. The reason behind this is due to the less water is lost by concrete at higher humidity thereby resulting in lower plastic shrinkage and creep effect.

- **Aggregate Ratio Effects**

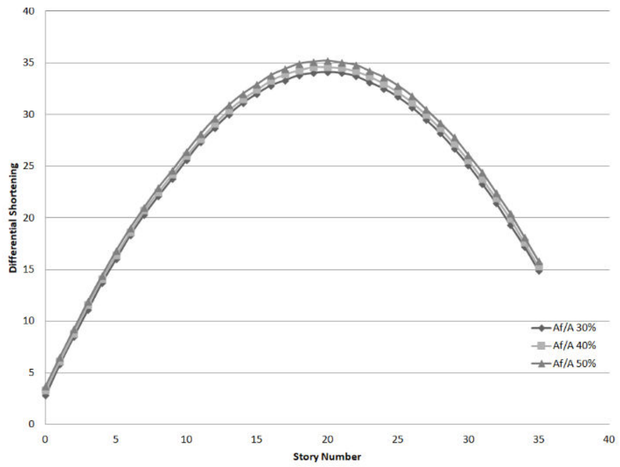
Creep and Shrinkage is also affected by the change in aggregate ratio. It the fine aggregate ratio is increased with respect to total aggregates than the creep and shrinkage also increases. In the study 30,40,50 % ratio of fine to total aggregate ratio is considered and the graph is plotted (refer below graphs) separately for both the buildings.



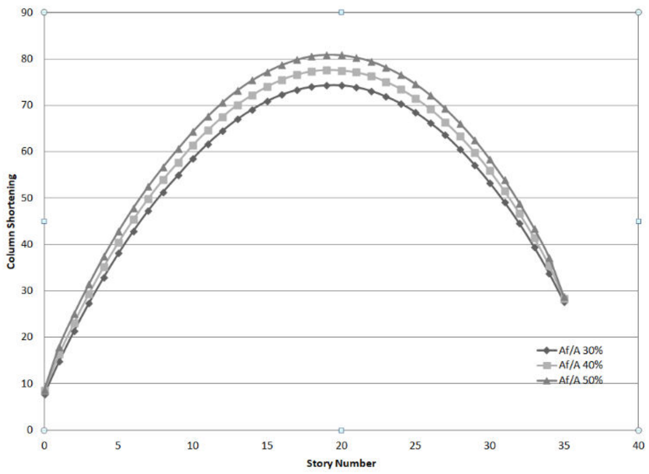
Graph- 5 Column Shortening of 25 story building for Different aggregate ratios



Graph- 6 Differential Shortening of 25 story building for Different aggregate ratios



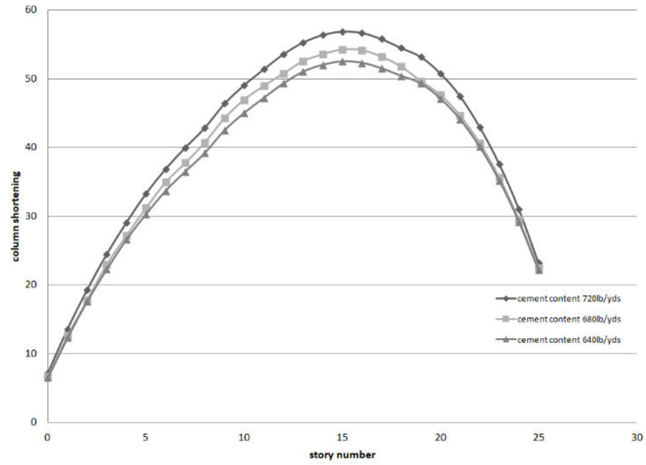
Graph- 7 Column Shortening of 35 story building for Different aggregate ratios



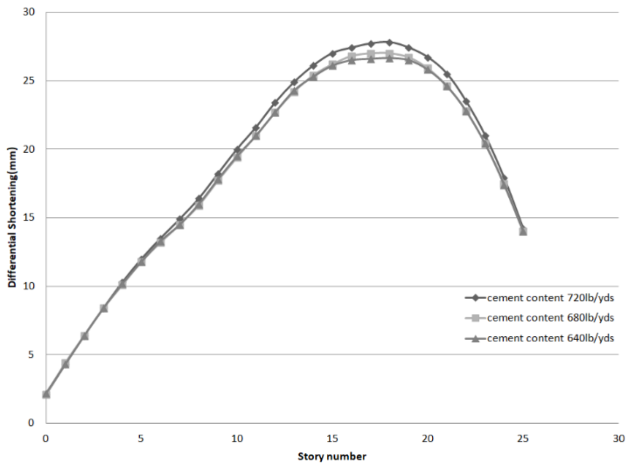
Graph- 8 Differential Shortening of 35 story building for Different aggregate ratios

➢ **Cement Content:**

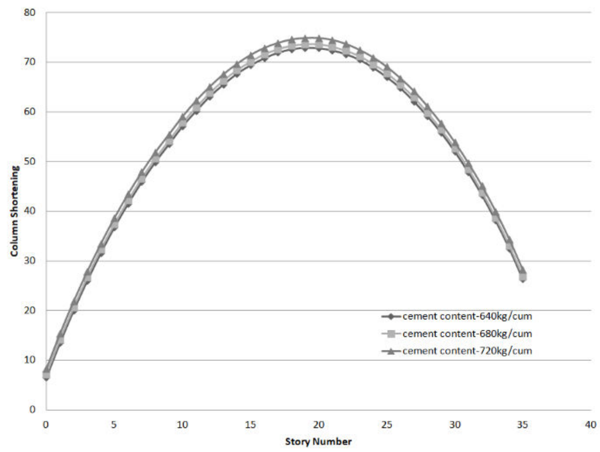
Creep and Shrinkage is affected by cement content present is the concrete paste. In this study 640, 680,720 lb/yds is considered. For both the buildings it is calculated separately and the graph is plotted (refer below graphs) between story number and change in cement content and it is observed that with the increase in cement content the creep and shrinkage is also increases.



Graph- 9 Column Shortening of 25 story building for Different cement contents



Graph- 10 Differential Shortening of 25 story building for Different cement contents



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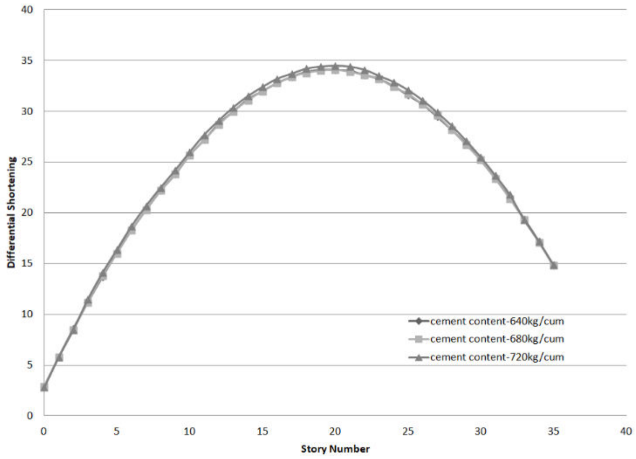
Graph- 11 Column Shortening of 35 story building for Different cement contents



Graph- 12 Differential Shortening of 35 story building for Different cement contents

3. CONCLUSIONS:

Results show that, for high rise buildings, a non linear staged construction analysis can lead to more realistic and significant results with considering creep and shrinkage effect, observed results are explained below.

I. Maximum differential and column shortening is nearer to the middle of the building, and it doesn't have much effect on the lower and top of the building.

II. This study indicates that, shortening in columns could be reduced by 20-10% in 25 and 35 story buildings by increasing the relative humidity from 40-80%

III. Differential shortening and column shortening at the required floor level can be obtained from relevant figures, depending on relative humidity of surrounding environment, cement content in concrete and aggregate ratio used in building.

REFERENCES

1. ACI committee 209R-)2; Prediction of Creep, Shrinkage, and Temperature effects in concrete structures, American Concrete Institute, Farmington Hills.
2. ACI 209.2-08. Guide for modelling and calculating shrinkage and creep in hardened concrete. In Reported by ACI committee 209. American concrete institute, Farmington Hills.
3. Vafai, A.; Ghadian, M.; Estekanchi, H. E.; Desai; C. S.: "Calculation of Creep and Shrinkage in Tall Concrete Buildings using Nonlinear Staged Construction Analysis", Asian Journal of Civil Engineering, 2009, 10(4), 409-426.
4. Hansoo, K. and Seunghak, S. (2014), "Reduction of differential column shortening in tall buildings", J. Civil Environ. Struct. Constr. Architect. Eng., 8(2), 145-148.
5. Maya Nastic, Evan C. Bentz. Oh-Sung Kwon, Vassilis papanikolaou,Tchener(2019)" Shrinkage and Creep Strains of Concrete exposed to low relative humidity and high temperature environments".
6. Ali B Jahromi, Abdulazeez Rotimi and Joseph Rizzuto(2017) " Evaluation of the influence of Creep and Shrinkage determinants on Column shortening in midrise buildings. Advance Concrete Constructions Vol.5 no.2.
7. Ruben Correia , Paulo Silva Lobo, "Simplified Assessment of the Effects column Shortening on the Response of Tall concrete buildings".Procedia Structural Integrity 5(2017).
8. Taehun Ha and Sungho Lee(2013) " advanced Construction analysis of high rise building Considering Creep and Shrinkage of Concrete. Advances in Structural Engineering.