# LONG TERM STATIC PERFORMANCE OF HIGH-RISE BUILDING BY CONSIDERING GEOMETRIC & MATERIAL NON-LINEARITY EFFECT.

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*Abstract:* Non-Linear static Analysis in term of material non-linearity and geometrical has been analysed with staged construction analysis in three high rise building with different structural systems. In the concrete structures, behavior of material properties is not changes linearly with the time ex. Creep, shrinkage, modulus of elasticity etc. Geometrical non-linearity affects the serviceability and strength criteria effectively with staged construction analysis. Mostly these effects have been ignored while designing of high rise structures. Now a day with the use of finite element software it becomes easy to incorporate these effects into design consideration. Analysis of material non-linearity as per CEP-FIP model code 1990 and P-delta analysis with staged construction analysis on three high rise G+27 buildings with different structural system studied.

***Index Terms* – Long term, high rise building, nonlinear, geometric, material, staged construction analysis.**

## I. INTRODUCTION

The process of designing high-rise buildings have changed over the past years.in the most recent years it is not unusual to model full three-dimensional finite element models of the buildings. This due to the increased computational power and more advanced software. However, these models produce huge amount of data and result where possible errors are easily overlooked, especially if the model is big and complex. If the engineers is not careful and have a lack of knowledge of structural behavior and finite element modeling, it is easy to just accept the result without critical thoughts. Material non-linearities occur in solid mechanics when the relationship between stress and strain, otherwise known as constative relationship of the material, is no longer linear. The direct proportionality of stress and strain can no longer be assumed, as it is in the simpler linear elastic case. A case of material non-linearity in solid mechanics for which rate independence is assumed is non-linear elastic behavior, where the stress is not linearly related to the strain. In this case the deformation is recoverable and not linearly related to the strain. Plasticity is another case of material no linearity which can be assumed to be rate independent for particular material under specific condition is plasticity. Plasticity describes non-linear material behavior where the material deforms permanently due to the application of a loading condition. Some material exhibit rigid-plastic or to be more specific almost rigid-plastic behavior when large deformation occur, where the elastic strains are negligible when compared to the plastic strain. Geometric nonlinearity may not even be explicitly introduced in a fundamental course on structural mechanics. In fact, geometric linearity is often tacitly assumed. In a geometrically linear setting, the equations of equilibrium are formulated in the un-deformed state and are not updated with deformation. This may sound a bit alarming at first, since computing deformation is what structural mechanics is all about. However, in most engineering problems, the deformations are so small that the deviation from the original geometry is not perceptible. The small error introduced by ignoring the deformation does not warrant the added mathematical complexity generated by a more sophisticated theory. This is why a vast majority of analyses are made with an assumption of geometric linearity.

## II. REVIEW OF LITERATURE

**W. Jiang, J. Gong, G. de Schutter, Y. Huang, Y. Yuan (2012)** illustrated the analysis of the vertical deformation of the high-rise Shanghai World Financial Centre building. They used prediction models of CEB-FIP 90 for calculating shrinkage and creep. The fictitious degree of hydration method has been applied for calculating the creep behaviour of the early age concrete. Finally, they determined differential deformation between the concrete and the mega structure column. This study concludes that instead of the superposition method, the fictitious degree of hydration method can be used for calculating early-age concrete creep deformations caused by early-age loading of vertical concrete elements in a high-rise building and the preconstruction deformation increases with construction height. However, maximum post construction deformation occurs at the mid-height of the building.

**R. Pranay, I. Yamini Sreevalli, Er. Thota. Suneel Kumar (2014)** presents the study and comparison of the variation in deformation and forces for the transfer girders, for the floating column on girders and for the frames which is above transfer girders. They analysed and designed building using ETABs software. Their study concludes that simulation of sequence of construction in the analysis leads to considerable variation in deformations and design forces obtained by conventional one step analysis. It is, therefore necessary that for multi-storeyed building frames with transfer girders and floating columns system, the construction sequence effect shall be taken into consideration.

**Viji R Kumar and Binol Varghese (2017)** studied the effects of construction sequence analysis along with P-Δ and material non-linearity on floating column structure. Three- dimensional modelling for G+29 story building of concrete is done and the analysis results are taken for the same. For the seismic analysis zone factor for zone II and medium soil type is considered according to IS: 1893 (part1)-2002. Therefore, the analysis result helps them to comprehend the structural responses against load variations for sequential analysis. Finally, they did relative study of displacements for construction sequence model using the finite element analysis software ETABs v16.

### 1) OBJECTIVES

- To analyse high rise building prototypes by considering geometric and material nonlinearity using CEB FIP model code 1990.
- Suggest suitable method for reducing an axial shortening effect in the design stage.
- To analyse performance of actual high-rise building situated at vartak nagar, Thane. (G+30) in which floating columns and transfer girder are provided.

## III. MODELLING OF G+27 BUILDING

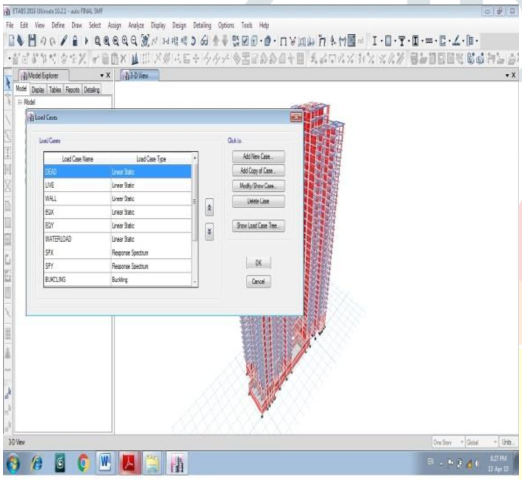


Fig1. load apply on slab

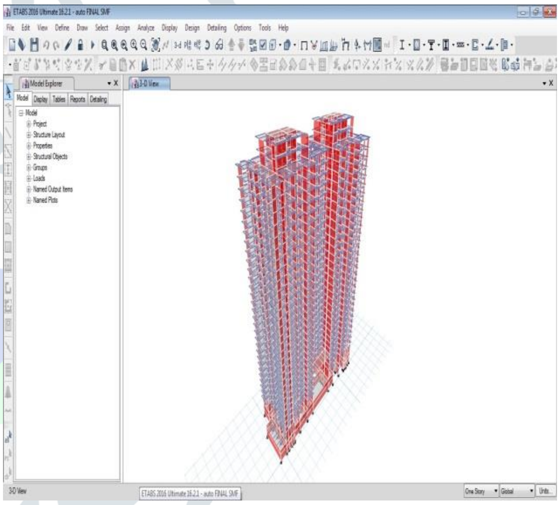


Fig2.Modelling of structure

## Earthqauke load :

EQ.X =seismic load at X direction.
EQ.Y = seismic load at Y direction
Zone factor=0.16
Soil type =2(medium soil)
Importance Factor=1
Response reduction factor=4 for RC frame as per IS 1893-2016

## Load combination:

1)1.5(AutoSeq±LL)
2)1.2(AutoSeq+LL±WX)
3)1.2(AutoSeq+LL)-1.2WX
4)1.2(AutoSeq+LL+WX)
5)1.2(AutoSeq+LL)-1.2WX
6)1.5(AutoSeq+WX)
7) 1.5(AutoSeq)-1.5WX
8) 1.5(AutoSeq+WY)
9) 1.5(AutoSeq)-1.5WY
10) 0.9 (AutoSeq)+1.5 WX
11) 0.9(AutoSeq) -1.5 WX
12) 0.9 (AutoSeq)+1.5 WY
13) 0.9(AutoSeq) -1.5 WY
16)1.5(AutoSeq+SPX)
17) 1.5(AutoSeq+SPY)
18)0.9(AutoSeq)+1.5SPX
19)0.9(AutoSeq)+1.5SPY
20)1.5(DL+LL+Wall+WallLoad)

14)1.2(AutoSeq+LL+SPX)
15)1.2(AutoSeq+LL+SPY)

**Table :1 Modelling parameter for RC frame**

- **Material Properties**
  - Concrete – M20
  - – M25
    - Steel – Fe415
- **Load Definition**
  - Floor Finish - 1.5 kN/m$^2$
  - Live Load - 2.0 kN/m$^2$
  - Wall Load - 11.5 kN/m$^2$
  - Water & LMR - 20.0 kN/m$^2$
  - Stair Case:
    - Dead Load - 3.0 kN/m$^2$
    - Live Load - 4.0 kN/m$^2$

**Height of The Structure**

1. Total - 95.3 m
2. Ground Floor - 2.55 m
3. 1$^{st}$ Floor - 5.4 m
4. Floor 2$^{nd}$ to 30$^{th}$ Level - 2.9 m

**Plan Dimension – 67m x 23m**

- **Section Sizes -**

**1. Beams-**

1. 230mm*500mm
2. 230mm*700mm

**2. Transfer Girder**

1. 2000mm Thick

**3. Slab Thickness**

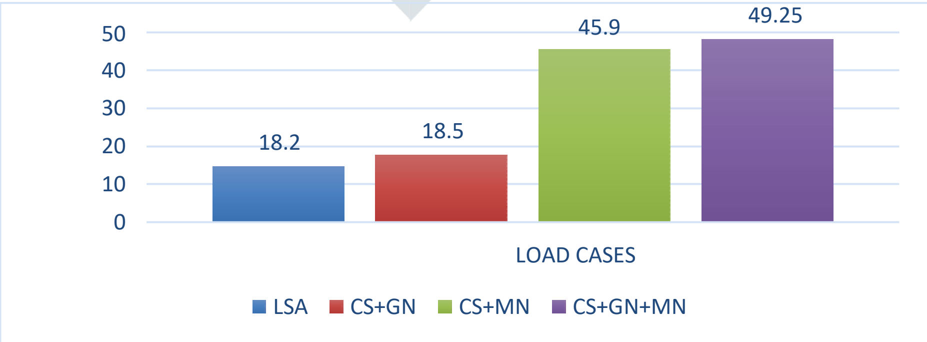
1. 125 mm
2. 150 mm
3. 200 mm
4. 300 mm
5. 400mm

**4. Wall Thickness**

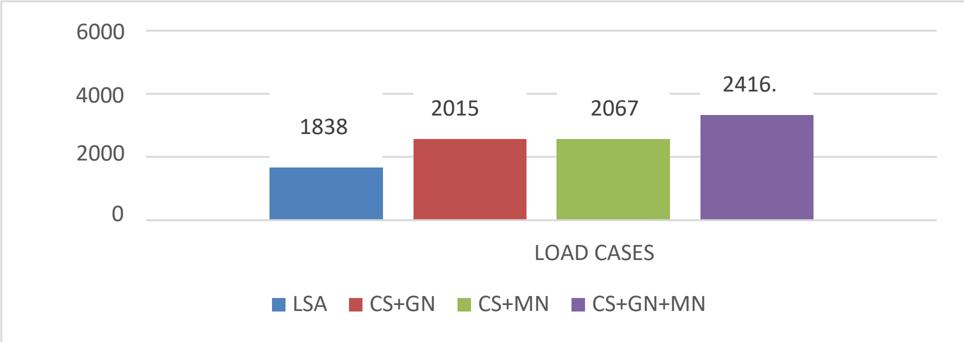
6. 230mm
7. 250mm
8. 300mm
9. 350mm
10. 400mm
11. 450mm
12. 500mm
13. 900mm

## IV. . RESULT AND COMPARISON

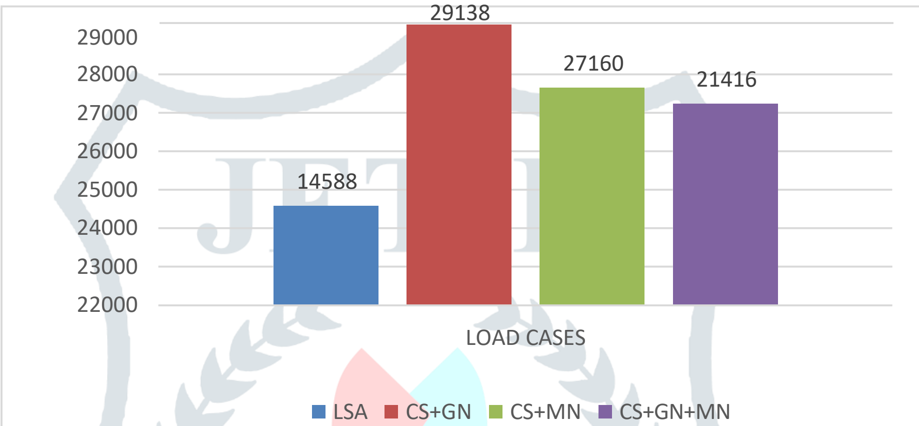
The results and comparison are in terms of parameters such as Maximum Bending moment, Maximum Shear Force, and Maximum Axial force, mid span moment, support moment, middle strip moment, column strip moment as shown in below tables and related graphs for 5m,6m,7m,8m Span.




**Displacement Results Comparison in Transfer Girder**




**Absolute Maximum Shear Force in Transfer Girder**




**Absolute Maximum Bending Moment in Transfer**

## V. STABILITY CHECKS AS PER INDIAN STANDARD CODE

1. Maximum Inter-Story drift – 0.0012 < 0.004
2. Maximum Deflection of the Structure against wind – 45.51mm < H/500
3. Maximum Deflection of the Structure against earthquake – 102.01 < H/250
4. Maximum deflection of beams and slab < span/350
5. Fundamental Time Period of the structure – 3.006 □ 0.1*No. of levels
6. 1$^{st}$ mode of vibration is in translation mode
7. Frequency of the building is less than 1Hz hence wind dynamic analysis is performed.

## VI. CONCLUSION

1) Construction staged analysis with geometric and material nonlinearity as per CEB-FIP Model code 1990 reflecting deformation due to creep and shrinkage of the G+30 story reinforced concrete structures shows the following effects:
2) Maximum deflection in transfer girder due to construction sequence with geometric and material nonlinearity effect is approximately varying 2.5 to 3 times the deflection due to static linear analysis.
3) we have modelled one Building with considering the geometric and material non linearity as per CEB-FIP model code 1990 reflecting deformation due to creep and shrinkage G+30 story RCC structures.
4) We have noted down the vertical deflection on transfer girder and we have found that moment frame structure has experienced the melt vertical deflection. After doing creep analysis for 60 years.
5)shear force and bending moment taken by transfer girder due to construction sequence analysis with geometric non linearity and material on linearity is less than the construction sequence analysis with geometric non linearity only.so while designing CSA (construction sequence analysis) with GN (geometric nonlinearity) should be taken in the combination.
6) It is necessary to do CSA with GN and MN (material nonlinearity) for the key element line transfer beam for proper vertical deflection results.

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