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# EFFECT OF CONSTRUCTION SEQUENCE ANALYSIS ALONG WITH P-DELTA AND MATERIAL NON LINEARITY ON FLOATING COLUMN STRUCTURE

**Viji R Kumar[1], Binol Varghese[2]**

[1] *P.G. Student, Department of Civil Engineering, Cochin Institute of Science & Technology, Muvattupuzha, Ernakulum, India*
[2]*Assistant Professor, Department of Civil Engineering, Cochin Institute of Science & Technology, Muvattupuzha, Ernakulum, India*

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**Abstract -** *High rise multi-storey building structures was analysed in a single step using linear static analysis on the assumption that the structures are subjected to full load once the whole structure is constructed completely. But in actual practice the dead load due to each structural element is applied in various construction stages of each story of the building structure due to the material non-linearity behaviour. The loads considered in linear static analysis change in every construction stages and hence the outcomes will not be suitable and satisfactory for the serviceability criteria. Therefore the building structure should be analysed at every stage of construction taking into account the load variations. Here, in this project the effects of construction sequence analysis along with p delta and material nonlinearity on floating column structure is analysed. Three dimensional modelling for G+29 storey 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 to comprehend the structural responses against load variations for sequential analysis. Also this project emphasis construction sequence analysis importance on the serviceability. Finally, a relative study of displacements was done for construction sequence model using the finite element analysis software "ETABS v. 16".*

***Key Words***: Construction sequence analysis, P-Delta effects, serviceability, floating column structures

## 1. INTRODUCTION

Structural analysis is the determination of the effects of loads on physical structures and their components. The results of the analysis are used to verify a structure's fitness for use. Structural analysis is thus a key part of the engineering design of structures.

In this project work variation of displacement resultant due to CSA (construction sequence analysis) along with P-Delta and material nonlinearity is studied and categorized. Bending moment and shear force in transfer girder is also compared between LSA (Linear Static Analysis) and CSA along with material nonlinearity and P-Delta effects. Building system is analyzed using ETABS v 16 which is one of the prominent analysis software and all the outcomes such as bending moment is counted in KN-m whereas displacement and shear force are measured in mm and KN respectively.

### 1.1 Objective

The objective of this project is to study the behavior of structures with linear static loads, P-Delta effects and CSA. Also to study how time dependent properties of the material affects the structure.

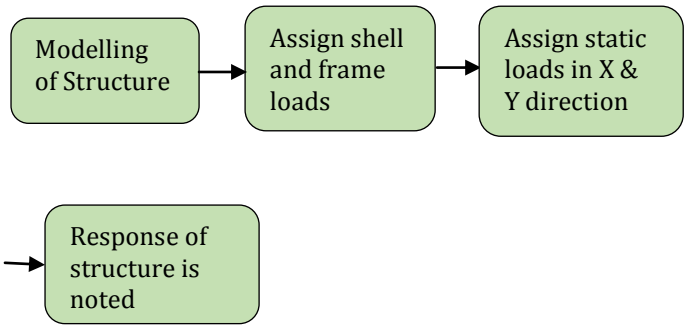
### 1.2 Scope

- Deformation and forces with reference to Pdelta effects, material nonlinearity and construction sequence and how we can include these effects in designing
- Nonlinear analysis helps to avoid overdesign and built better products.

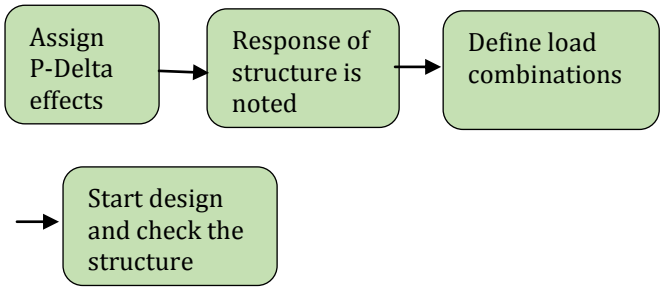
## 2. METHODOLOGY

Study the ETABS v. 16 software and referred to acquire knowledge about nonlinear analysis (geometric nonlinearity and material nonlinearity), pdelta effects, and construction sequence analysis. Then generate mathematical prototype model of a 30 storey building with floating columns and assigned beams, shear wall and slabs. Loads are also assigned. After the modelling, structure have been analyzed with pdelta effects, construction sequence effects and material nonlinearity. Results i.e., displacement, moment,

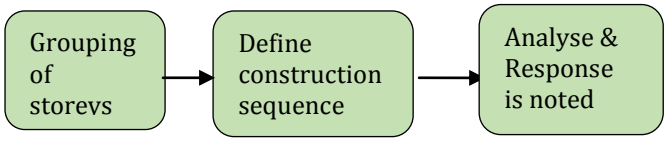
and shear force is noted and compared the results with that of linear static analysis.



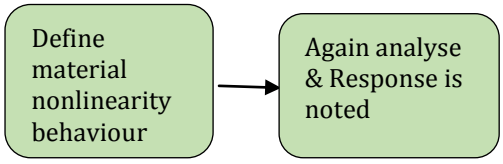

Step 1[1]: Procedure for the LSA of building analysis




Step 2[1]: Procedure for the P-Delta effects




Step 3[1]: Procedure for the CSA of building analysis




Step 4[1]: Procedure for the material nonlinearity

**Fig-1[1]:** Steps for LSA, P-Delta effects, CSA and material non linearity.

## 3. MODELLING IN ETABS

A G + 29 storey prototype mathematical model is modelled in ETABS. These section include building description about the prototype its structure data, properties of materials used, seismic details etc.

In ETABS modelling, first generate mathematical model by assigning slabs, beams, shear walls, columns and supports. Then assign shell loads both dead and live and frame loads. Load cases defined are linear static, nonlinear, nonlinear static staged construction sequence analysis.

**Table -1:** Building Description

| | |
|---|---|
| Number of storeys | 30 |
| Total height of the structure | 90 m |
| Plan dimension | 30m × 30m |
| Height of each storey | 3m |
| Size of beams | 300mm × 750mm, 400mm × 750mm |
| Size of transfer girder | 300mm × 1800mm |
| Size of column | 900mm × 900mm |
| Size of floating column | 230mm × 600mm |
| Thickness of slab | 150mm |
| Grade of concrete | M50 |
| Grade of rebar | HYSD500 |
| Support at base | Fixed |
| Shear wall sizes | 400mm |
| Shell loads | 1.5$KN/m^2$ (dead), 2$KN/m^2$ (live) |
| Seismic zone | II |
| Response reduction factor | 3 |
| Soil type | Medium |

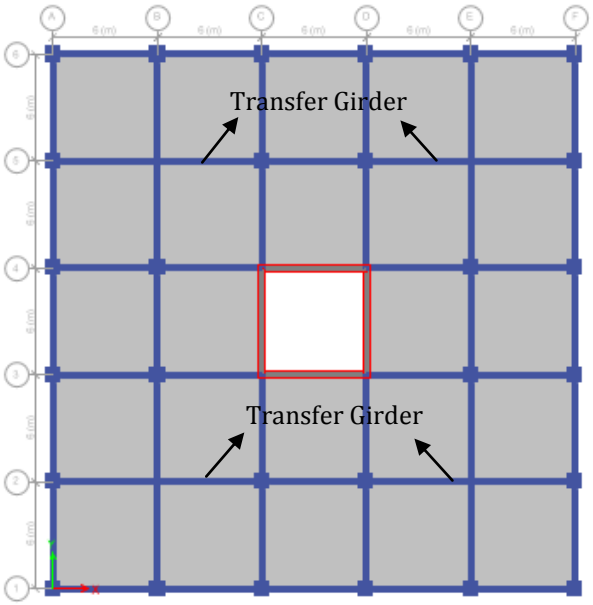



**Fig-2**: Plan view of ground floor showing transfer girder

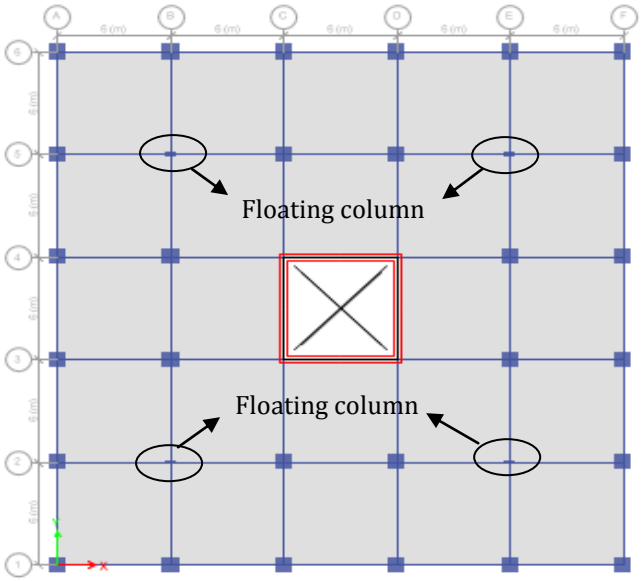



**Fig-3:** Plan view of first floor showing floating column

### 3.1 P-Delta Effects

In this project Iterative Based on Load Cases is applied, in which load is computed from a specified combination of static load cases, then known as the P-Delta load combination. Here the specified load combination is 1.5 × dead. This is an iterative method which considers P-Delta on an element-by-element basis. Local buckling is captured more effectively [8].

### 3.2 Storey Cases for Construction Sequence Analysis

Firstly the storeys are grouped i.e., storey 1 is grouped as group 1, storey 2 as group 2.Similarly grouped all storeys to get 30 groups, then define stage operations. There are 36 stage operations which considers the structure after 1year, 10year, 20 year and 40year. Stage operation include adding of structure, removal of structure, loading of added objects and load if added i.e., live load.

### 3.3 Material Nonlinearity case

Time dependent properties considered for M50 concrete is as follows:

- Time dependence considered for creep, shrinkage, compressive strength and stiffness Creep analysis type is full integration
- Current time dependent type is CEB-FIP90
- CEB-FIP90 parameters are

| | |
|---|---|
| Cement type coefficient | – 0.25 |
| Relative humidity | – 50% |
| Shrinkage coefficient (Bsc) | – 5 |
| Shrinkage start age | – 0days |

## 4. RESULTS

Results of all the different types of analysis such as linear static analysis, nonlinear analysis considering only pdelta, construction sequence analysis without considering material nonlinearity and construction sequence analysis considering material non linearity is obtained and mentioned here.

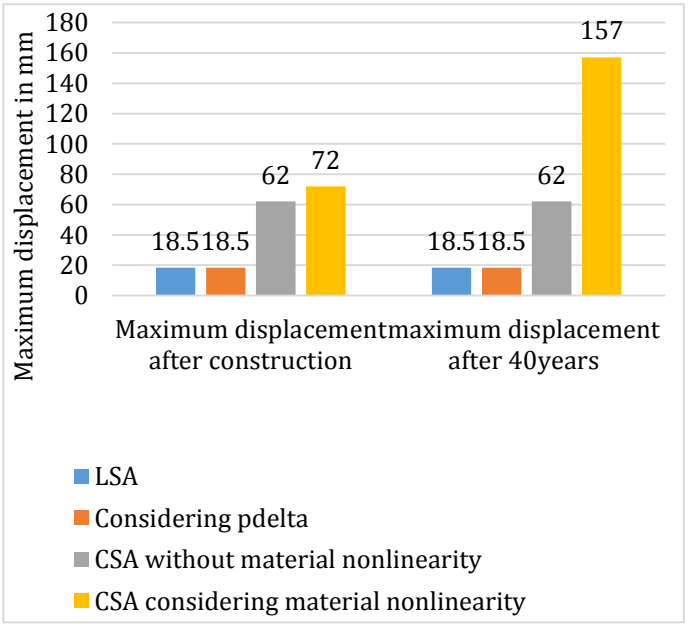



**Chart-1:** Comparison of maximum displacement

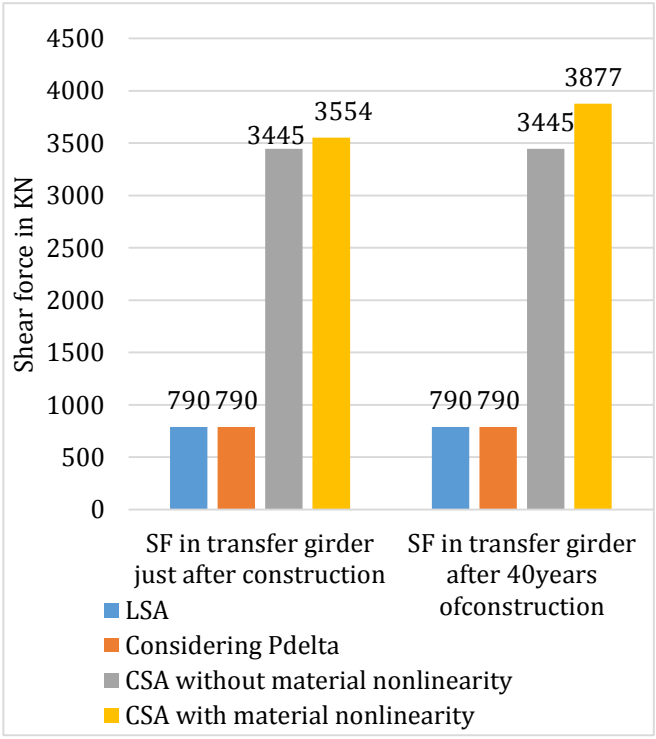



**Chart-2:** Comparison of shear force in transfer girder

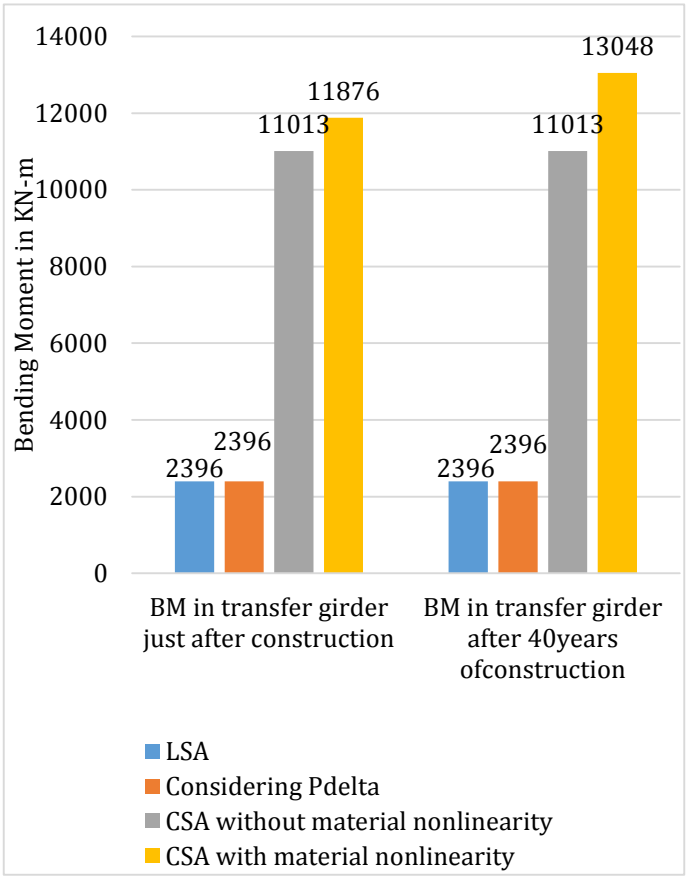



**Chart-3:** Comparison of bending moment in transfer girder

From the obtained results which are shown in the chart above it is clear that the effects of construction sequence analysis are adverse than the linear static analysis in which the responses of the structure are in increasing order. From chart 1, displacement is greater when CSA along with P-Delta and material nonlinearity is considered and increasing as the building gets older. In case of moment and shear force, is also greater in transfer girder for CSA along with P-Delta and material nonlinearity and increasing as the building gets older.

## 5. CONCLUSIONS

The result obtained from the study is concluded in following points.

- Displacement resultant is greater when CSA along with P-Delta effects and material nonlinearity when compared with LSA
- Also displacement is greater for CSA considering material nonlinearity than CSA not considering material nonlinearity. So consideration of material time dependent characteristics is important.
- Moment and shear force results also shows greater for nonlinear analysis.
- Ignoring P-Delta effects in high rise building with floating columns or shear wall design leads to failure at early stages
- From the design results, it is observed that required amount of moment rebar at top axis is more when pdelta effects is considered than pdelta not considered.
- From the observation, it is evident that CSA along with P-delta and material nonlinearity is necessary for multi-storey irregular structures for its long live.

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