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CONSTRUCTION SEQUENCE ANALYSIS IN DESIGN OF HIGH-RISE BUILDING

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Abstract-While analyzing Tall structure in Conventional method the gravity loads is applied after modeling the whole structure. In actual practice the complete frames are constructed at various stages and the stability of frames varies accordingly. The applied load assumed in Conventional method will be unsuitable as per the actual construction practice. The frame should be analyzed at every construction stage considering the effect of variation of loads at each stage. This methodology is known as construction sequential analysis. In this project the realistic structure in seismic zone III as per IS 1893:2002 (Part 1) considered to study the effect of construction sequence. Tall building of three different heights has been considered for comparative study and effect on columns and beams has been studied based on different structural parameters. Based on study the necessity of the construction sequence analysis for tall building has been understood.

Keywords:*Linear Static analysis, Linear Dynamic analysis, Construction Sequence analysis, Tall buildings, ETABS*

I. INTRODUCTION

Generally, engineers, researcher and decision makers have determined the behavior of structures using linear static elastic finite element analysis including summations of vertical column loads. While building height increases in construction phase, the structural responses, i.e. axial loads, bending moments and displacements, of such typical analysis may increasingly diverge from actual behavior. Time-dependent, long-term, deformations in response to construction sequence can cause redistribution of responses that would not be computed and considered by conventional methods. This analysis was complex in nature and so many parameters have to be taken into account during analysis. But now advancement of finite element modeling and simulation has made nonlinear analysis easy, well managed and popular among engineers, researchers and decision makers which accelerate proper design of structures especially high-rise. Construction sequential analysis is becoming an essential part during analysis as many well recognized analysis software included this facility in their analysis and design package. However this nonlinear static analysis is not so popular because of lack of knowledge about its necessity and scope. Like so many other analysis, construction sequential analysis have specific purposes in design phase of the structures. As it is mentioned earlier, it deals with nonlinear behavior under static loads in the form of sequential load increment and its effects on structure considering the structural members are started to react against load prior of completing the whole structure. For finite element analysis one of the leading analysis software "ETABS (Extended 3D analysis of building systems) Version 9.7.4" is used and all displacement outcomes are measured in mm while moment and axial load are measured in KNm and KN respectively.

A.DESCRIPTION OF CONSTRUCTION SEQUENTIAL ANALYSIS.

In short, linear static analysis is performed in one step while construction sequential analysis is performed in a manner, after each story construction like the real condition. A comprehensive sequential analysis involves some essential steps which are not generally performed during linear static analysis. In order to get the sequential effects manually using software, each story should be analyzed with its prior stories assigning the vertical and lateral loads till that floor from bottom of whole structure. Eventually outcomes will represent the structural response of building till that floor. Once each story follows the same procedure the complete sequential effects could be visualized. Now-a-days analysis software are sufficiently developed to auto perform the sequential analysis easily. In this procedure, after assigning vertical and lateral loads each story is grouped to command the software to

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perform the analysis till that particular floor from bottom while avoiding higher story than that floor. After grouping the software eventually ask for which facility should be taken and then the outcomes could be comparing among different conditions.

B. OBJECTIVE

This study represents sequential analysis carried out on a building and computation of structural response. The objective can be summarized as follows:

- Carrying out linear static finite element analysis of a building structure.
- Carrying out sequential non-linear static analysis of the same building structure for the different stories.
- Comparing the structural response for the above two cases

II. LITERATURE REVIEW

MazzaReinforced concrete (R.C.) existing structures with asymmetric plan may require the assessment of the seismic vulnerability directions in terms of displacement and strength. To this end, a computer code for the nonlinear static analysis of spatial framed structures is developed, adopting a path-following analysis based on the arc-length method to obtain the pushover curve for an assigned in-plan direction of the seismic loads. The seismic response of the R.C. frame members is simulated with a simplified lumped plasticity model, which includes a flat surface model of the bounding surface of the axial load–biaxial bending moment elastic domain, at the end sections of girders and columns where inelastic deformations generally occur.

Njomo ,GirayOzay In this paper have studied sequential analysis combined with an optimized substructure technique modelled on 3D-frame construction process. They said that model uses the assumption that any subpart of the entire structure can be constructed at a time. They applied permanent gravity load i.e. dead load, variable gravity loads .i.e. construction load, live load and non-gravity loads or effects are either sequentially or following the conventional method on a realistic 3D-frame building. They investigated their individual contributions on bending moments, key of design.

RosenboomIn the analyses, the construction sequence and expected shrinkage were modelled. A nonlinear static pushover was also performed using the Capacity Spectrum Method. The analyses demonstrated that a state of sustained tensile stress created from the construction sequence offered the best explanation for the unique cracking pattern. They conclude that expanding a non-linear static analysis to include time-dependent material properties, construction sequence, and the effect of creep and shrinkage reveals the importance of these effects on structural behaviour, particularly when complex gravity load paths and restraint conditions create non-intuitive stress fields.

GhabdianIn this paper attempts to calculate column are shortening and differential shortening between columns and walls in concrete frames using a nonlinear staged construction analysis based on the Dirichlet series and direct integration methods. Prototype frame structures are idealized as two-dimensional and the finite element method (FEM) is used to calculate the creep and shrinkage strains. It is verified with respect to published experimental and analytical results. B3 model and methods such as AAEM, EMM, IDM, and RCM are used for verification purposes. For each frame, effects of creep and shrinkage parameters such as relative humidity percent, rate of construction, shrinkage parameter, and concrete strength have been taken into consideration separately.Results show that, for tall concrete buildings, a nonlinear static staged construction analysis can result in more realistic and significantly different results as compared to traditional analyses that ignore this phenomenon.

III. METHODOLOGY

The present study involves conducting sequential analysis of a building of 30 floors. The aim of study is to find out the differences in forces & displacement of an irregular shaped high-rise building using ETABS software as compared to normal static linear analysis.

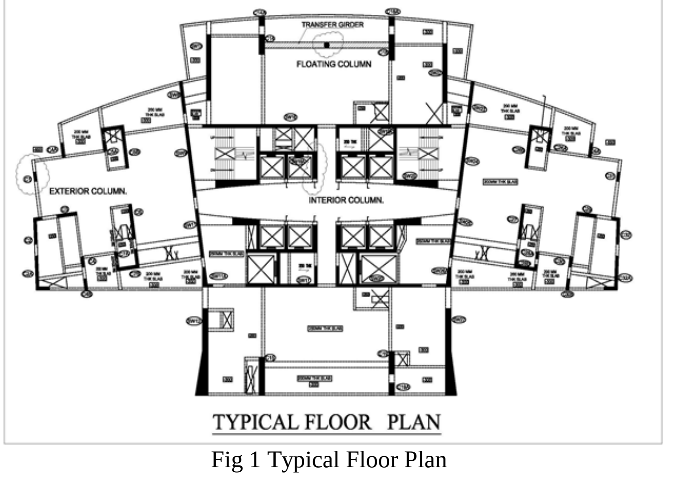

Fig 1 Typical Floor Plan

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A. DESCRIPTION OF STRUCTURE

No of Floors: G+ 30 floors
Typical Floor height: 3000mm.
Total height of the Building: 94.5 mtrs.
Width in X-Direction: 64.8 Mtr
Width in Y-Direction: 38.1 Mtr.
Transfer Girder Level: Present @ first floor level.
Depth of Transfer Girder: 2000mm.
Minimum thickness of Wall: 300 mm.
Maximum thickness of Wall: 1200 mm tapered to 600 mm.
Grade of Concrete: M50.
Grade Of reinforcement: Fe 500.

IV. RESULT AND DISCUSSION

The structure has been studied for parameters axial force, bending moment, shear force and deflection for conventional method and compared with CSI for Envelope combination as shown below.

A. MODELING ETABS

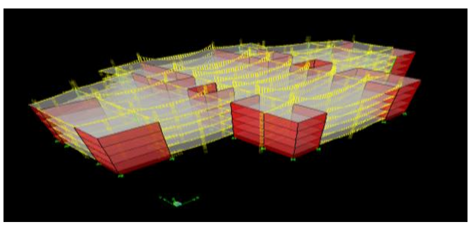


Fig 2 Modeling of Storey 5

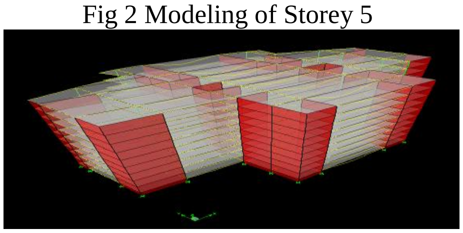


Fig 3 Modeling of Storey 10

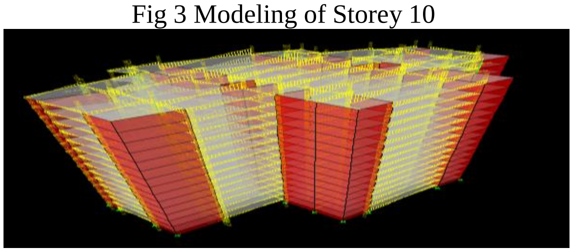


Fig 4 Modeling of Storey 15

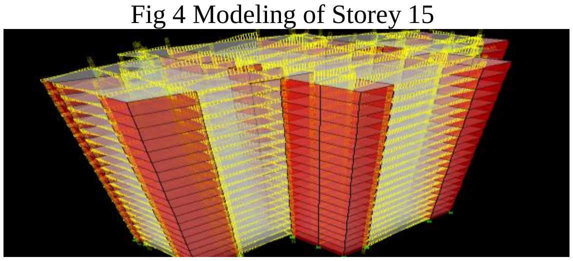


Fig 5 Modeling of Storey 20

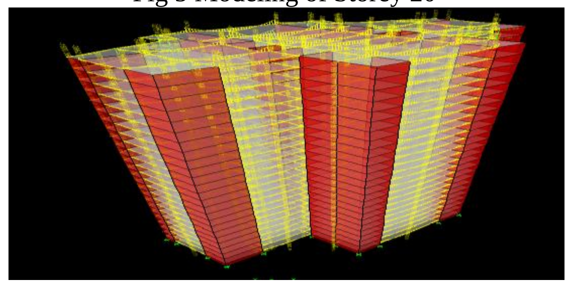


Fig 6 Modeling of Storey 25

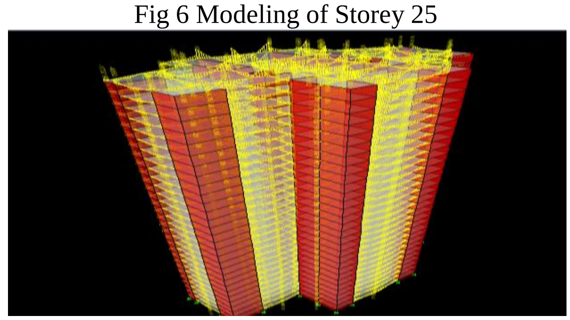
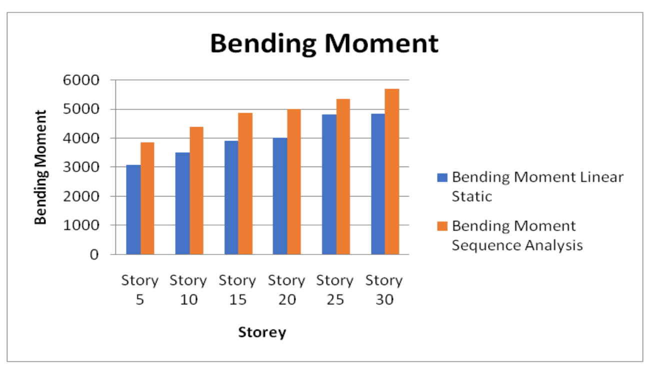


Fig 7 Modeling of Storey 30

B. COMPARISON OF RESULTS

Table 1 Comparison of Bending Moment

BENDING MOMENT		
Story	**Linear Static**	**Sequence Analysis**
Story 5	3086.864	3858.58
Story 10	3529.2	4411.5
Story 15	3910.504	4888.13
Story 20	4016.072	5020.09
Story 25	4816.845	5352.05
Story 30	4846.173	5701.38



Graph 1 Comparison of Bending Moment

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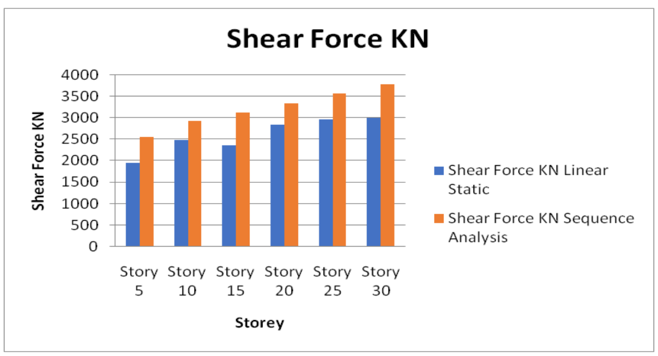
Above graph shows the result of Comparison of Bending Momentof 5 , 10 , 15, 20 ,25 and 30 storey building, its conclude that the Shear Force results of sequence analysis for this all models is greater than liner static analysis around 5-10%

Table 2 Comparison of Shear Force

SHEAR FORCE KN		
Story	**Linear Static**	**Sequence Analysis**
Story 5	1948.9668	2564.43
Story 10	2495.7955	2936.23
Story 15	2373.0544	3122.44
Story 20	2844.0745	3345.97
Story 25	2963.0309	3569.61
Story 30	2996.9756	3793.64

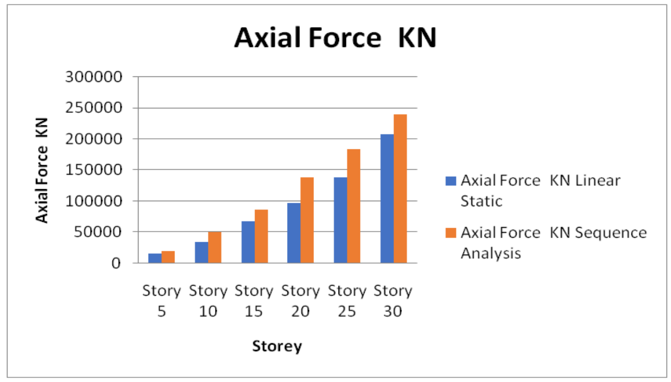


Graph 2 Comparison of Shear Force

Above graph shows the result of Comparison of Shear Forceof 5 , 10 , 15, 20 ,25 and 30 storey building, its conclude that the Shear Force results of sequence analysis for this all models is greater than liner static analysis around 15-20%

Table 3 Comparison of Axial Force

AXIAL FORCE KN		
Story	**Linear Static**	**Sequence Analysis**
Story 5	15638.0406	20048.77
Story 10	35002.996	50004.28
Story 15	67763.2722	86875.99
Story 20	97139	138770
Story 25	138030.9375	184041.25
Story 30	208299.2367	239424.41



Graph 3 Comparison of Axial Force

Above graph shows the result of Comparison of Axial Force of 5 , 10 , 15, 20 ,25 and 30 storey building, its conclude that the Axial Force results of sequence analysis for this all models is greater than liner static analysis around 20-30%

CONCLUSION

- The study reveals the necessity of performing nonlinear static analysis becomes important with increasing slenderness while the each additional floor creates a significant load upon the columns. With increasing slenderness the necessity to perform sequential analysis nonlinear of behaviour of the structures become a significant issue.
- Moments and shear in supporting beam are higher in sequential analysis which must be considered during manual or computer aided design in the design phase for avoiding cracking of beam and column due to sequence effects.
- Axial load may found lower after consideration of sequential effects but it should not be considered as to reach final stage each preliminary stage must be fulfilled and structures have to be designed strongly for each and every stage not the final one only.
- In the case of displacement sequence considered structure have much worst side condition than the linear static considered structures and it pushes toward the sequence considered.

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