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THE EFFECTS OF P-DELTA AND CONSTRUCTION SEQUENTIAL ANALYSIS OF RCC AND STEEL BUILDING WITH RESPECT TO LINEAR STATIC ANALYSIS

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Abstract - ***During analysis of a building structure, normally after complete modeling full loads are applied on entire building frame and linear static analysis is done. 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 transitory situation and hence the outcomes will not be suitable and satisfactory. Therefore the building structure should be analyzed at every stage of construction taking into account the load variations. Finite element modeling enhances the precision of finite element prototype which takes into account the effects of construction sequence. Here, in this study the effects of linear static analysis, time dependent and construction sequential analysis for two construction materials RCC and steel are compared. Three dimensional modeling for 30 storey building of concrete and steel is done and the analysis results are taken for the same. Both RCC and steel structures have rigid frames. For the seismic analysis zone factor for zone IV and hard soil type is considered according to IS: 1893 (part1)-2002. Therefore the analysis result helps to comprehend the structural responses against load variations for linear static analysis, time dependent and sequential analysis. Finally, a relative study of shear forces, bending moments and displacements was done at every story for conventional model and construction sequence model for two construction materials RCC and steel respectively using the finite element analysis software "ETABS version 13".***

Key Words: *Linear static analysis, Construction sequential analysis, P-Delta, and ETABS etc…*

1. INTRODUCTION

Usually the performance of building structures have defined by researchers and engineers from commonly used linear static finite element analysis considering the sum of loads of all columns. At the stage of construction as the building height increases the responses of the structural system such as bending moments, shear force and displacements of such predictable analysis may increasingly differ from real circumstances. Previously sequential analysis was complicated in nature and many constraints have to be counted at the time of analysis. Then nonlinear analysis is made easy and standard due to the advancement of finite element modeling among researchers and engineers that speed up the suitable structural design especially for high-rise. Sequential analysis is developed into prominent part during analysis several well-known analysis software comprises this provision in their analysis and design tool. This however is not so widespread ever since there is lack of information about its need and choice. Similarly as other analysis, construction sequential analysis ensure explicit objectives in design parts of the structures.

This research categorize how the variation of structural outcomes i.e. moments, shear forces and displacements due to sequential analysis including p-delta effect the outcomes of single stage analysis called linear static analysis for reinforced concrete and steel which are the two main construction materials. Building system is analyzed using ETABS v13 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 Importance of the study

In the modern era the demands of high-rise are greater than earlier due to the provision that the number of satisfactory people can be accommodated in that but the inappropriate design may lead to catastrophic demolition or destruction of the structure which is obvious from the earlier few decades. Therefore the structures are susceptible to cause by a number of structural parameters

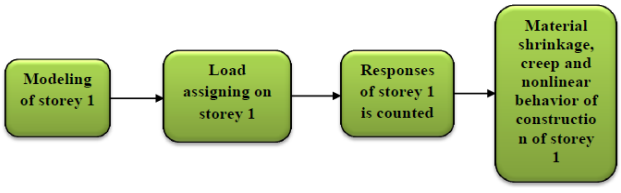
for its framed system and its own weight. The multistorey buildings are analyzed using the general one step linear static analysis assuming the full loads to be applied on the structure. But there may be lot of differences in the outcomes obtained from this analysis against the practical aspect i.e. the results may lead to an incorrect design due to which further there may be very terrible damage to the structure. Therefore to understand and overcome briefly about this problem a non-linear static construction sequential analysis including P-Delta effects is performed for the structure in which the loads are imposed on every phase of construction i.e. storey by storey loading is done on the structure and the results are also obtained for each storey parameters.

1.2 Objective

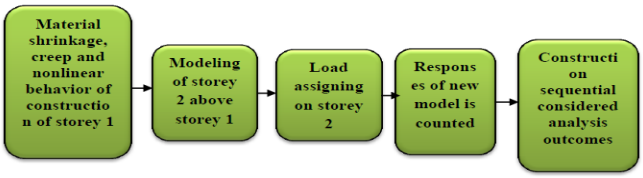
The objective of this study is to recognize in what way the time-dependent and construction sequence analysis including P-Delta effects influence the variation of responses of structure such as bending moments, displacements and shear forces against linear static analysis for two main construction materials of the structures i.e., reinforced concrete and steel.

2. METHODOLOGY

In sequential analysis there is involvement of several important steps which usually are not included during the general linear static analysis. To obtain the effects of construction sequential analysis of each storey is done with the preceding storeys in such a way that the assignment of lateral loads and vertical loads is done from the base of the entire structure till that particular floor. Ultimately the results will signify the response of the building structure up to that floor. As the similar procedure is followed by every storey of the building the thorough sequential effects can be pictured. The procedure followed here is such that once the assignment of lateral loads and vertical loads is done every individual storey is grouped and the software is allowed to accomplish the analysis up to that particular floor from the bottom of the structure neglecting the storeys above that floor. After final grouping of the storeys the software ultimately requests for next provision such that the comparison of the possible outcomes for various conditions could be done. An illustrative two storied structure as a sample is considered in Fig-1 which is restricted up to step 2 for easy understanding of the sequential analysis.



Step 1[1]: Procedure for the building analysis for storey 1



Step 2[1]: Procedure for the building analysis for storey 2

Fig-1[1]: Steps included in Construction sequential analysis of a usual two storey building

3. BUILDING DESCRIPTION

Table-1: Building Description

Particulars	RCC Structure	Steel Structure
Plan dimension	20mx20m	20mx20m
Total height of the building	90m	90m
Height of each storey	3m	3m
Size of beam	300X450	ISMB300
Size of column	300X800	ISHB450
Size of transverse girder	300X600	ISMB450
Thickness of slab	150mm	150mm
Seismic zone	V	V
Soil type	Hard	Hard
Response reduction factor (R)	5.0	5.0
Importance factor (I)	1.0	1.0
Seismic zone factor (Z)	0.36	0.36
Grade of concrete	M30	M30
Grade of reinforcing steel	Fe415	Fe415
Grade of structural steel	-	Fe250
Density of concrete	25KN/m^2	25KN/m^2
Supports at base	Fixed	Fixed
Diaphragm	Rigid	Rigid

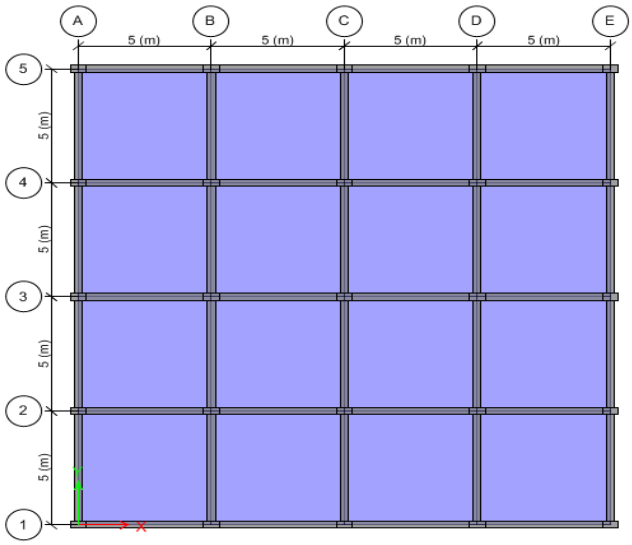


Fig-2: Typical plan of building

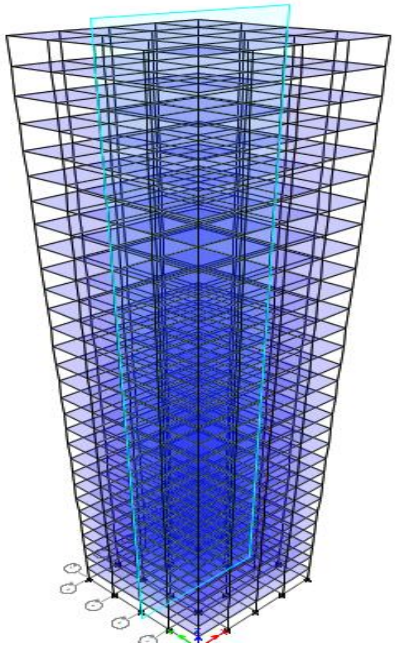


Fig-3: 3-Dimensional view of the building

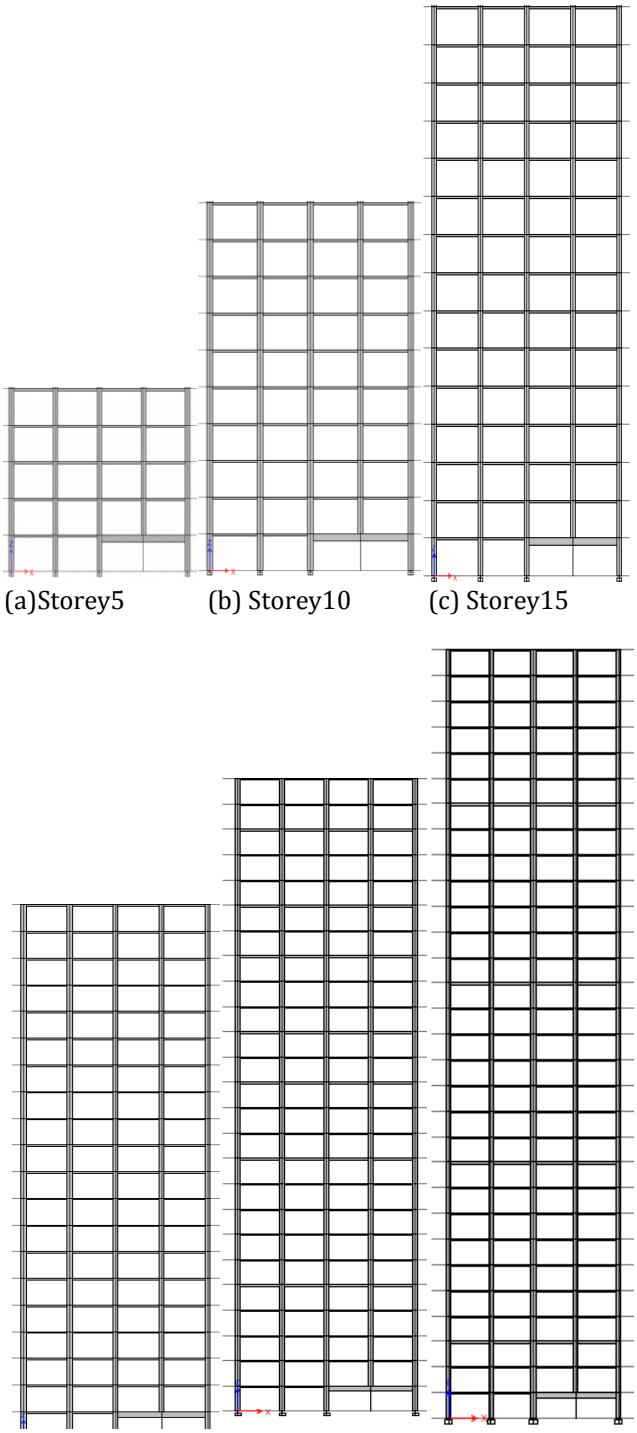
4. FINITE ELEMENT MODELING AND ANALYSIS

Finite element models are developed to notice the variation of responses due to the effects obtained from static nonlinear analysis against linear static analysis using ETABS v13. For the cases of two construction material and two different procedures of analysis all the sections and the imposed loads are selected and designed cautiously to meet the objective of the study. For 12 finite element models of three dimensional analysis all the parameters such as the stiffness variation of concrete with time, settlement of the foundation, loading in the form of sequences and effects of creep and shrinkage which are time dependent are accounted in which 6 models are characterized into sequential analysis and other 6 characterized into the linear static analysis that represents the distinct time during the construction of structure. Storey cases considered for RCC and steel building analysis are shown in Table-2. The responses of the structure which takes place for every step of time are justified and recorded such as to further study these expected structural responses due to time-dependent effects.

Table-2: Storey cases for construction sequence analysis and linear static analysis

Material	Type of analysis	Number of storeys					
		5	10	15	20	25	30
		Storey cases					
RCC	CSA	1	2	3	4	5	6
	LSA	7	8	9	10	11	12
Steel	CSA	13	14	15	16	17	18
	LSA	19	20	21	22	23	24

Storey cases taken to obtain the effects of construction sequence in the structures having rigid joints are 5 and the variations of storeys is from 5th storey to 30th storey, and boundary limits are obtained for the system of rigid joint frame. The storey cases taken here are 5, 10, 15, 20, 25 and 30 as shown in Fig-4.



(a)Storey5 (b) Storey10 (c) Storey15

(d) Storey20 (e) Storey25 (f) Storey30

Fig-4: Storey cases (a) storey5 (b) storey10 (c) storey15 (d) storey20 (e) storey 25(f) storey30

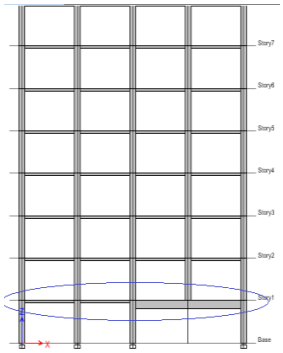


Fig-5: Elevation of D phase of the structure highlights floating column at support D

5. RESULTS

Results of all the different types of analysis such as linear static analysis and construction sequence analysis for RCC and Steel structures are obtained and mentioned here.

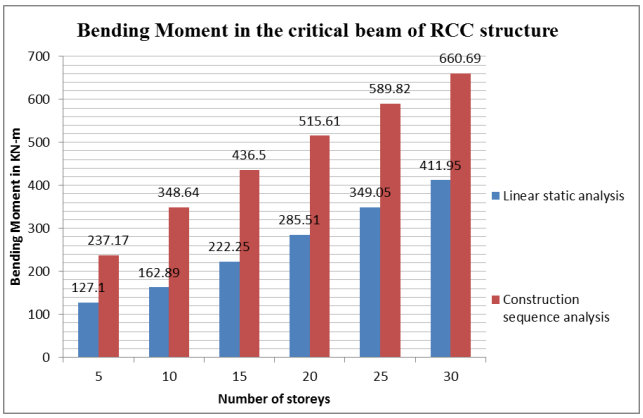


Chart-1: Bending Moment in the critical beam of RCC structure due to linear static and construction sequence analysis

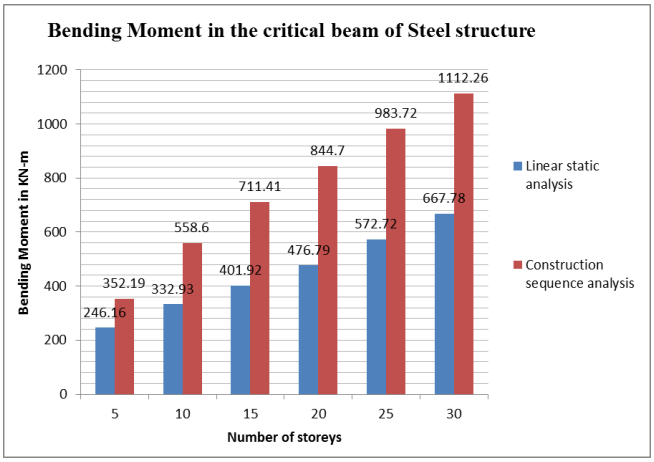


Chart-2: Bending Moment in the critical beam of Steel structure due to linear static and construction sequence analysis

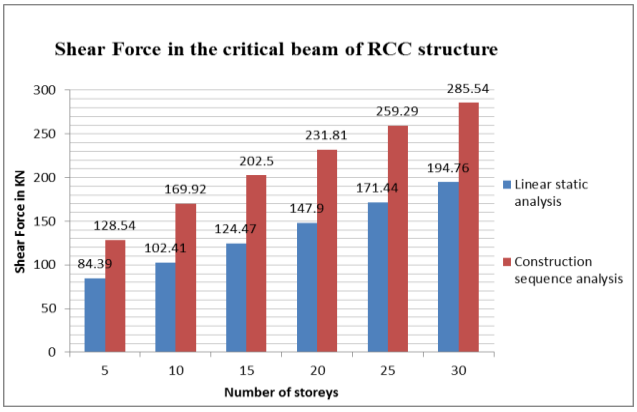


Chart-3: Shear Force in the critical beam of RCC structure due to linear static and construction sequence analysis

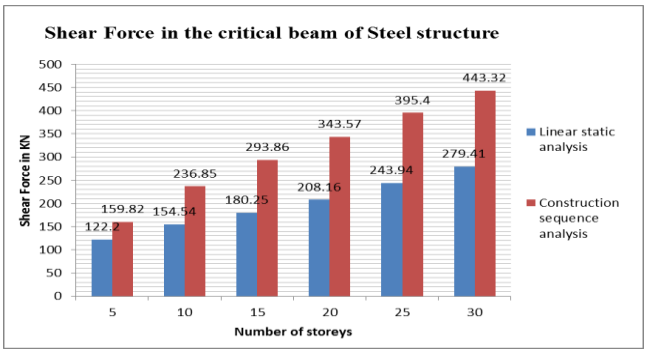


Chart-4: Shear Force in the critical beam of RCC structure due to linear static and construction sequence analysis

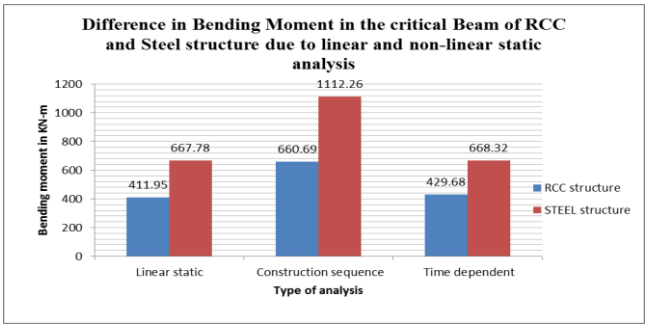


Chart-5: Difference in Bending Moment in the critical beam of RCC and Steel structure due to linear and non-linear static analysis

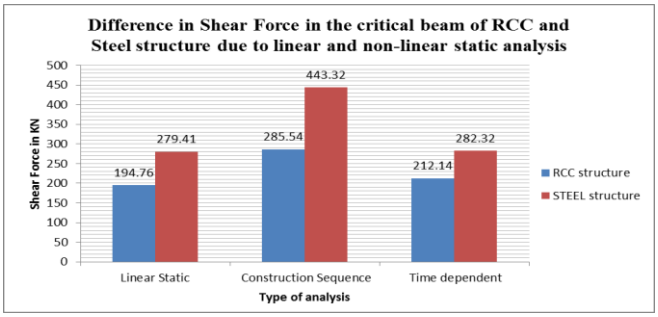


Chart-6: Difference in Shear Force in the critical beam of RCC and Steel structure due to linear and non-linear static analysis

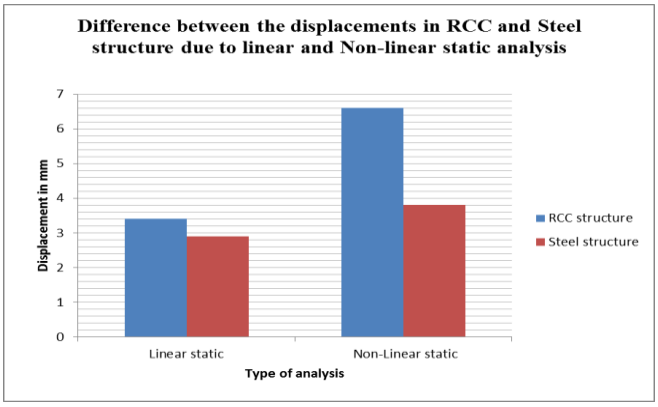


Chart-7: Difference between the maximum displacements in RCC and Steel structure due to linear and non-linear static analysis

From the obtained results which are shown in the charts 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 such as shear forces and moments for steel structure when compared to RCC structure.

6. CONCLUSIONS

The results obtained from the different analysis for different materials are concluded in the following points:
It is observed from the analysis that the results obtained for the moment due to sequential analysis with P-Delta are most significant than that obtained due to linear static analysis since during construction phase itself the sequential effect counts the load.

- Moment and shear force results observed are greater in the supporting beam due to construction sequence analysis.
- Regarding displacement results, structure considered sequential effects shows the worst part than that of structure which have not considered these effects i.e. Linear static analysis which makes it significant to consider the effects of sequence and time-dependent.
- Therefore, the outcomes obtained from the analysis shows that much moment and shear force is taken by the steel structure than the RCC structure which proves that steel structure resists maximum moment and shear force but with lesser displacements than that of RCC.
- The results taken from the analysis turns to be worst part for constructional sequence analysis than linear static analysis, therefore for the construction of high-rise involving many floor constructions along with time consuming sequential effects consideration is must.
- Hence preference is drawn first for the steel structure than the RCC structures for construction sequence analysis for the loading effects of long term.

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