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Comparative study of Chronological Construction Sequence Analysis and Conventional analysis

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Abstract: *While analyzing a Structural frame, conventionally all the probable loads are applied after modeling the entire building frame. In reality the dead load due to the each structural components and finishing items are imposed in separate stages as the structures are constructed story by story. Accordingly, the stability of structural frame differs at every stage of construction. Even during construction freshly constructed slab with material is supported by previously cast floor by its falsework. Thus, the loads assumed in conventional analysis will vary in different situation. Definately the results obtained by the conventional analysis will be unsuitable. Therefore, the frame should be analyzed at every stage of construction taking into account variation in loads. Thus the phenomenon known as Chronological construction sequence Analysis helps to rectify this problem. This paper analyzes several numbers of multi-storey RC building frames having different bay width and length, storey height and number of stories using STAADpro, followed by the Chronological construction sequence Analysis of each model. Also all frames models are analyzed for earthquake forces in Zone - II (IS 1893:2002) by Chronological construction sequence Analysis. Finally, a comparative study of Axial forces, Bending moments, Shear forces and Twisting moments will be done at every storey for full frame model (With & without earthquake forces) and Chronological construction sequence model (with & without earthquake forces) were compared for knowing the significance of any one of them.*
Keywords: *Chronological construction sequence Analysis, Conventional/ Conventional analysis, Construction loads, Sequential gravity loads*

I. Introduction

Structural failure frequently occurs during the process of construction. Structure is most liable to failure during construction. Structural failures involving components or partially completed structures often occur during the process of construction. A failure during construction may not the only reason of construction error. It may be the result of an error made during design. Structural Engineers must take efforts to reduce the potential for structural failure during the construction phase to reduce the risk of injury, costs and delays.

Most of the structural failures are occurred due to lack of stability. The designer considers the structure as a completed assembly, with all elements are ready to resist the loads. Stability of the completed structure depends on the presence of all structural members, including floors. The configuration of incomplete structure is constantly changing during the process of construction and stability often relies on temporary bracing. Construction sequencing is extremely important for determining the stability of incomplete under constructed structures. Another cause of structural failures during construction is excessive construction loading which are not considered in conventional method of design and hence the loads applied to structural members while construction, are in excess of service loads anticipated by the designer. This is due to fresh floors are supported by previously cast floors by the false work system. This is the big challenge for engineers to do Analysis of the stability requirements for these incomplete, irregular, and constantly changing assemblies. To ensure stability at all times, account shall be taken of probable variations in loads during step by step construction, repair or other temporary measures. The 'Chronological Construction Sequence Analysis' that reflects the fact of the sequential application of construction loads during level-by-level construction of multistorey buildings can provide more reliable results and hence the method should be adopted in usual practice.

II. Objectives

the main objective of this work is to reduce the potential for structural failure during the construction phase ultimately reducing the risk of injury, and of unforeseen costs and delays in construction projects. as per is 456:2000, clause 20.3, 'to ensure stability at all time, account shall be taken of probable variation in dead load during construction, repair or other temporary measures'. through this project it is expected from practicing engineers to give attention towards the above mentioned clause. for satisfying the above mentioned objectives, here we will observe the behavior of structure during construction at different stages and comparing the results of these stages with full model of the structure for different number of stories, their height and different bay width.

III. System Development

In this project we have analyzes several models of G+5 and G+7 RC buildings frames with 4 bays along length and width using STAADpro. Various stiffness governing factors such as bay width or length, storey height, sizes of supports etc. are decided as basic parameters. Three frames each of five storied and seven storied Reinforced concrete buildings of bay width/length 4m, 5m and 6m and storey height 3m was modeled and analyzed with conventional as well as Chronological Construction Sequence Method. Then three frames of five storied RC building of storey height 4m and bay width/length 4m, 5m, and 6m was also analyzed by both the methods. These nine models were used for the comparison of responses of various forces in terms of axial forces, bending moments, shear forces and twisting moments and also compared with the Earthquake forces for Zone - II (IS 1893:2002)

Figure 1 shows the typical floor plan of the models.

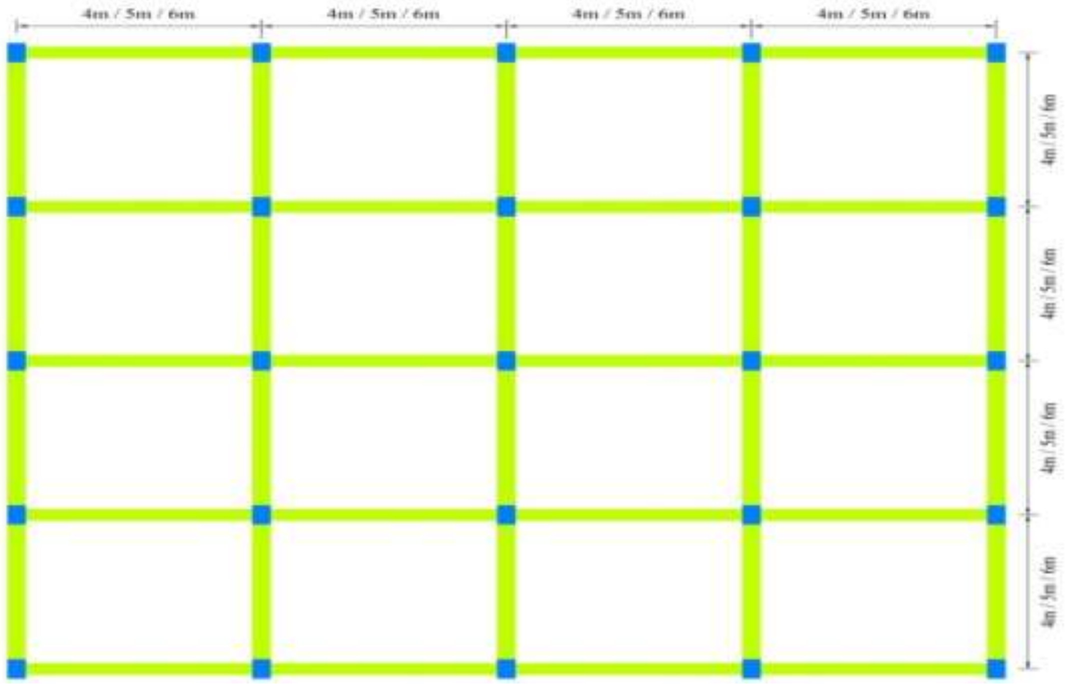

Fig.1: Plan of a Reinforce Concrete Building

III.1. Bay,Column,Beam Sizes & slab thickness for Modelling of Building Frame and Description

Table 1: Structural Component Sizes

Bay Width/Length	4 m	5 m	6 m
Column Size (m x m)	0.23 x 0.60	0.30 x 0.60	0.30 x 0.75
Beam Size (m x m)	0.23 x 0.45	0.30 x 0.60	0.30 x 0.60
Slab thickness (mm)	150	150	200

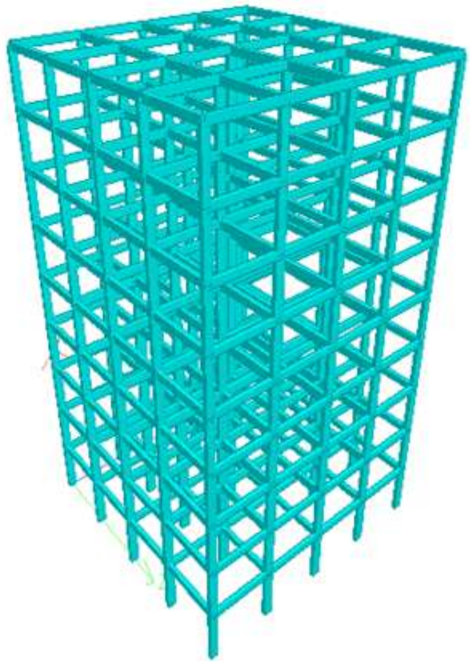

Fig.2: 3D View of Conventional analysis frame model

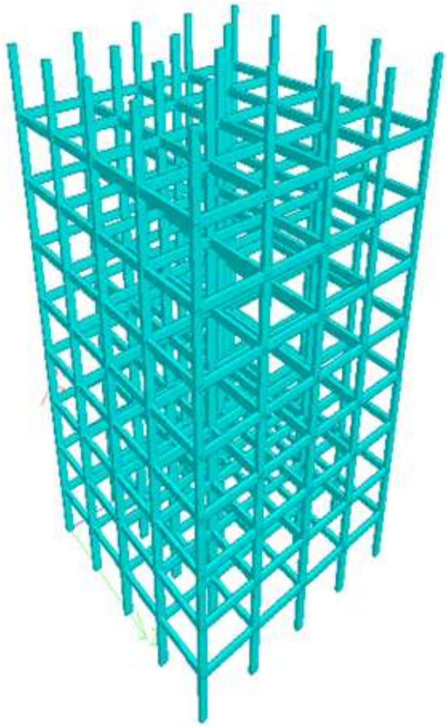

Fig.3: 3D View of Construction sequence frame model

3.2 LOADINGS

For analyzing structure different loadings and their combinations are taken as follows

A) Without Earthquake Forces:
a) Load Cases:
1)Dead Loads:
i)Selfweight of columns and beams;
ii)Selfweight of wet concrete slab (weight density =25 KN/m3
iii)Floor finish load (assumed 1 KN/m2).
2)Imposed Loads:
i)Occupancy live load on C floor slab [2.5 KN/m2 (refer IS 875 : 1987)].
b) Load Combinations:
1) 1.5 times dead loads and imposed loads [i.e. 1.5(DL+LL)].
B) With Earthquake Forces:
a) Seismic Definitions:
1) Zone: 0.1 (Zone II)
2) Response reduction Factor (RF): 5
3) Importance factor (I): 1
4) Rock and soil site factor (SS): 1
5) Type of structure: 1 (RC Frame Building)
6) Damping ratio (DM): 5
b) Load Cases:
1) Earthquake forces in X-Direction (EQx)
2) Earthquake forces in Z-Direction (EQz)
3) Dead Loads (DL):
i) Selfweight of columns and beams;
ii) Selfweight of wet concrete slab (weight density = 25 KN/m3);
iii) Floor finish load (assumed 1 KN/m2).
4) Reducible Imposed Loads (LL/rLL):
i) Occupancy live load [2.5 KN/m2 (refer IS 875 : 1987)].
c) Load Combinations (refer IS 1893 : 2002):
1) 1.5(DL+LL);
2) 1.2(DL+rLL+EQx);
3) 1.2(DL+rLL-EQx);

4) 1.2(DL+rLL+EQz);
5) 1.2(DL+rLL-EQz);
6) 1.5(DL+EQx);
7) 1.5(DL-EQx);
8) 1.5(DL+EQz);
9) 1.5(DL-EQz);
10) 0.9DL+1.5EQx;
11) 15 0.9DL-1.5EQx;
12) 0.9DL+1.5EQz;
13) 0.9DL-1.5EQz.

IV. Chronological Construction Sequence Analysis

Consider a typical floor (say C) of a frame shown in figure 4. Assuming the building is constructed one floor at a time, the C floor is constructed on the top of the frame that was completed so far [i.e., up to (C - 1) floor]. The slab of (C-1) floor supports the self-weight of freshly poured C floor slab by the formwork in addition to its own self-weight. Also the construction live load on C floor equal to the inspection live load on (C-1) floor will be transferred to the slab of (C-1) floor. Figure 4 clearly illustrates how the loads transfers on the frame in construction sequence analysis.

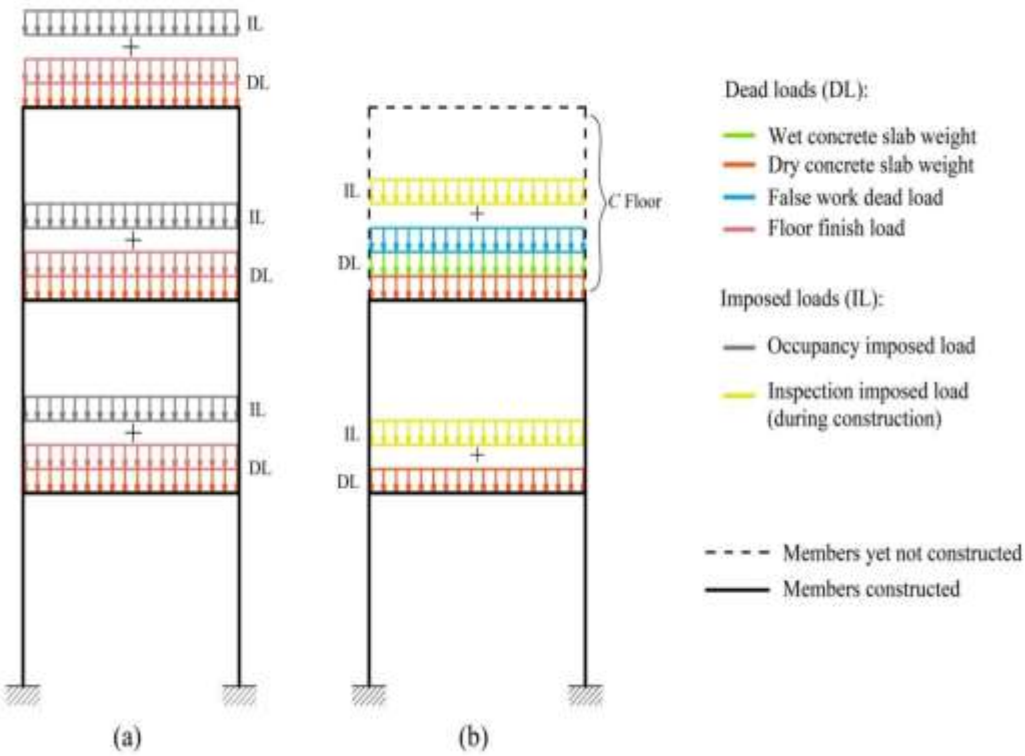

Fig.4: a) Conventional analysis b) Chronological construction sequence analysis

The manual analysis procedure is summarized for a sample structure of two story only in Figure 5 which is limited into 2 step by its nature. Step of analysis can be increase as per the number of stories.

Fig.5: Steps involving in chronological Construction Sequence Analysis of a typical two story building

V. Comparison Of Outcomes

Several numbers of reinforced concrete building frames of Different sizes were analyzed using STAAD pro. The results obtained were Compared with Chronological construction sequence model. Then all full frame models were analyzed for earthquake forces in Zone–II in accordance with IS 1893:2002. The results of construction sequence model were compared with conventional analysis considering earthquake forces. Here comparison graph of first storey of G+7 building frame are shown:

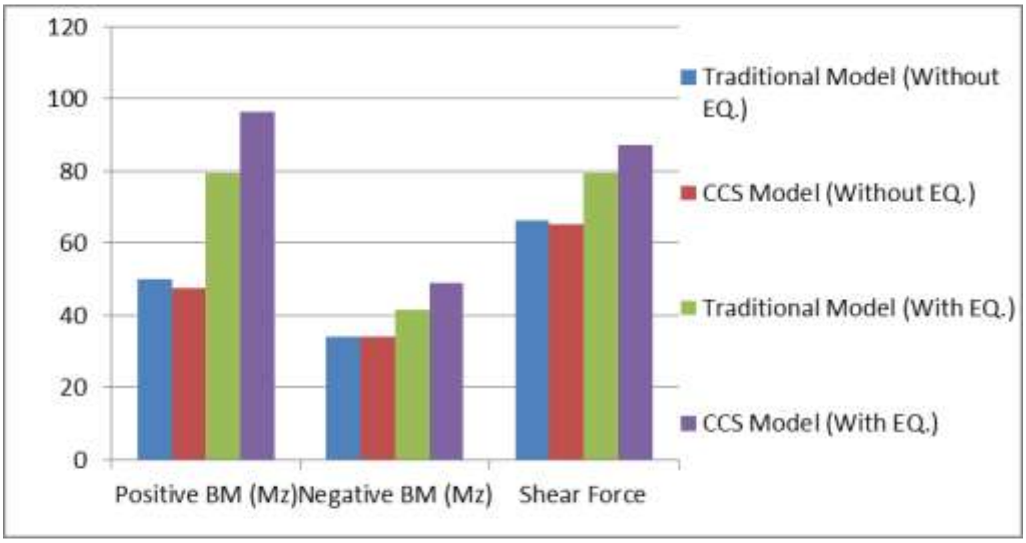

Fig.6: Responses in Interior Beams at 1st Storey of G+7 (3m Storey height) RC Building

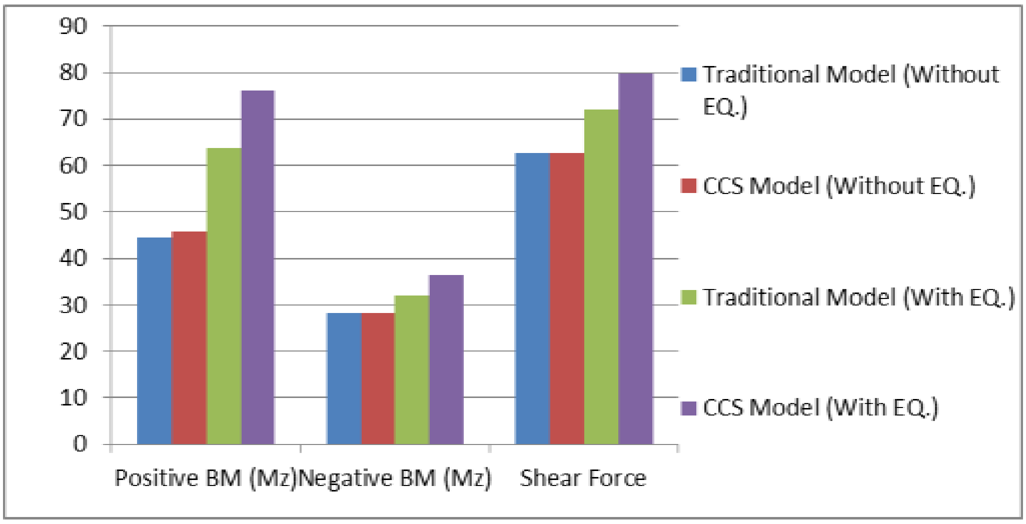

Fig.7: Responses in Exterior Beams at 1st Storey of G+7 (3m Storey height) RC Building

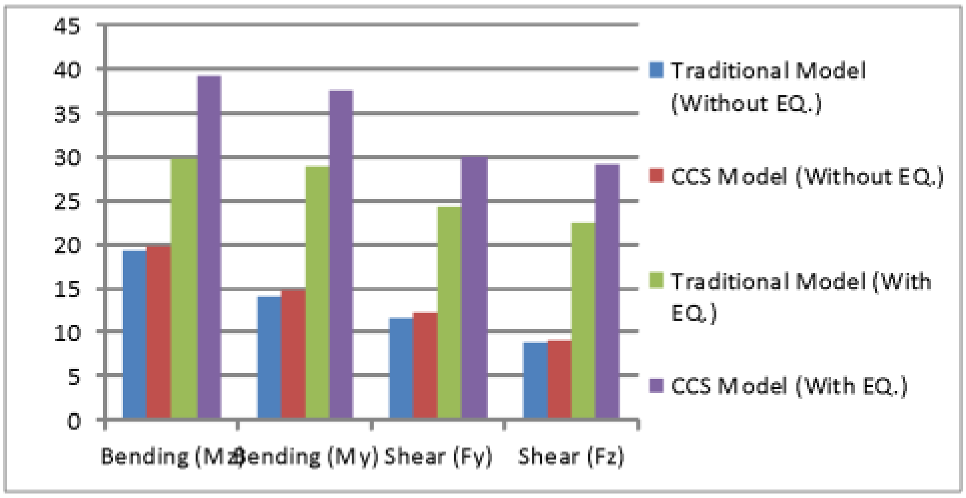

Fig.8: Responses in Corner Column at 1st Storey of G+7 (3m Storey height) RC Building

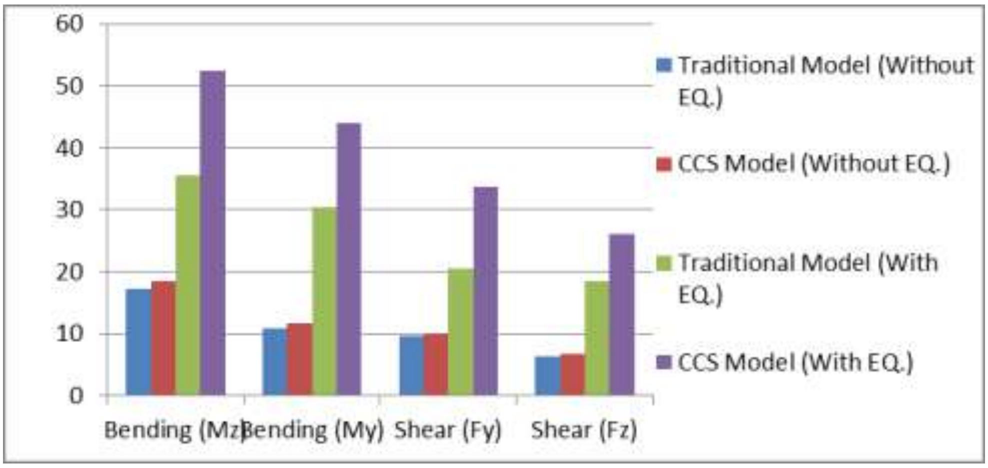

Fig.9: Responses in Exterior Column at 1st Storey of G+7 (3m Storey height) RC Building

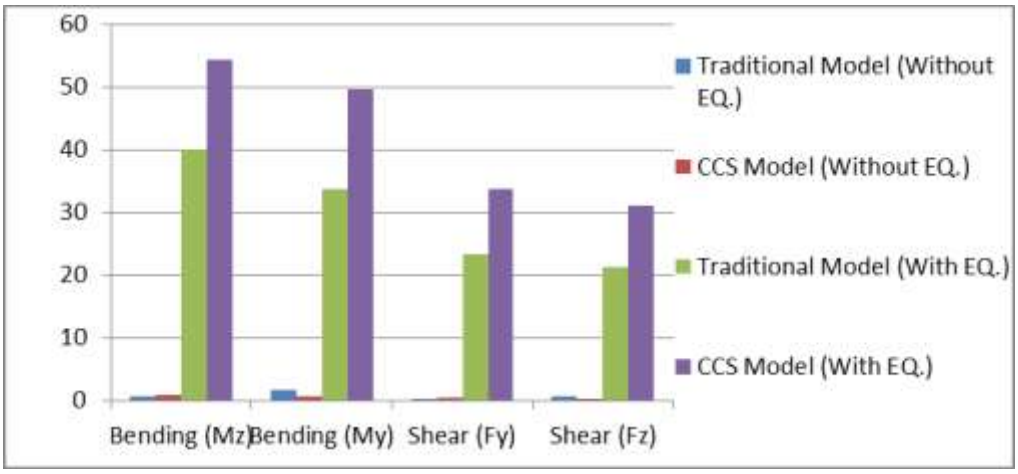

Fig.10: Responses in Interior Column at 1st Storey of G+7 (3m Storey height) RC Building

The comparison graph at each storey for different bay width and storey are found to be almost same.

VI. Discussion

Beams

1) Edge beams are found to be critical for all the responses except twisting moment and span moment if analyzed conventionally considering earthquake forces.

2) Whereas, interior beams are always critical during construction. Therefore, chronological construction sequence analysis is most suitable.

Columns
1) Corner columns are found to be critical during earthquake and not during construction.
2) Whereas edge columns are critical if analyzed by chronological construction sequence analysis.
3) For interior columns all the responses are governed by earthquake forces.
There is no effect of number of stories or storey height on the responses of the external forces.

VII. Conclusion

The study reveals the necessity of performing Chronological Construction sequence analysis is necessary to improve the analysis accuracy in terms of displacement, axial, moment and shear force in supporting beam and column near of it and also for the whole the structure overall. ,No significant advantage in case of column design is considered but there is a scope to check the columns considering the primary rotations at every stage. While design moments are taken into consideration the Interior beams are always critical in chronological construction sequence. Chronological construction sequence analysis is proved critical with & without considering earthquake forces.

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