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Construction Stage Analysis of Flat Slab Structure with respect to Non Linear Time History Analysis using Software Aid

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Abstract: While evaluating a multi-Story building frame, usually all the possible loads are imposed after modeling the entire building frame. But in actual case, the frame is constructed in several stages. Accordingly, the stability of the frame fluctuates at every construction stage. Even during construction, freshly placed concrete floor is held by previously casted floor by formwork system. Thus, all the loads assumed in traditional analysis will fluctuates in transient condition. Obviously, results derived by the traditional analysis will be incompatible. Therefore, the frame should be analyzed at every construction level taking into account variation in loads. The phenomenon known as Construction Stage Analysis reflects these uncertainties accurately. In this study the Flat slab frame for G+10 were modelled, analyzed for nonlinear analysis under seismic zone IV and Soil type II considering construction stage followed by Time History Analysis and Construction Sequence Analysis. Construction Stage Analysis shown more criticality of the structural component during construction stage due to additional loads. Hence, it is worthwhile to analyze the structure with construction stage analysis.
Keywords: Construction Sequences Analysis, Time History Analysis, Flat Slab, Seismic Parameters.

I. INTRODUCTION

A structure is most vulnerable to failure while it is under construction. Structural failures involving components, assemblies or partially completed structures often occur during the process of construction. A collapse during construction may not necessarily indicate a construction error. It may be the result of an error made during the design process. A collapse of stadium expansion project, structural steel, 1987 in Pacific Northwest served to remind construction professionals of a vulnerability of incomplete structures. A failure during construction of structure is always economically undesirable, and in extreme case, it may result in injury or death to the people. Efforts made to decrease the potential for structural failure during the construction phase will decrease the risk of injury to people, and of unexpected costs and delays. Possibly the most remarkable structural failures during construction are those which are resulting from the lack of stability. The designer considers of the structure as a completed single entity, with all elements acting together to resist the loads. Stability of the completed structure depends directly on the existence of all structural members, including floors. During the process of construction, however, the configuration of the incomplete structure is changing constantly, and stability often depend on temporary bracing. Construction sequence of the structure is extremely important in evaluating the stability of incomplete structures. Another frequent cause of structural failures during construction is excessive construction loading. While construction is taking place, the loads are often applied to structural members, are in excess amount of service loads predicted by the designer. The main reason is that the fresh floors are supported by previously casted floors by the false-work system. Analysis of the stability requirements for these incomplete, constantly changing and irregular assemblies presents a challenging problem to the most of capable structural engineers. To ensure stability of the structure at all times, account shall be taken of all the probable variations in loads during repair, construction or other temporary measures. The Construction Sequence Analysis that reflects the fact of the sequential application of construction loads during level by level construction of multistoried structure can provide comparatively more reliable results and hence only this method should be adopted in usual practice of designing.

II. LITERATURE REVIEW

Amrut Manvi [1] studied the cost comparison of flat slab structure and conventional RC slab structure having Baasement+Ground+3 Story structure situated in seismic zone 2 using software ETABS. This study found that the weight of the flat slab structure was less than that of RC beam structure. The cost of the flat slab structure was 15.8% less compared to that of the conventional slab structure. The study concluded that the flat slab structure is the best solution for the high rise structure as compared to that of conventional RC structure in terms of cost of material.

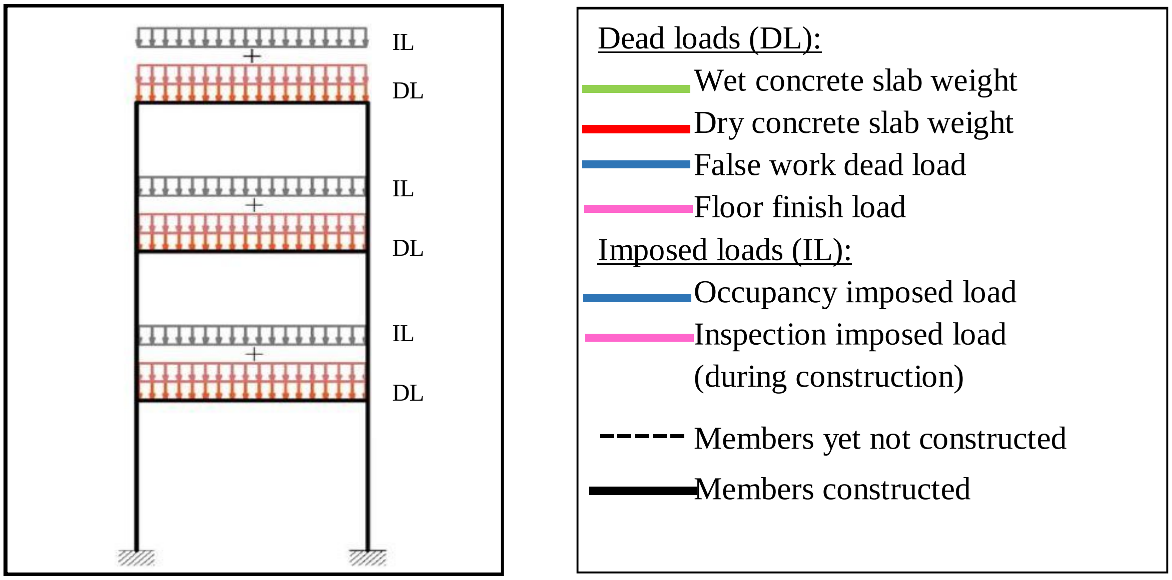

Figure 1 Conventional Analysis

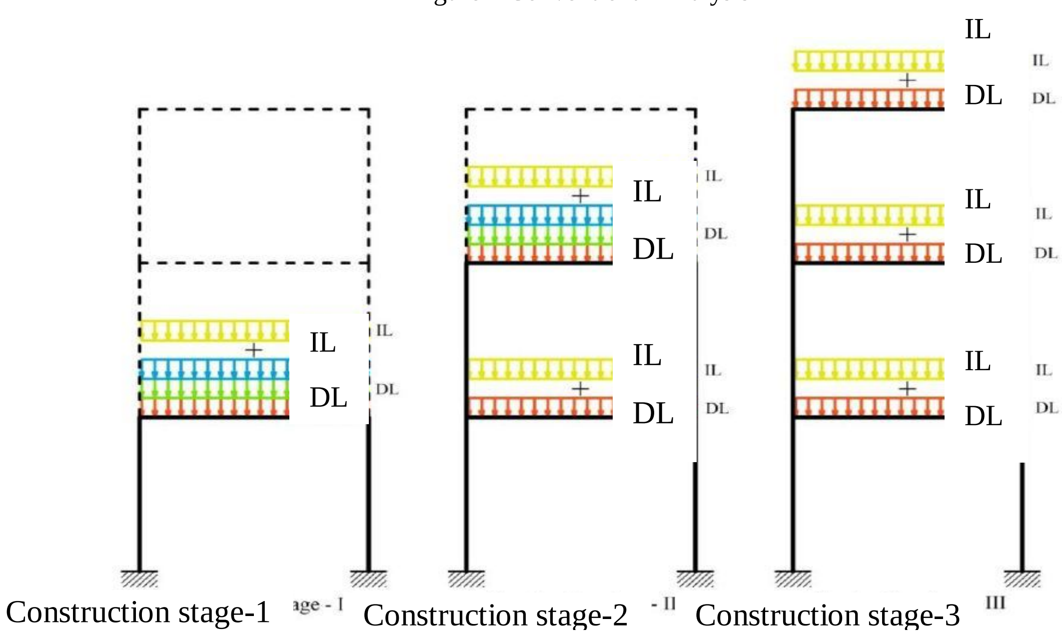

Figure 2 Construction Stage Analysis

Bothara, D. S.,Varghese V. [2] studied the comparative effect of earthquake on Grid floor & flat slab system containing beam spaced at regular intervals in perpendicular directions, monolithic with slab

K. G. Patwari [4] studied the effects of the flat slab building having shear walls as a structural element with different positions for different heights of the structure. The behaviour of Flat slab building and shear wall building was studied with the help of 3 models with Time History analysis carried by ETABs Software. The study revealed that the Natural time period of the conventional structure is more as compared to the flat slab structure because of the monolithic construction.

Mohana H.S [7] studied behaviour of Ground+5 storied commercial structure using ETABS for different seismic Zones of India. This study concentrated on the performance of the both the building under various loading condition and also studied the behaviour of both the structure for various parameters. This study concluded that base shear of flat slab building is 6% more as compared to

RC slab. This study also stated that design axial force on flat slab building is 5.5% more as compared to that of RC structure. As the seismic level increased, all the seismic parameters like are increased.

Sumit Pahwa [8] studied the case study for comparison of several structural parameters of flat slab building and RC frame building without shear wall for earthquake zone III, IV and V with varing heights 21m, 27m, 33m, and 39m. This investigation also stated about seismic behaviour of heavy slab without end fixed. This study stated that for all the cases considered, drift values tracked a parabolic path along Story height with extreme value lying near the middle Story. In Zone III and IV the use of flat slabs with drop panel are well within tolerable limits, even lacking shear walls.

III. CRITICAL REMARK FOR LITERATURE

A. Based on Review from Various Case Studies and Literatures, the Following Conclusions Are Drawn

1) Performance of RC frame building was better than flat slab building.
2) Performance of flat slab building improved much more with the use of shear wall.
3) Story drift (Sway) in buildings with flat slab is significantly more compared to conventional RC frame building.
4) As a result of this, additional moments were developed. Therefore, the columns of such buildings should be designed by making an allowance for additional moment caused due to the drift.
5) The presence of sequential load case in the analysis of high rise structure delivers more realistic design than that of the conventional design and in addition the seismic performance of structure can be improved.

IV. OBJECTIVE

To focus behavior of the Structure consisting of Flat Slab as a structural Element by carrying out the Non-linear Analysis under Construction Stage Analysis and Time History Analysis and. To find various seismic parameters like: Base Shear, Lateral Displacement, Inter Story Drift, Story Shear, Time Period

V. SCOPE OF WORK

A. Modelling of Flat Slab building with ETABs Software.
B. To Analyse the structure by Construction Stage Analysis.
C. To Study Several seismic parameters for Lateral Loads (i.e. Seismic Load) and Gravity Load (Live load, Dead Load, & Floor Finishes).
D. To evaluate performance of structure by non-linear Time History Analysis with and without considering Construction Sequence Analysis.
E. To mention the suggestions if any to increase the performance of the structure.

VI. PROBLEM FORMULATION & MODELLING

The Flat-Slab structure is analyzed by Time History Analysis and Construction stage analysis with CSI ETABS 2016 v2.

The Building Configuration is as given:

Table 1: Building Configuration Data

Dimension of building	30m x 30m
Number of Story	G+10
Height of each Story	3.0m
Dimension of Hidden-Beam	300 x 175 mm
Dimension of column	600 x 600 mm
Thickness of slab	175 mm
Thickness of wall	230 mm
Seismic zone	IV
Zone factor	0.24
Importance factor	1.0
Type of soil	Medium
Response reduction factor	5.0
Typical story Imposed load	4.0 kN/m^2

Typical story Floor Finish	1.0 kN/m^2
Roof Imposed load	1.5 kN/m^2
Roof Floor Finish	3.0 kN/m^2
Density of masonry wall	20 kN/m^3
Wall load on Typical story beams	12 kN/m
Parapet Wall load on Exterior Roof beams	4.6 kN/m
Grade of concrete	M25
Grade of steel	Fe415

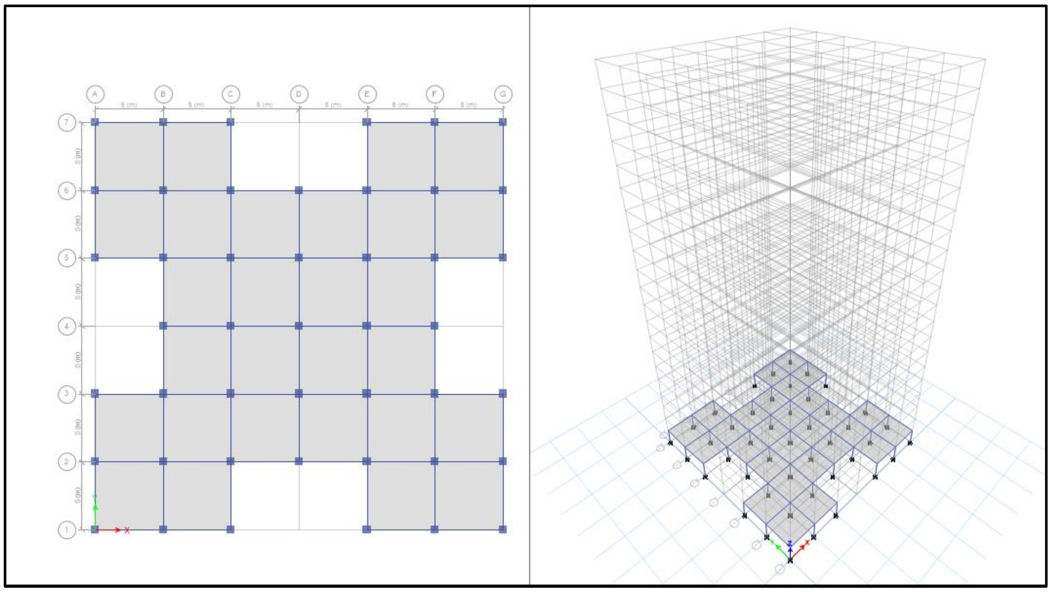

Figure 3 Building Plan Layout

VII. PREPARATION OF MODEL ANALYSIS

Table 2: Model Configuration

Type of Building:	Flat Slab Building
Type of Analysis:	1. Construction Stage Analysis
	2. Time History Analysis
Structural Components:	Flat Slab
No of Story:	G+10
Zone factor:	IV
Soil Type:	Medium

A. Modelling of r.c. Frame building as per given data is done as follows:

1) First step is to define grid in the software. It is required to define length and width of bays and number of bays in X and Y direction and number of Story.
Insert grid from new model > Grid Only

2) After defining the grid, material properties of concrete, steel etc. is to be defined. Material can be defined from Define > material property

3) After defining material properties structural members like beam, column and slab are defined.
Structural member can be defined from Define > Section property >Frame section.

4) After defining Section Properties, all The Frame members are Drawn on the Grid Plan.

5) Then Define Load Pattern: Define> Load Pattern.

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6) Then Define Time History Function: Define > Function > Time History.
7) Define Construction Sequence Load Case: Define > Auto Construction Sequence Load Case.
8) Define P-delta properties: Define > P-Delta Options.
9) Define Mass Sources: Define > Mass Source data.
10) Define Load Cases: Define > Load Combinations.
11) Define Modal Cases: Define > Modal Case data.
12) Set Load Cases to run: Analyze > Set Load Cases to Run.
13) Check Model: Analyze > Check Model
14) Run Analysis: Analyze > Run the Analysis.

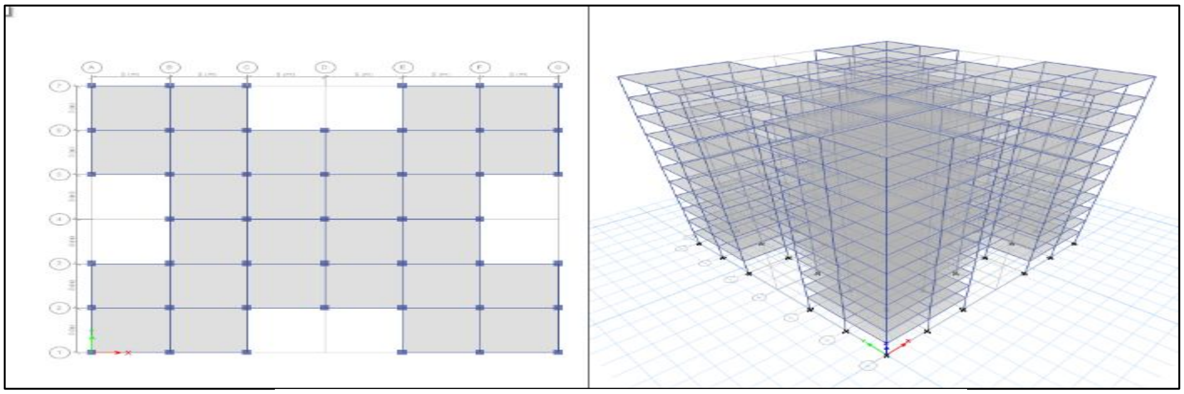

Figure 4 Modelling for G+10 Building in Etabs

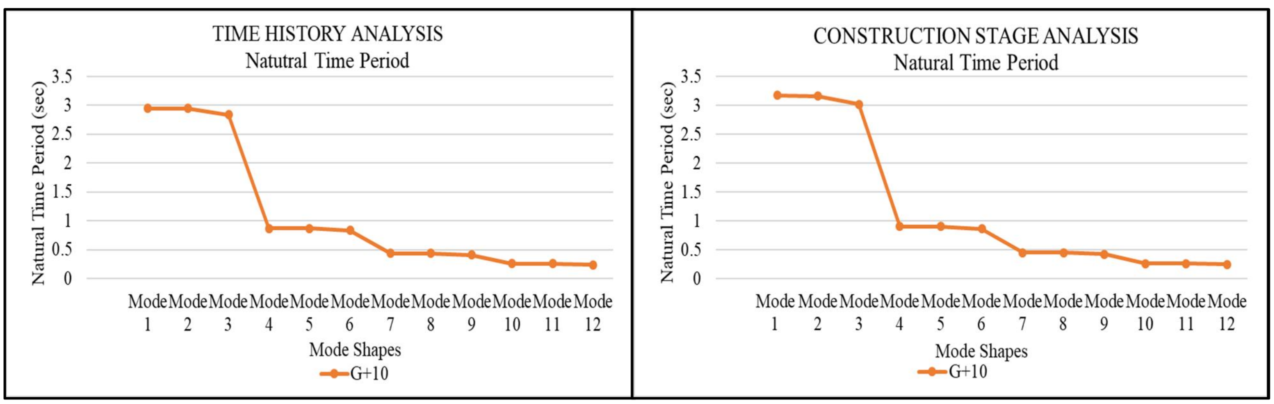

Figure 5 Natural Time Period

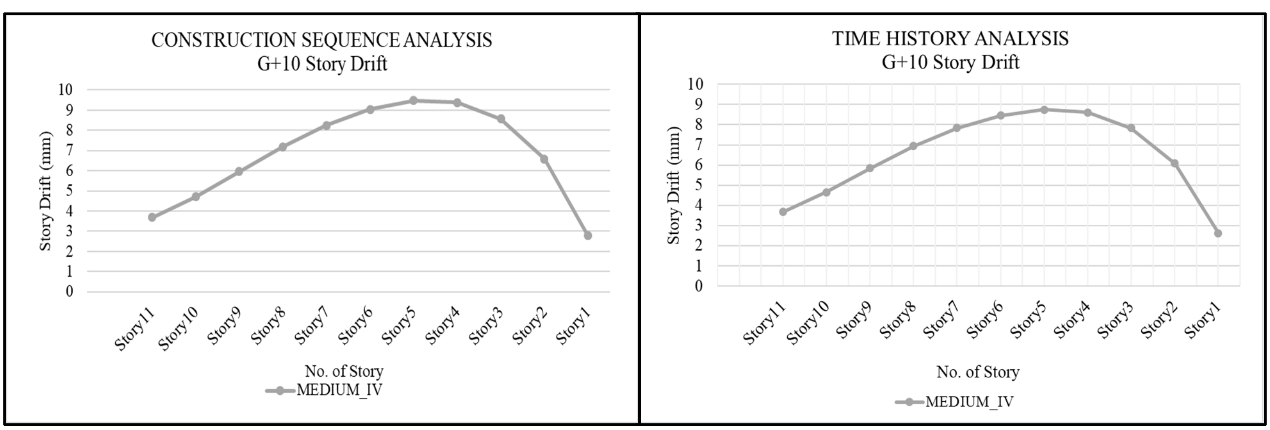

Figure 6 G+10 Story Drift

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VIII. ANALYSIS AND RESULT

Table 3: Model Time Period

TIME HISTORY ANALYSYS		CONSTRUCTION STAGE ANALYSIS	
MODE	TIME PERIOD (sec)	MODE	TIME PERIOD (sec)
	G+10		G+10
MODE 1	2.946	MODE 1	3.173
MODE 2	2.946	MODE 2	3.163
MODE 3	2.836	MODE 3	3.021
MODE 4	0.874	MODE 4	0.906
MODE 5	0.874	MODE 5	0.906
MODE 6	0.836	MODE 6	0.863
MODE 7	0.438	MODE 7	0.448
MODE 8	0.438	MODE 8	0.448
MODE 9	0.414	MODE 9	0.423
MODE 10	0.26	MODE 10	0.264
MODE 11	0.26	MODE 11	0.264
MODE 12	0.243	MODE 12	0.247

IX. CONCLUSIONS

Table 1: Story Drift for G+10 Building

TIME HISTORY ANALYSYS		CONSTRUCTION STAGE ANALYSIS	
Story Drift (mm)		Story Drift (mm)	
MODE	IV_Medium	MODE	IV_Medium
	G+10		G+10
Story11	3.681	Story11	3.696
Story10	4.661	Story10	4.71
Story9	5.839	Story9	5.969
Story8	6.936	Story8	7.195
Story7	7.834	Story7	8.254
Story6	8.459	Story6	9.047
Story5	8.748	Story5	9.475
Story4	8.603	Story4	9.393
Story3	7.835	Story3	8.564
Story2	6.075	Story2	6.588
Story1	2.631	Story1	2.802

In the present study the Flat slab structures for G+10 was modelled and analyzed for non-linear analysis including construction stage by the Etabs. The structure was analysed for Seismic Zone IV for Medium Soil type.
The results derived from various analysis are compared and concluded as below:

A. Natural Time Period increases as the number of story increases. Time Period of Structure analysed with Construction Stage Analysis for G+10 story building is 7.154% more compared to Structure analysed with that of Time History Analysis.
B. At intermediate story level, story drift is maximum.
C. Story Drift also increases as the Zone Factor increases,
D. Structure analysed with Construction Stage analysis has 7.67 % more story drift as compared to structure with time history analysis.
E. The base shear also increases as the No. of Story increases
F. All the Seismic Parameters are more serious for Construction Stage Analysis.

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IMPORTANT WEBSITES

[1] www.sciencedirect.com
[2] www.nicee.org

IS CODES

[1] IS 456:2000 PLAIN AND REINFORCED CONCRETE - CODE OF PRACTIC
[2] IS 800:2007 GENERAL CONSTRUCTION IN STEEL - CODE OF PRACTICE
[3] IS 1893:2016 CRITERIA FOR EARTHQUAKE RESISTANT DESIGN OF STRUCTURES. PART 1 GENERAL PROVISIONS AND BUILDINGS

SOFTWARE

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