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Construction Sequence Analysis of G+30 RCC, Steel Residential Building with Floating Column

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Abstract- **While examining a multistory building frame using FEM based software mostly a complete model is made then the model is applied with loads at once, but this is not the case in real structures, the actual load comes on the structure in steps, as the construction progresses stages by stages. So, to overcome the above issues construction sequence analysis came in to existence, which is a non-linear static analysis method that analysis the structure in step wise by creating an auto construction load case in FEM based software. The current exploration conducted on a G+30 residential structure having vertical irregularity which is analyzed by methods namely construction sequence analysis for dead load case and conventional Equivalent static analysis along with dynamic response spectrum analysis all this is achieved in CSI ETABS 2016 software. The structure is RC and steel frame type consisting of floating column and resides in zone 4 and zone 2 as per Indian standard code IS: 1893-2016. Results such as bending moment, shear force, column axial force, story drift, displacement are abstracted from the analyze results which are collated with CSA, ESA and considering load combination to compare the results with RSA.**

Key words- Construction Sequence Analysis, Equivalent Static Analysis, Floating Column, ETABS, response spectrum analysis.

1. INTRODUCTION

The frame structure is mostly fails during construction stage. Some of the failure involve such as components failure, joints failure, incomplete member failure, under strength reinforced concrete member failure. Some failures are mostly happened due to poor stability that may be frame and often may be due to unstable soil strata. This failure during construction process will be uneconomical to the construction cost and may cause injuries and loss of life may happen

In analysis of a frame there are number of facts that has a key role for the accuracy of analysis some of them are listed below

1. The load from construction process due to stage-by-stage construction
2. The impact of column shortening due to creep and shrinkage
3. Time-dependent properties impact of material such as shrinkage
4. The effect due to irregularity of frame structure
5. Proper distribution of stress and displacements coming from upper storeys

The definition of construction sequence analysis (CSA) is that in case of analyzing a structure using FEM based software mostly a complete model is made then the model is applied with loads at once, but this is not the case in real structures, the actual load comes on the structure in steps, as the construction progresses stages by stages. So, to overcome the above issues construction sequence analysis came in to existence, which is a non-linear static analyzing method that analyses the structure in step wise by creating an auto construction load case in FEM base software.

Construction sequence analysis is applied to all type of structures which are construct in stages, the major use of construction sequence analysis is in a structure where floating column are present. Since a conventional equivalent linear static

Analysis neglects the effect of floating column. Elements that are vertical that rests either on beam or on transfer girder but does not touch the foundation is referred to as a floating or hanging column. A structure with floating columns is used to create more floor space and the floor space may be utilized as a parking lot and considerably more. The transfer girders in seismically active areas must be designed, properly analyzed, and detailed.

OBJECTIVES

- To know the real behavior in tall structure under non- linear static construction sequence analysis considering only dead load case
- To understand the load transfer mechanism in floating column and to eliminate virendel truss action from structure
- To get the analysis results from RCC, Steel structure having vertical irregularity with floating column
- To compare the results which are collated with CSA, ESA and considering load combination to compare the results with RSA

2. MODELLING AND ANALYSIS

The four models consider in this study with two models of reinforced concrete in seismic zone 2, 4 and two models of steel structure in seismic zone 2, 4. The plan and position of floating column is kept same for all four models.

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sl.no	Type of models	RCC frame	Steel frame
1	Program used	ETABS 2016	
2	Support condition	Fixed support	
3	Size of bay in x and y direction	32mx26 m	
4	Spacing in x direction c/c	6.5, 4, 3.5, 4,3.5, 4, 6.5	
5	Spacing in y direction c/c	6.5, 4,5, 4, 6.5	
6	Concrete grade	M55, m30	M30
7	Steel grade	Fe500	Fe345
8	Wall thickness	230mm	
9	Type of structure	SMRF	
10	Number of storeys	30	
11	Floor height	3.2m	
12	Soil range	Medium	

Wall load used in the four models is 5.38 KN/m. The details of four models are as follows

Model 1- RCC model in zone 4 Model 2- Steel model in zone 4 Model 3- RCC model in zone 2 Model 4- Steel model in zone 2

Structural Elements		
Column Size	600X600 mm	STEEL TUBE 650X650 WITH COVER 25 mm
Beam Size	600mmx300mm	ISMB 500
Secondary Beam Size	600mmx300mm	ISMB 400
Depth Of Slab/Deck	150mm	

Following is the plan at second story which represents the position of floating column in all the four models.

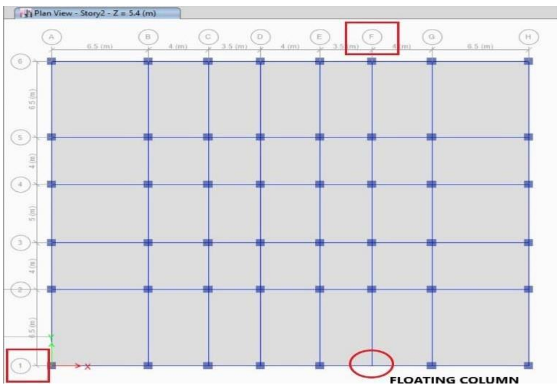

Fig -1: 2D plan view of All Models at Storey 2

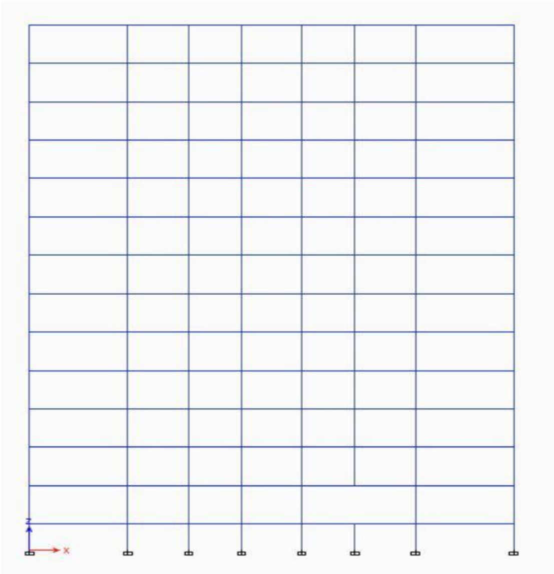
Fig -2: 2D Elevation View Along Grid 1 For All 4 Models

Construction Sequence Analysis Process

- Create the model by assigning material properties, section properties, and so on.
- Assign all dead loads and live loads such as the floor finish, wall load, typical live load
- In ETABS, define the auto construction sequence from the define menu, and the following template will appear.
- In the load instances shown below, the new load case will be generated as an auto nonlinear static stage construction.
- To obtain the findings, select the load case as the auto sequence is to be run along with other load defined in conventional method and perform the analysis

Response Spectrum Analysis

Step 1- Define the response spectrum function in accordance with the code.

Step 2- Define the mass source for calculating the structure's seismic weight.

Step 3- Determine the number of modes to be examined on a situation basis. Furthermore, the number of modes must be modified to meet the codal requirement.

Step 4- A minimum of 90% of the total seismic mass should be represented by the sum of the modal masses of the Nm modes that will be used in the study for earthquake shaking along a direction.

Step 5- Establish the load case as the response spectrum in both the x and y directions with a modal dampening of 5% and a program-based initial scale factor. Additionally, the scale factor must be modified to meet the codal requirement

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Seismic Parameters			
1	Seismic Zone	2 AND 4	2 AND 4
2	RS Factor	5	
3	Importance Factor	1	1
4	Damping	5%	5%
5	Soil Type	2	2
Loads Considered			
6	Typical Live Load	3 KN/M^2	3 KN/M^2
7	Floor Finish	1.5 KN/M^2	1.5 KN/M^2
8	Wall Load	5.38 KN/M	5.38 KN/M
9	Roof Live	1.5 KN/M^2	1.5 KN/M^2

3. RESULTS

The following results compared for construction sequence dead load and for equivalent static dead load for the beam which supports floating column that is referred as transfer. To get the above set of objectives following results are compared by collating the following results. Construction sequence dead load and equivalent static dead load at story 2 for transfer beam Values such as bending moment, shear force where taken, and from the obtained values percentage difference is find out. Following tables represent for bending moment and shear force and axial force of column which connects to transfer beam

Table -1: Percentage Difference Between with CS Dead Load and Without CS Dead Load

TYPE OF MODEL	SEISMIC ZONE	BENDING MOMENT	SHEAR FORC E	AXIAL FORCE	
				COLUMN A	COLUMN B
MODEL 1(RCC)	4	29.86%	24.84%	0.77 %	1.89%
MODEL 2 (STEEL)	4	45.60%	38.35%	0.97 %	1.91%
MODEL 3 (RCC)	2	29.86%	24.84%	0.77 %	1.89%
MODEL 4 (STEEL)	2	45.60%	38.35%	0.97 %	1.91%

Storey displacement

Displacement of the storeys is plotted in the form of charts. Results of storey displacement are taken for static response that is EQX and EQY and dynamic response that is RSX and RSY. Load case type for EQX and EQY is equivalent static and for RSX and RSY is response spectrum

The maximum storey displacement in the entire four models is for the load combination which has construction sequence dead load that 1.5AUTODL+1.5RSX. %Difference when taken for load combination with CSA dead load verses without CSA dead load, the point is to note that there is very minor difference ranging between 0.22 to 0.57 percent only.

Table -2: Percentage Difference for 1.5DL+1.5RSX, 1.5AUTODL+1.5RSX

TYPE OF MODEL	SEISMIC ZONE	BENDING MOMENT	SHEAR FORCE	AXIAL FORCE	
				COLUMN A	COLUMN B
MODEL 1(RCC)	4	20.12%	14.19 %	0.88%	1.63%
MODEL 2(STEEL)	4	28.67%	22.67%	1.22%	1.79%
MODEL 3(RCC)	2	25.58%	18.92 %	0.96%	1.88%
MODEL 4(STEEL)	2	38.11%	29.19 %	1.22%	2%

Table -3: Storey Displacement % difference

Type Of Model	Zone	Percentage Difference		Percentage Difference		Percentage Difference	
		EQ X	RS X	EQ Y	RS Y	1.5dl+ 1.5RS X	1.5autodl+ 1.5RSX
Model 1 (RCC)	4	21.28%		37.49%		0.22%	
Model 2 (Steel)	4	19.81%		37.18%		0.24%	
Model 3(RCC)	2	21.25%		37.47%		0.57%	
Model 4 (Steel)	2	19.79%		37.14%		0.57%	

4. CONCLUSION

- From the table 1 it is concluded that the percentage difference in Bending moment, shear force in transfer beam and axial force in supporting column is same in both the zones (2 and 4), when the percentage difference is taken between construction sequence dead load case and equivalent static dead load case
- From table 2 it is concluded that the percentage difference in bending moment, shear force in transfer beam and axial force in supporting column is different for both zones (2 and 4), when the percentage difference is taken between the load combination 1.5DL+1.5RSX and 1.5autoDL+1.5RSX
- From table 1 and table 2 it is concluded that the effect of construction sequence load case has less impact on axial force of column as it shows a minor percentage difference ranging from 0.77-2 percent only.
- The story displacement value is maximum in model 2 which is in zone 4
- From table 3 it is concluded that the effect of auto dead load case used in load combination has less impact on story displacement as it shows a

percentage difference ranging from 0.22-0.57% only

- The storey displacement with response spectrum and equivalent static response shows a percentage difference ranging between in all four models 19.81-21.28% only.
- From tables it is seen that the variation is more in case of steel structure in both zones 2 and 4
- In all four models, the storey drift is highest for static response in the x-direction that EQX

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