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COMPARATIVE STUDY OF CONSTRUCTION SEQUENCE ANALYSIS WITH CONVENTIONAL LUMPED ANALYSIS

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Abstract

While analysing of a multi-storied framing structure, conventionally all loads which would act are added once the modelling of the whole frame is completed. But in actual practice, construction is carried in different stages. Consequently, the stability of the frame differs at every stage of construction. Even at the time of construction, freshly placed concrete floor is supported by previously cast floor by formwork. Construction sequence analysis helps to analyse the building in a staged fashion. Despite its importance, our knowledge of Construction sequence analysis is poor, and its implementation is imperfect. In this study we have analysed two models of Ground+20 storied building located in zone-4 one using Construction sequence analysis and the other using Conventional Lumped Analysis, study is conducted on various structural parameters such as Shear Force, Maximum Bending Moment, Maximum Displacements of the transfer-girder, Axial Loads and Differential displacements of floating column resting on the transfer-girder and interior column, the results are compared to understand the behaviour of the building. This study definitively answers the question with respect to the collapse of buildings at the time of the construction phase and how can it be prevented using Construction sequence analysis. However, experimental studies are required to establish actual values of structural parameters.

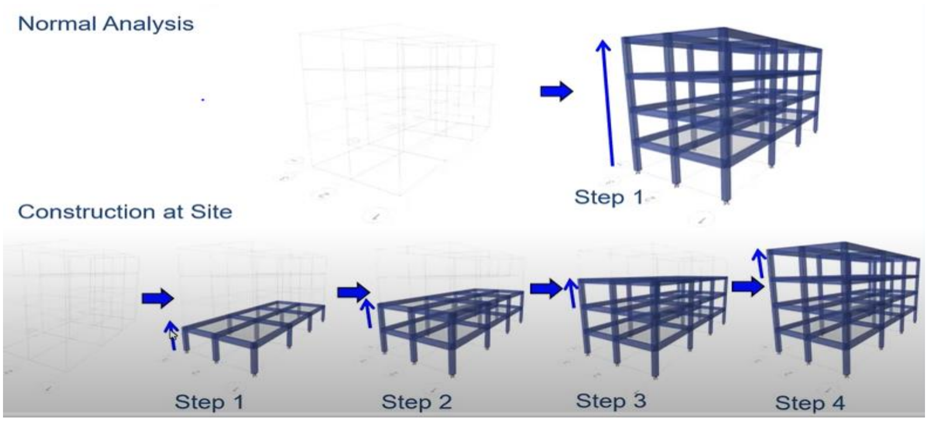
Keywords: Construction Sequence Analysis, Conventional Lumped Analysis, Floating column, Response spectrum analysis, transfer girder.

1. Introduction

Over a very long duration of time the multi-storied structural frames has been subjected to analysis based on the assumption that the entire load is applied to the whole structure with every single loads acting on the building structural such as dead load, super-imposed load, typical-live load, earthquake loads, wind loads which are enforced on the completed framed structure suddenly as a one-step analysis. Although in actual method the dead load due to each structural element and floor finish loads are imposed in different stages as the structural frame is constructed storey by storey in a sequential system.Hence, so as to analyse the structure in step with the particular construction practices, this is referred to as construction sequence analysis (CSA). Construction sequence analysis is additionally referred to as staged construction analysis that could be a non-linear static style of analysis that takes into consideration the conception progressiveloading. Many urban high-rised structures in our country currently have first storey opened as an inevitable characteristic. Typically this characteristic is implemented to deal with parking space and even for lobby for reception in the 1st floor. The floating column is a vertical component that rests on the beam yet do not pass on the load immediately to the below footing.Floatingcolumn acts as a concentrated-load on the beam and the beam under action pass on the load to its underlying columns. The column might also start out on the first or second or some other intermediate ground at the same time as resting on a beam. Usually the vertical member halt on the footing to distribute the loads from the other structural members such as beam and slab element, but the floating column halt on the beam.

Types of Analysis carried out in etabs :

1. Conventional Lumped Analysis.
2. Staged Construction Sequence Analysis.
3. Staged Construction Sequence Analysis considering Time Effects such as Creep and Shrinkage.

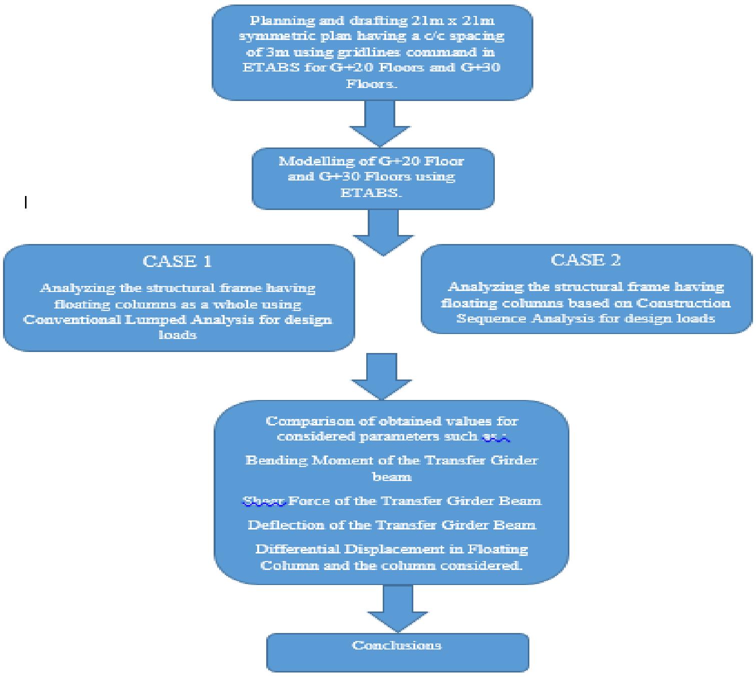


2. Objectives

- The principal objective isto decrease the potentialfor thestructural collapse at constructionphase conclusively decreasing therisk of injuries anddelaysin completionof constructionprojects.
- To know thebehaviour of highrisestructureanalytically at the time ofconstruction in differentstagesusingconstructionsequentialanalysis.
- Comparativeinvestigation of ConstructionSequence Analysis along withConventionalLumpedAnalysis.
- Compare the values with respect to the parameters considered for the study so as to understand the importance of ConstructionSequenceAnalysisin construction of highrise structure.

3.Methodology

The modelling of building is prepared inetabssoftware. The software is proficient enough to analyse multi-storied framedstructures including and excluding stimulation of construction sequence. During analysis by conventional lumped method, it is assumed that the multi-storey is constructed and only later the loads are added, thus it is a single-step process. After which, the multi-storey analysis is carried out by a construction-sequence. Here, the multi-storey is subjected to analysis at individual floor, thus loads are applied to each individual floor as the construction advances. Thereby subjecting the structure to actual simulation to understand its actual behaviour. The parameters such as axial-forces, shear-forces, and bending-moments, displacements were studied and the obtained results are compared.



4. DESCRIPTION AND MODELLING OF BUILDING

Themodelling of building is prepared inETABS software. A 3D RC frames for G+20 floors with 7 bay by 7 bay of dimension 21m x 21m (each storey height is 3, with plinth height of 1.5m), has been taken for analysis. The building model in consideration is symmetric and it is a fixed base building and the structure is located in Earthquake Zone-4 as per IS Code 1893:2016 (Part 1).

Beam Section Dimension	G+20 = 700 mm x 800 mm
Column Section Dimension	G+20 = 1000mm x1000mm
Transfer Girder Beam Dimension	G+20 = 1100mmx1400mm
Slab thickness	150 mm.
Concrete Grade	M40.
Grade of Rebar	Fe 500.

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Imposed Wall Load	(3.2-Beam Depth=H) 2.6X0.2X1X20 = 10.4 KN/m
Floorfinish	1.5 kN/m^2
Imposed load acting on slab	3 kN/m^2
Imposed load acting on roof	0.75 kN/m^2
Seismic Zone= Z	4
Response Reduction= R	5
Site Type	2
Importance Factor = I	1.2
For 20 Storey	Tx= 0.96 Ty=0.96

Table 4.1. Modelling data of the building.

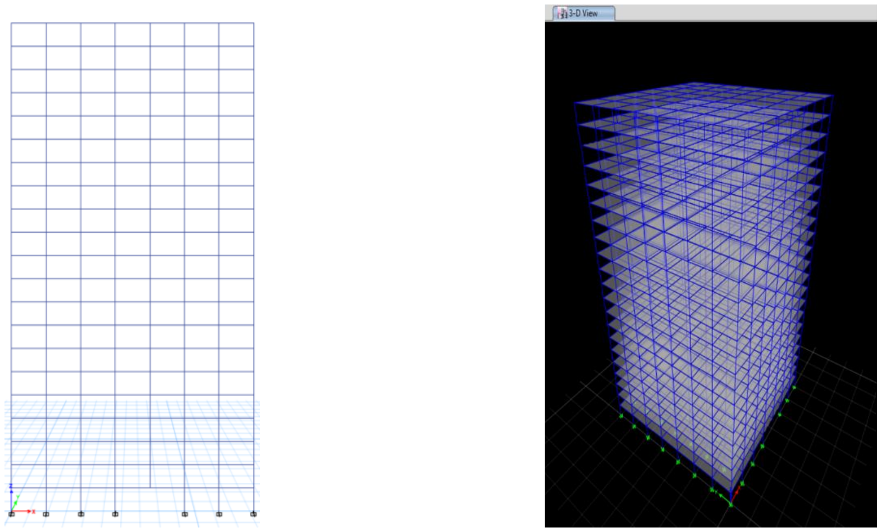

Fig.4.1 G+20 Floor Elevation.

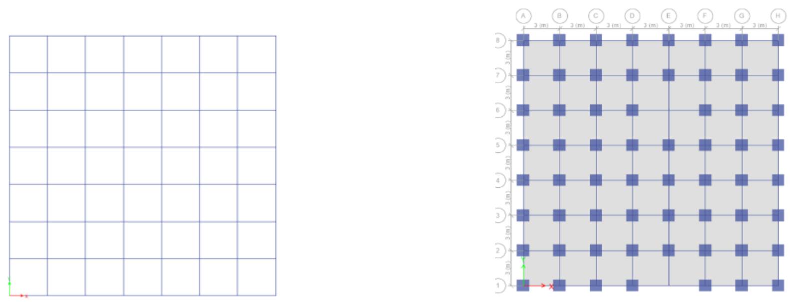

Fig.4.2Plan of both G+20F.

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5.RESULTS AND DISCUSSIONS

STOREY	Conventional Lumped Analysis	Construction Sequential Analysis
GF	4089.24 kN-m	5679.93 kN-m

5.1Maximum moment ofTransfer GirderBeam

Table 5.1. Maximum moment ofTransfer GirderBeam

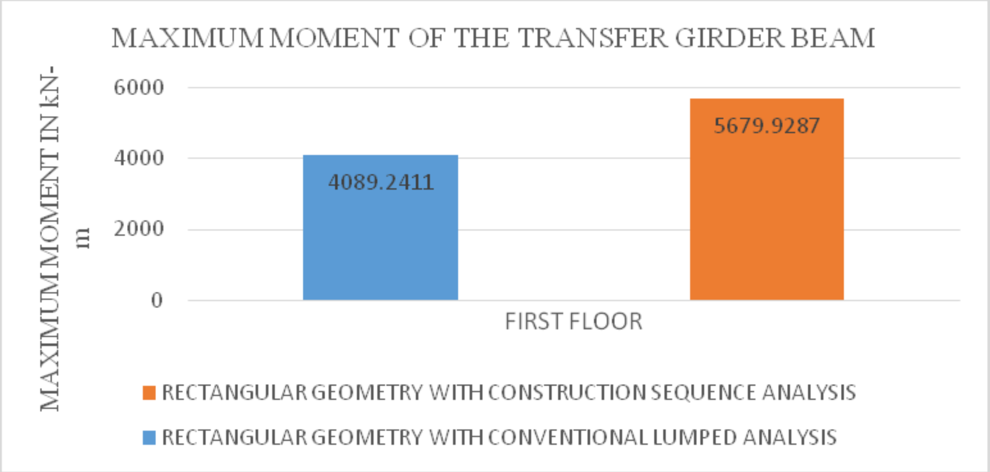

Fig 5.1. Maximum moment ofTransfer GirderBeam

From fig.5.1 we can observe that the maximum moment obtained in the Transfer Girder beam considering ConstructionSequenceAnalysis (2) is 38.90% higher than the maximum moment obtained considering ConventionalLumpedAnalysis (1).

5.2 Maximum Shear Force of Transfer Girder Beam

STOREY	Conventional Lumped Analysis	Construction Sequential Analysis
GF	1597.84 kN	2132.18 kN

Table 5.2. Maximum Shear Force of Transfer Girder Beam

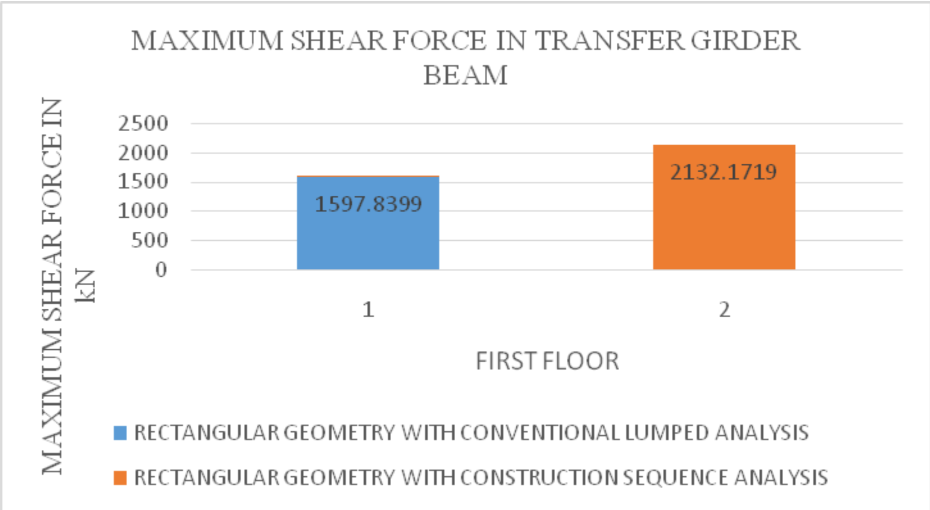

Fig.5.2. MaximumShearForce ofTransfer GirderBeam

5.3 Maximum Deflection of Transfer Girder Beam.

STOREY	Conventional Lumped Analysis	Construction Sequential Analysis
GF	4.701 mm	5.76 mm

Table 5.3. Maximum Deflection of Transfer Girder Beam.

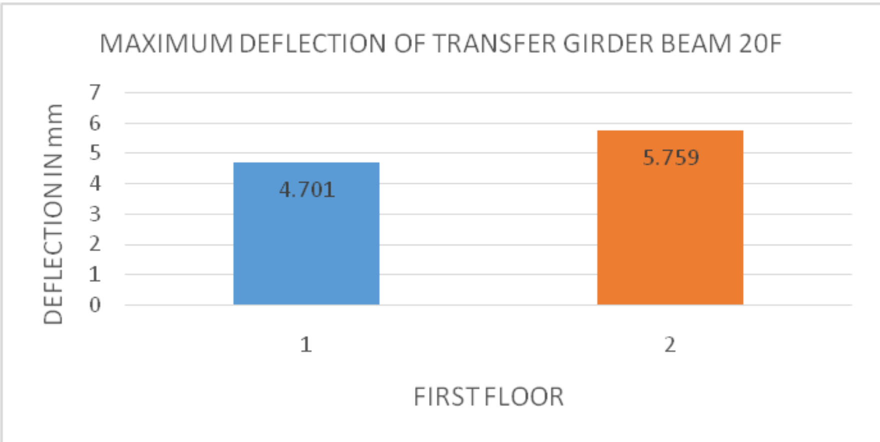

Fig.5.3. Maximum Deflection of Transfer Girder Beam

From fig.5.3 we can observe that the maximum Deflection obtained in the Transfer Girder beam considering ConstructionSequenceAnalysis (2) is 22.51% higher than the maximum moment obtained considering ConventionalLumpedAnalysis (1).

5.4 Total Axial Load on Floating Column.

STOREY	Conventional Lumped Analysis	Construction Sequential Analysis
5	3462.98 kN	4662.97 kN
10	2775.46 kN	3914.58 kN
15	1438.19 kN	2142.59 kN
20	203.57 kN	335.28 kN

Table 5.4. Total Axial Load on Floating Column

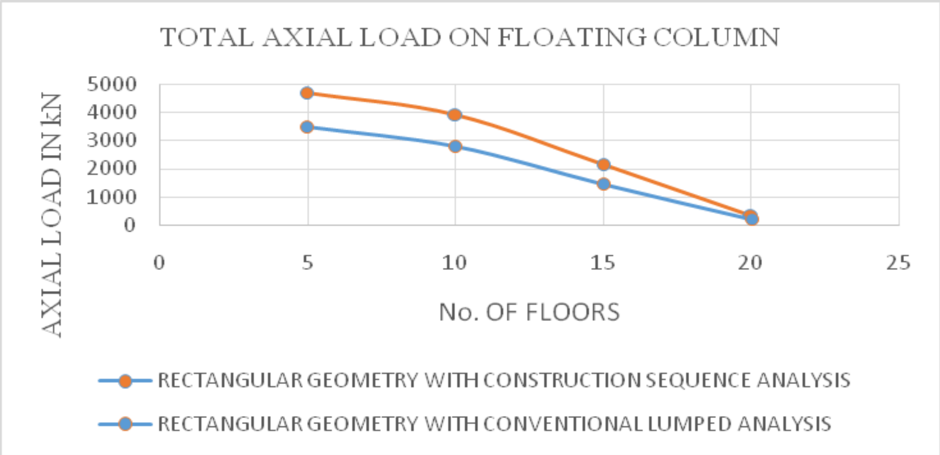

Fig.5.4. Total Axial Load on Floating Column

From fig.5.4 we can observe that the Total Axial load of 4662.9686 kN, is obtained in the exterior columns considering ConstructionSequenceAnalysis in the 5th floor and goes on decreasing as the floors increase andaxial load obtained at the 20th floor is 203.58 kN, similarly the Axial load obtained considering ConventionalL umpedAnalysis is 3462.9781 kN at the 5th floor and goes on decreasing as the floors increase and is axial load obtained at the 20th floor is 203.58 kN.

5.5Total Axial Load on column

STOREY	Conventional Lumped Analysis	Construction Sequential Analysis
GF	8522.92 kN	11809.56 kN
5	4986.23 kN	8419.03 kN
10	3210.31 kN	5517.68 kN
15	1597.76 kN	2836.53 kN
20	204.48 kN	396.38 kN

Table 5.5. Total Axial Load on column

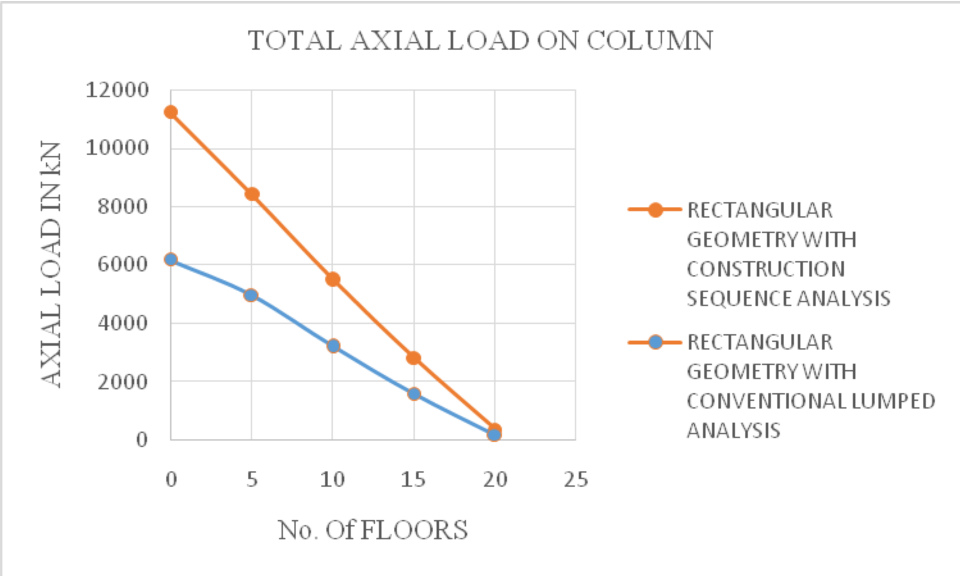

Fig.5.5. Total Axial Load on column

From fig.5.5, we can observe that the Total Axial load of 13809.5504kN,is obtained in the exterior columns considering ConstructionSequenceAnalysis in the 5th floor and goes on decreasing as the floors increase and is axial load obtained at the 20th floor is 396.3754 kN, similarly the Axial load obtained considering ConventionalLumpedAnalysis is 3462.9781 kNat the 5th floor and goes on decreasing as the floors increase and is axial load obtained at the 20th floor is 203.5619 kN.

5.6. Differential displacement in Column of Floating column.

STOREY	Conventional Lumped Analysis	Construction Sequential Analysis
GF	2.435	1.94
5	7.011	4.26
10	10.040	4.07
15	11.391	2.99
20	11.874	0.61

Table 5.6. Displacement in Column of Floating column.

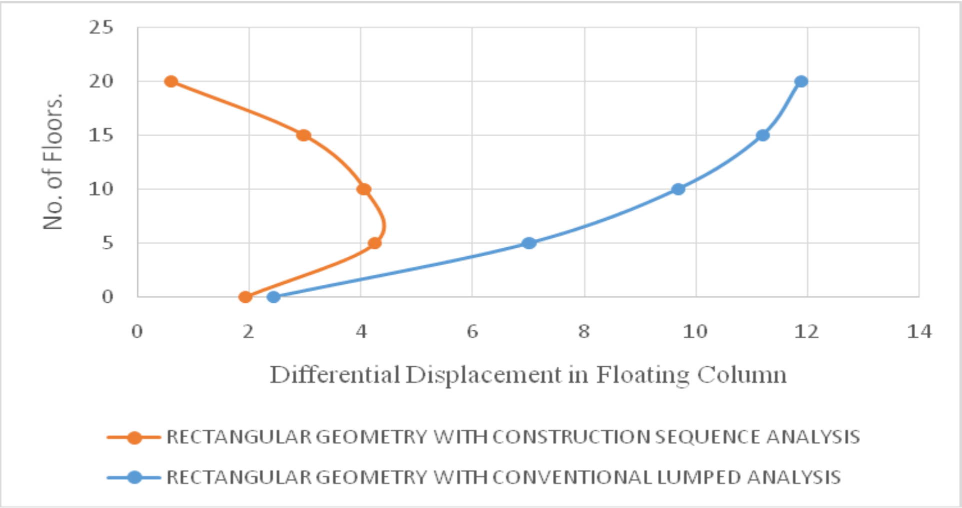

Fig.5.6. Displacement in Floating Column.

From fig.5.6, we can observe that the maximum floor displacement is 1.94 in ground floor and 0.61in 20th floor under C S A whereas in lumped analysis it is 2.44 in ground floor and 11.874 in 20th floor.

5.7 Differential displacement in Column.

STOREY	Conventional Lumped Analysis	Construction Sequential Analysis
GF	1.31 mm	0.82 mm
5	5.92 mm	3.09 mm
10	9.05 mm	3.88 mm
15	10.87 mm	2.8 mm
20	11.5 mm	0.49 mm

Table 5.7. Differential displacement in Column.

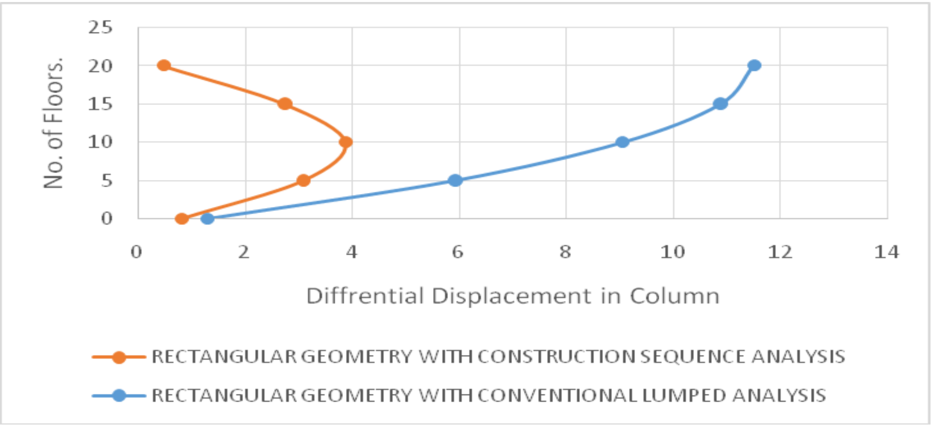

Fig.5.7. Differential Displacement in Column.

From fig.5.7, we can observe that the maximum floor displacement is 0.82 in ground floor and 0.49in 20th floor under C S A whereas in lumped analysis it is 1.31 in ground floor and 11.5 in 20th floor.

6. Conclusions

1. Analysis by constructionsequential methodology is essential in order to escalate the precision of analysis outcomes with respect to the parameters such as displacement, axialforce, moment due to bending and shearforce in transfer girder beam & the column supported by it & similarly for the entire structure.
2. The bending moment, Shear Force, Deflection values of the transfer girder beam when analysed using Construction Sequence Analysis is much higher than when analysed using Conventional Lumped Analysis (Staged Construction Method). Hence, it is necessary that for a multi-storied structures involving floating column and transfer girder system, staged construction method shall be taken into consideration.
3. The value of differential shortening of vertical member in Conventional Lumped Analysis is more when compared to Construction Sequence Analysis, the value will be maximum at the middle stories and decreases as the storey height increases, but in case of Conventional Lumped Analysis the value keeps increasing as the storey height increases which doesn't make sense, thus staged construction analysis method provides much realistic design approach.
4. Sequential method should be adopted mainly for columns located in the interior part of structure.
5. Thus, from the above we can conclude that analysis by construction sequential method gives much superior results when in comparison to analysis by conventionallumpedmethod & hence shouldn't be ignored during the design.

7. Scope for further studies:

1. Further analytical study could be made on thebuilding including shearwalls and infillwalls. Also practical experiment is necessary tolearn its authenticity.
2. Analytical study can be conducted for a various plan configuration buildings.
3. Analytical study can be conducted for different seismic zones with involving different soil strata.
4. Study can also be made on steel structures and difference in their behaviour can be compared to known the most suitable analysis required so as to obtain most optimistic design.
5. Analysis by sequential method can also be conducted using various types ofcementing elements along with variouscombination of meshes & mortars.

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