Staged Construction Analysis For High Rise Building With Seismic Analysis

Laxmi Kanhaiya Jangam[1], Ganesh Chandrakant Jawalkar[2]
[1, 2] Dept of Civil Engineering
[1, 2] N.B. Navale Sinhgad College of Engineeering, Solapur.

Abstract- *While analyzing high rise structure in Conventional method the gravity loads are applied after modeling the whole structure. In actual practice the complete frames are constructed at various stages and the stability of frames varies accordingly. The applied load assumed in Conventional method will be unsuitable as per the actual construction practice. The frame should be analyzed at every construction stage considering the effect of variation of loads at each stage. This methodology is known as construction sequential analysis. In this project the realistic structure of G+11 and G+14 in seismic zone IV as per IS 1893:2016 (Part 1) considered to study the effect of construction sequence. Tall building of three different heights has been considered for comparative study and effect on columns and beams has been studied based on different structural parameters. Based on study the necessity of the construction sequence analysis for tall building has been understood.*

Keywords- Linear Static analysis, Linear Dynamic analysis, Construction Sequence analysis, High raised buildings.

I. INTRODUCTION

Generally civil engineers, structural engineers, researcher and decision makers have determined the behavior of structures using conventional methods. The multi-storey building frames have been analyzed in a single step as a complete frame with all the loads acting on the building frame at a given instant when the construction of the whole frame is completed. In actual, the dead load due to each structural components and finishing items are imposed in separate stages as the structures are constructed storey by storey. The performance of a structure with the various loads applied in a single step differs significantly from that when the loads are applied in stages. Hence, in order to simulate the actual condition during the construction of the frame, construction sequence analysis is used.

In this project the three different models are taken by keeping all the parameters same for three models i.e. G+11 and G+14 to check the variation in the result of conventional and sequential analysis which gives the actual behavior of structural members.

A. CONSTRUCTION SEQUENTIAL ANALYSIS CONCEPT

The performance of a structure with the various loads applied in a single step differs significantly from that when the loads are applied in stages. Hence, in order to simulate the actual condition during the construction of the frame, the frame should be analyzed at every construction stage taking into account variation of loads. The phenomenon known as Sequential Construction Analysis is used to analyze the structure at each storey. Sequential construction analysis is a nonlinear static analysis which takes into account the concept of incremental loading. Sequential construction is also important on analysis of high rise buildings where creep and shrinkage must be considered.

II. EASE OF USE

The Comparison of responsive member forces between conventional and sequential construction method of analysis by using dynamic analysis. Which will gives an idea about the design parameters of structural elements.

III. METHODOLOGY

1. Selection of specifications of structures.
2. Modeling of the selected structure by using finite element software
3. Applying response spectrum analysis on selected building models
4. Applying sequential construction analysis and analysis of results.
5. Compare the results of conventional and sequential analysis.

1. Selection of specifications of structures.

Live Load	3KN/m^2
Density of RCC considered:	25KN/m^3
Steel	HYSD 500
Thickness of slab	150mm

Depth of beam	450mm
Width of beam	230mm
Dimension of column	380x720mm
Height of each floor	3m
Earthquake Zone	IV
Damping Ratio	5%
Importance factor	1.2
Type of Soil	Medium soil
Type of structure	Special Moment Resisting Frame
Response reduction Factor	5
No of Models	3 (G+11, G+14, G+17)
No of modes (Each floor 3 no of modes)	For Storey G+11 =36 For Storey G+14= 45 For Storey G+17=54
Type of diaphragms	Rigid
Modal combination	SRSS
P-Delta effect	Non –iterative-Based on mass
Direction of lateral force	X-direction and Y-direction
Load combination	All load combination as per IS 1893-2016
Type of support at base	Fixed

2. Modeling of the selected structure by using finite element software

Fig.1 plan for G+11,G+14 and G+17

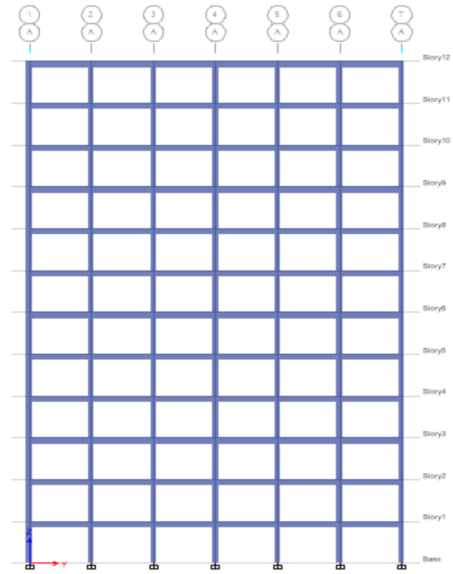


Fig. Elevation of G+ 11 model

3. Applying response spectrum analysis on selected building models.

Response Spectrum Analysis:-

This approach permits the multiple modes of response of a building to be taken into account. This is required in many building codes for all except for very simple or very complex structures. The structural response can be defined as a combination of many modes. Computer analysis can be used to determine these modes for a structure. For each mode, a response is obtained from the design spectrum, corresponding to the modal frequency and the modal mass, and then they are combined to estimate the total response for the structure. In this the magnitude o forces in all directions is calculated and then effects on the building is observed.

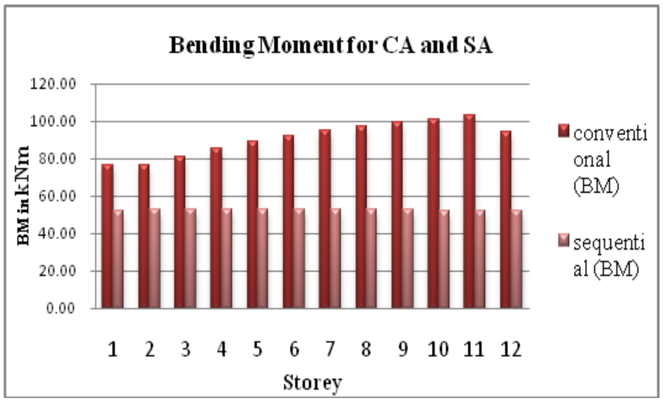
4. Applying sequential construction analysis and analysis of results.

A. Define grid line
B. Define material properties.
C. Define section properties.
D. Assign section properties to grids.
E. Assign gravity loads.
F. Define response spectrum function.
G. Define mass source
H. Define modal cases.
I. Define load pattern.
J. Define load cases.
K. Define auto construction sequence.
L. Analyze and study the results.

5. Compare the results of conventional and sequential analysis.

Table 2: Difference between Conventional and Sequential Analysis of BM (G+11)

Storey	Bending moment in kNm (1.5DL+1.5LL)		% Reduction	Factor
	Conventional	Sequential		
Storey1	76.34	52.42	31.34	0.69
Storey2	76.86	52.70	31.43	0.69
Storey3	81.20	52.66	35.15	0.65
Storey4	85.45	52.90	38.09	0.62
Storey5	89.18	53.08	40.48	0.60
Storey6	92.43	53.16	42.48	0.58
Storey7	95.19	53.14	44.17	0.56
Storey8	97.48	53.03	45.60	0.54
Storey9	99.31	52.82	46.81	0.53
Storey10	100.60	52.54	47.77	0.52
Storey11	102.82	52.33	49.11	0.51
Storey12	93.98	52.29	44.35	0.56



Graph 1: Difference between Conventional and sequential analysis of BM (G+11)

Observations

From above graph of Responsive member forces for bending moment following points are observed.

1. The maximum percentage reduction of bending moment from above table is 49.11 % at storey 11
2. The bending moment for conventional analysis shows increasing values except first storey (storey 1) and second last storey (storey 11)
3. Table shows bending moment for sequential analysis are in increasing order up to 6 storey's after it will get reduces i.e. it shows the summit curve like shape.

Table 3: Difference between Conventional and Sequential Analysis of SF (G+11)

Storey	Shear force in kN (1.5DL+1.5LL)		% Reduction	Factor
	Conventional	Sequential		
Storey1	138.6383	93.4625	32.59	0.67
Storey2	142.1302	93.5786	34.16	0.66
Storey3	145.7616	95.082	34.77	0.65
Storey4	148.2168	96.2855	35.04	0.65
Storey5	149.8245	97.0558	35.22	0.65
Storey6	151.7886	97.4023	35.83	0.64
Storey7	153.4616	97.3338	36.57	0.63
Storey8	154.8496	96.8584	37.45	0.63
Storey9	155.9514	95.9829	38.45	0.62
Storey10	156.7662	94.7197	39.58	0.60
Storey11	157.8934	93.0912	41.04	0.59
Storey12	153.6643	91.842	40.23	0.60

Graph 2: Difference between Conventional and sequential analysis of SF (G+11)

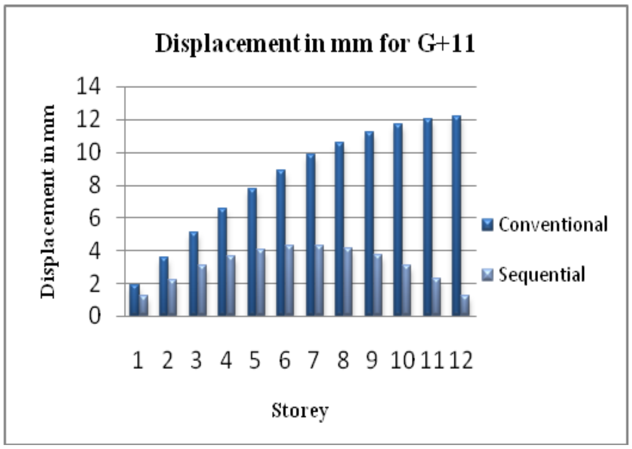
Observation

From above graph of Responsive member forces for Shear force following points are observed

1. The maximum percentage reduction of Shear force from above table is 41.04 % at storey 11.
2. Table shows shear force for sequential analysis are in increasing order up to 6 storey after it will reduces up to 12 storey i.e it shows the summit cure like shape

Table 4: Difference between Conventional and sequential analysis of displacement (G+11)

Storey	Displacement in mm		% Reduction	Factor
	Conventional	Sequential		
1	1.85	1.21	34.59	0.65
2	3.56	2.22	37.64	0.62
3	5.12	3.04	40.63	0.59
4	6.52	3.66	43.87	0.56
5	7.77	4.07	47.62	0.52
6	8.86	4.28	51.69	0.48
7	9.8	4.29	56.22	0.44
8	10.58	4.09	61.34	0.39
9	11.21	3.69	67.08	0.33
10	11.67	3.07	73.69	0.26
11	11.98	2.26	81.14	0.19
12	12.13	1.23	89.86	0.10



Graph 3: Difference between Conventional and sequential analysis of displacement (G+11)

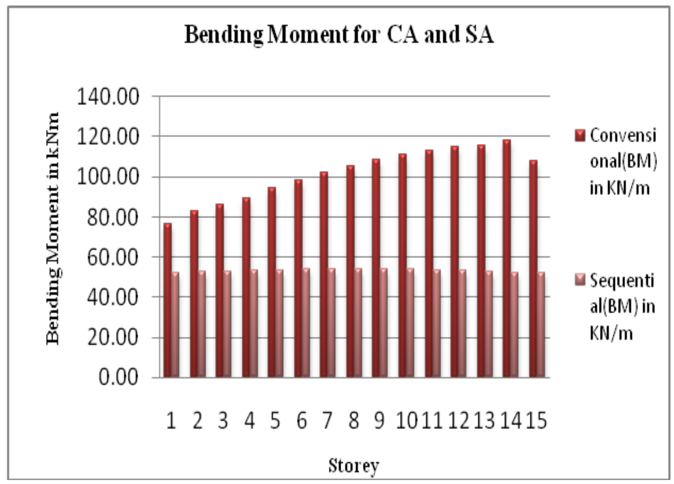
Observations

From above graph of Responsive member forces for Displacement following points are observed.

1. The maximum percentage reduction of deflection from above table is 89.86 % at storey 12.
2. The value of displacement for conventional analysis shows increasing values.
3. Table shows displacement for sequential analysis is in increasing order up to 6 storeys's after it reduces. i.e. it shows the summit cure like shape.

Table 5: Difference between Conventional and sequential analysis of BM (G+14)

Storey	Beam	Load Combination	Bending moment in kNm		% Reduction	Factor
			Conventional	Sequential		
1	B52	DCon2	76.48	52.42	31.46	0.69
2	B1	DCon14	82.89	52.70	36.42	0.64
3	B1	DCon14	86.04	52.98	38.43	0.62
4	B56	DCon2	89.37	53.39	40.26	0.60
5	B56	DCon2	94.11	53.70	42.94	0.57
6	B56	DCon2	98.37	53.91	45.20	0.55
7	B56	DCon2	102.17	54.02	47.12	0.53
8	B56	DCon2	105.52	54.04	48.78	0.51
9	B56	DCon2	108.43	53.97	50.22	0.50
10	B56	DCon2	110.91	53.81	51.48	0.49
11	B56	DCon2	112.96	53.57	52.58	0.47
12	B56	DCon2	114.61	53.23	53.55	0.46
13	B56	DCon2	115.75	52.83	54.36	0.46
14	B56	DCon2	118.06	52.24	55.75	0.44
15	B56	DCon2	107.75	52.21	51.54	0.48



Graph 4: Difference between Conventional and sequential analysis of BM (G+14)

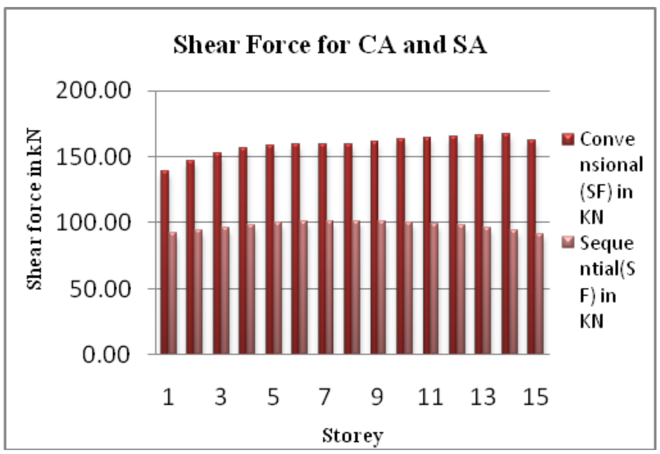
Observations

From above graph of Responsive member forces for bending moment following points are observed.

1. The maximum percentage reduction of bending moment from above table is 55.75 % at storey 14.
2. The bending moment for conventional analysis shows increasing values except storey 15.
3. Table shows bending moment for sequential analysis are in increasing order up to 8 storeys's after it will reduces. i.e. it shows the summit cure like shape.

Table 6: Difference between Conventional and Sequential analysis of SF (G+14)

Storey	Load Combination (B56)	Shear force in kN		% Reduction	Factor
		Conventional	Sequential		
1	DCon2	139.23	92.18	33.79	0.66
2	DCon3	146.74	94.47	35.62	0.64
3	DCon3	152.82	96.64	36.76	0.63
4	DCon3	156.20	98.37	37.02	0.63
5	DCon3	158.19	99.68	36.99	0.63
6	DCon3	159.27	100.57	36.86	0.63
7	DCon3	159.63	101.05	36.69	0.63
8	DCon2	159.70	101.14	36.67	0.63
9	DCon2	161.46	100.85	37.54	0.62
10	DCon2	162.96	100.18	38.53	0.61
11	DCon2	164.21	99.14	39.63	0.60
12	DCon2	165.20	97.74	40.84	0.59
13	DCon2	165.92	95.98	42.15	0.58
14	DCon2	167.11	93.89	43.81	0.56
15	DCon2	161.99	91.50	43.51	0.56



Graph 5: Difference between Conventional and sequential analysis of SF (G+14)

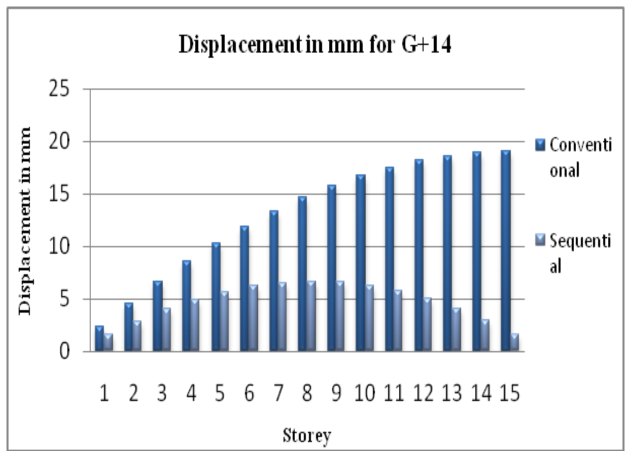
Observations

From above graph of Responsive member forces for Shear force following points are observed

1. The maximum percentage reduction of Shear force from above table is 43.81 % storey 14.
2. In conventional analysis the values shows in increasing order up to storey 14.
3. Table shows shear force for sequential analysis are in increasing order up to 8 storey after it reduces up to storey 15. it shows the summit curve like shape.

Table 7: Difference between Conventional and sequential analysis of Displacement (G+14)

Storey	Displacement in mm		% Reduction	Factor
	Conventional	Sequential		
Storey 1	2.36	1.53	35.17	0.65
Storey 2	4.57	2.86	37.42	0.63
Storey 3	6.63	4	39.67	0.60
Storey 4	8.54	4.93	42.27	0.58
Storey 5	10.29	5.67	44.90	0.55
Storey 6	11.88	6.19	47.90	0.52
Storey 7	13.32	6.52	51.05	0.49
Storey 8	14.6	6.63	54.59	0.45
Storey 9	15.72	6.54	58.40	0.42
Storey 10	16.68	6.24	62.59	0.37
Storey 11	17.48	5.73	67.22	0.33
Storey 12	18.17	5	72.48	0.28
Storey 13	18.6	4.07	78.12	0.22
Storey 14	18.92	2.92	84.57	0.15
Storey 15	19.07	1.56	91.82	0.08



Graph 6: Difference between Conventional and sequential analysis of Displacement (G+14)

Observations

From above graph of Responsive member forces for Deflection following points are observed.

1. The maximum percentage reduction of deflection from above table is 91.82 % at storey 15
2. The value of deflection for conventional analysis shows increasing values.
3. Table shows deflection for sequential analysis is in increasing order up to 8 storey's after it reduces to storey 15. (it shows the summit curve like shape)

IV. CONCLUSION

The structure has been studied for the parameters bending moment, shear force and displacement and it is observations are as follows.

1. The maximum percentage reduction in Bending moment, Shear force and displacement in sequential analysis as compare to conventional analysis as follows.

	Bending moment	Shear force	Displacement
G+11	49.11	41.04	89.86
G+14	55.75	43.81	91.82

2. The values of sequential analysis are lesser than that of conventional one.
3. It can be concluded that more realistic design approach obtained by using sequential analysis.

V. ACKNOWLEDGMENT

It is with a feeling of great pleasure that I would like to express my most sincere heartfelt gratitude to my guides, Prof. Ganesh Chandrakant Jawalkar Assistance professor, of Civil Engineering, NBNSCOE Solapur for their encouragement, advice, mentoring and research support throughout my studies. Their technical and editorial advice was essential for the completion of this dissertation. Their ability to teach, depth of knowledge and ability to achieve perfection will always be my inspiration.

I express my sincere thanks to Dr. S. D. Navale Principal of NBNSCOE Solapur & Prof. P. P. Tapkire, Head of Department, of Civil Engineering NBNSCOE, Solapur for providing me the necessary facilities in the department.

I would also take this opportunity to express my gratitude and sincere thanks to all faculty members of structural engineering, for their invaluable advice, encouragement, inspiration and blessings during the project.

I would like to thank all my friends; they really were at the right place at the right time when I needed. I would also express my sincere thanks to laboratory Members of Department of Civil Engineering, NBNSCOE, Solapur.

REFERENCES

[1] Lokanath Reddy & A Uday Kumar (Dec.2015) Construction Sequential Analysis and Design of Rc High Rise Buildings by Etabs, published by International Journal of Research (IJR) e-ISSN: 2348-6848, p- ISSN: 2348-795X Volume 2, Issue 12, December 2015

[2] Prof. MRS. K.MYTHILI*1 and MOHAMMED ABDUL RAHMAN2, “Construction sequence analysis of a building with vertical discontinuity” published by gjesr (oct.2015)

[3] Irwin, Baker, Korista, Weismantle & Novak (2006), “The Burj Dubai Tower: Wind Tunnel Testing of Cladding and Pedestrian Level”, Structure Magazine, published by NCSEA, November 2006, pp 47-50.

[4] Rosenboom O.A., Paret T.F.and Searer G.R.(2012), “Chronological Construction Sequence, Creep, Shrinkage and Pushover Analysis of an Iconic 1960s Reinforced Concrete Building”, published by 15th World Conference on Earthquake Engineering (15WCEE)

[5] IS 1893-2016 Criteria for Earthquake Resistant Design of structures.

[6] S.K. Duggal: Earthquake resistance design of structure.