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Static and Dynamic Analysis of Multy-Story Building

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Abstract- *This project represents the structural behavior of multy-story building under static and dynamic loading using ETABS. In this paper The study involves 1 Commercial G+23 storey building with loading as per IS codes and no infill walls and 1 Residential G+15 storey building with loading as per IS codes and no infill walls. The modelling and analysis is done using ETABS. Response spectrum method is used for analysis and the results obtainedare plotted for parameters such as storey displacement, storey drift and base shear.*
Index Terms- *ETABS, Response spectrum method, Seismic analysis, base shear, story drift*

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I. INTRODUCTION

Nowadays due to scarcity of Land and increase in Infrastructural requirements in urban areas there is considerable increase in F.S.I for upcoming structures which requires sophisticated approach towards planning and designing of a high-rise structure. Hence it is a challenge to find a particular approach to achieve structural stability along with feasibility in Architectural planning to tackle large Lateral loads to deliver safe and serviceable infrastructure to the society. Today is the era of Performance Based Engineering philosophies in the analysis and design of Civil Engineeringstructures. Qualitative analysis and design provisions require Structural Engineers to perform both static and dynamic analysis for the design of structures.

PROBLEM STATEMENT

a. Design and analysis s analysis of reinforced concrete moment resisting open frame with different locations,sizes of shear walls and columns.

b. To study Commercial G+23 storey building with loading as per IS codes and no infill walls and 1 ResidentialG+15 storey building with loading as per IS codes and no infill walls.

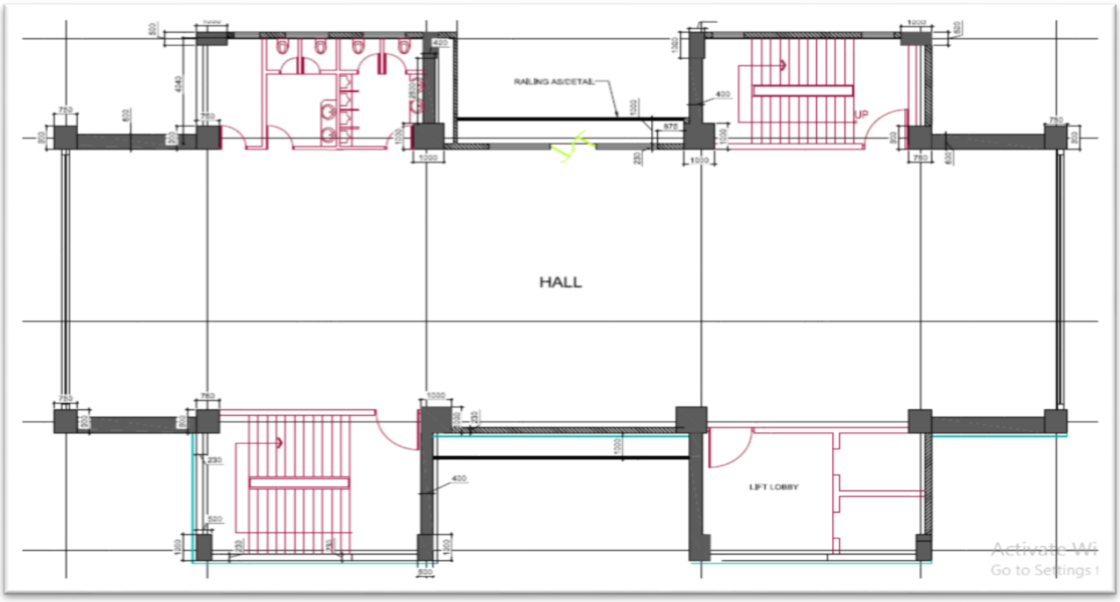
c. To study the response such as maximum storey displacement, storey drift and base shear.

MODELLING AND ANALYSISCOMMERCIAL PROJECT ANALYSIS

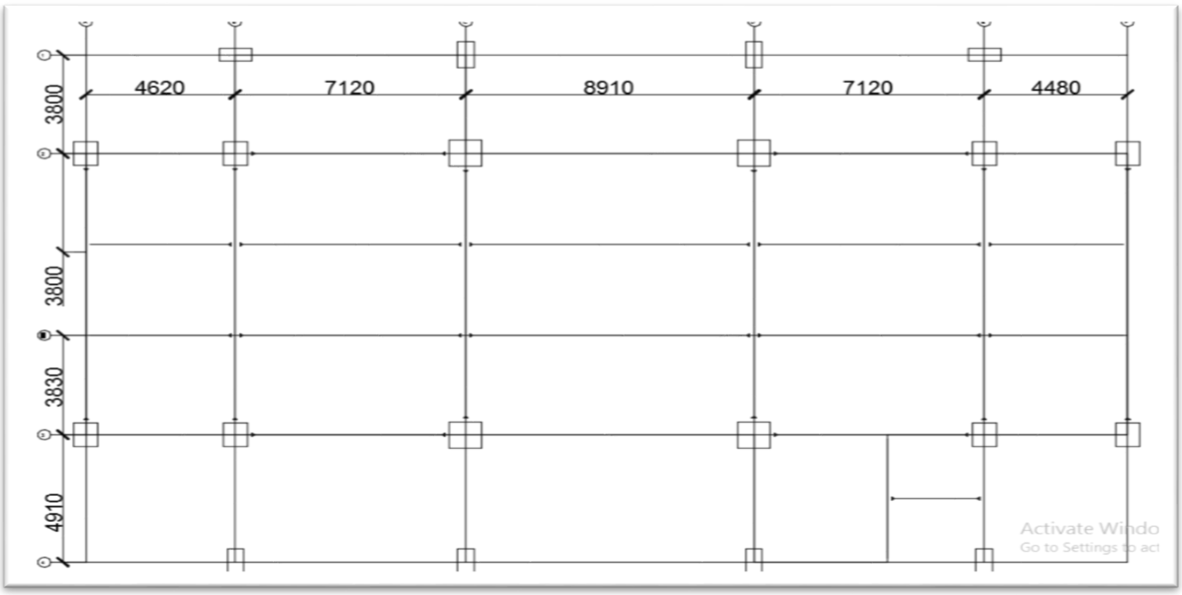
The preliminary model finalised for analysis is up to water tank top slab with presence of staircase along with columns and shear walls. The Details of commercial building are mentioned in below table.

Sr. No	Particulars	Details
1	Model	G+23
2	Seismic Zone	IV- Delhi Region
3	Storey height	Basement 5.1m, Other 3m & 3.6m
4	Plan size	32.9m x 20.6m
5	Size of columns	400mm x 1000mm , 500mm x 1000mm,750mm x 900mm , 1000mm x 1000mm
6	Size of beams	230mm x 450mm , 230mm x 600mm
7	Walls	External & Internal Partition Wall = 230mmStructural Wall(SW) = 400mm
8	Thickness of slab	125 mm
9	Type of soil	Type-II, Medium soil as per IS1893 (Part) I: 2016
10	Material used	Concrete M-30 and ReinforcementFe-500
11	Static analysis	Equivalent Lateral Force Method
12	Dynamic analysis	Response Spectrum Method

13	Earthquake load	IS1893 (Part) I: 2016
14	Wind load	IS875 (Part 3) : 2015
15	Live load	IS875 (Part 2) : 1987
16	Specific weight of RCC	25 KN/m^2
17	Specific weight of infill	10 KN/m^3
18	Software used	ETABS for both Static and DynamicAnalysis MS Excel for Wind load calculation



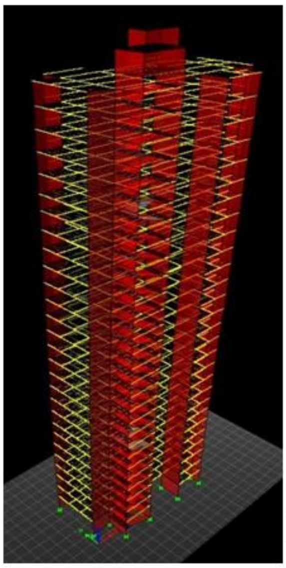
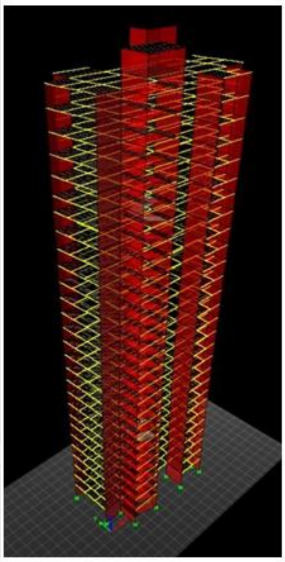
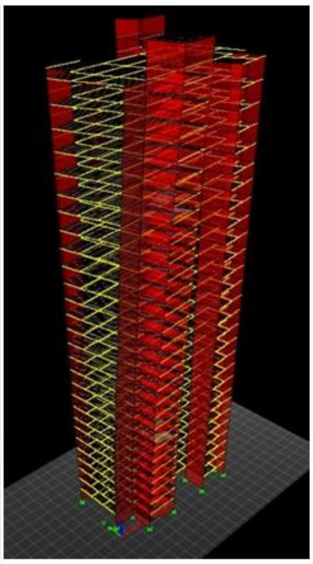
Architectural layout for typical floors (Commercial)



Centre line Structural layout for import in ETABS (Commercial)

MODEL - G+23 WT					
Sr. no	**Description of check**	**Result of Analysis**	**Requirement**	**Reference**	**Status of Analysis**
1	Fundamental time periodfor mode 1	7.523	8s max	IS16700:2017 Cl 5.5.2 pg 5	PASS
2	Fundamental time periodfor mode 2	6.601	8s max	IS16700:2017 Cl 5.5.2 pg 5	PASS
3	Fundamental time periodfor mode 3	5.855	8s max	IS16700:2017 Cl 5.5.2 pg 5	PASS
4	Behaviourin FundamentalMode 1	Translation	Pure TranslationExpected	Columns behave ingroup in pure translation	PASS
5	Behaviourin FundamentalMode 2	Translation	Pure TranslationExpected	Columns behave ingroup in pure translation	PASS
6	Behaviourin FundamentalMode 3	Torsional	TorsionalExpected	Indirectly Linked with IS16700:2017Cl 5.5.1 pg 5	PASS
7	Torsional modecheck	(0.9X6.915=6.22) >5.855	(0.9X6.915=6.22) >5.855	IS16700:2017 Cl 5.5.1 pg 5	PASS
8	Modal mass participation in first 3modes	SUM UX (3rd mode) = 66.69SUM UY (3rd mode) = 64.85	SUM UX (3rd mode) > 65% SUM UY (3rd mode) > 65%	IS1893(P1):2016 Pg17 Table5	PASS
9	First 2 Translational mode's check	(0.9x7.523=6.601)<7.88	(0.9x7.523=6.601) <7.89	IS1893(P1):2016 Pg17 Table6	PASS
10	Lateral DriftRatio (Δmax/hi)	WLX+ = (0.0048/3.6)=0.01 3 WLY+ = (0.010/3.6)=0.002	Maximum permissible H/500 = (107.15/500) = 0.2143	IS16700:2017 Cl 5.4.1 pg 5	PASS
11	Lateral Drift Earthquake(Drift)	RSX+ = 0.0026 RSY+ = 0.0031	Maximum permissible hi/250 = (3.6/250) = 0.0144	IS16700:2017 Cl 5.4.1 pg 5	PASS
12	Torsional	WLX+ = 1 WLY+ = 1	Ref pt i) 2) intable 5	IS 1893(P1):2016 Cl 7 Table 5 pg14	PASS

From above table it can be declared that the t model satisfies all stability requirements and the structural stiffness is not only adequate enough to resist all loads but also satisfies all parametric checks from IS Code. Hence stiffness used in trial 02 is adaptable practically. Fig. shows mode shape 1, 2 pure translation and mode 3 as torsional respectively

Mode shape 1 Translation along Y Mode shape 2 Translation along X Mode shape 3 Torsional

RESULT INTERPRETATION

As mentioned in 8.2 the trial 02 model is modelled with cracked section properties hence for comparison the same model was analysed without use of cracked section properties and the comparison in both is shown in table 8.2.2 which indicates that results obtained with the use of stiffness modifiers are on conservative side.

Comparison between results obtained from cracked and uncracked model

Comparison of Analysis Using Cracked And Uncracked Section Properties			
Sr.no	Parameter	ResultCracked model	Result Un Cracked model
1	Fundamental time period formode 1 time period	7.523	5.167
2	Fundamental time period formode 2 time period	6.601	4.547
3	Fundamental time period formode 3 time period	5.855	3.916
4	Base Shear (ELX+) in kN	3325.3356	3325.3356
5	Base Shear (ELY+) in kN	2589.7775	2589.7775
6	Base Shear (RSX+) in kN	1739.9778	1849.6141
7	Base Shear (RSY+) in kN	1812.1862	1918.1506
8	Max Story Drift (RSX+) in mm	0.0026	0.0011
9	Max Story Drift (RSY+) in mm	0.0031	0.00028
10	Max Story Drift (WLX+) in mm	0.0048	0.002
11	Max Story Drift (WLY+) in mm	0.01	0.0048

After satisfying all checks it can be concluded that Structural system adopted for G+23 model is notonly most efficient but also safe. Hence the work can be further proceeded towards the residential building modeling and analysis.

Analysis of G+15 Residential Building

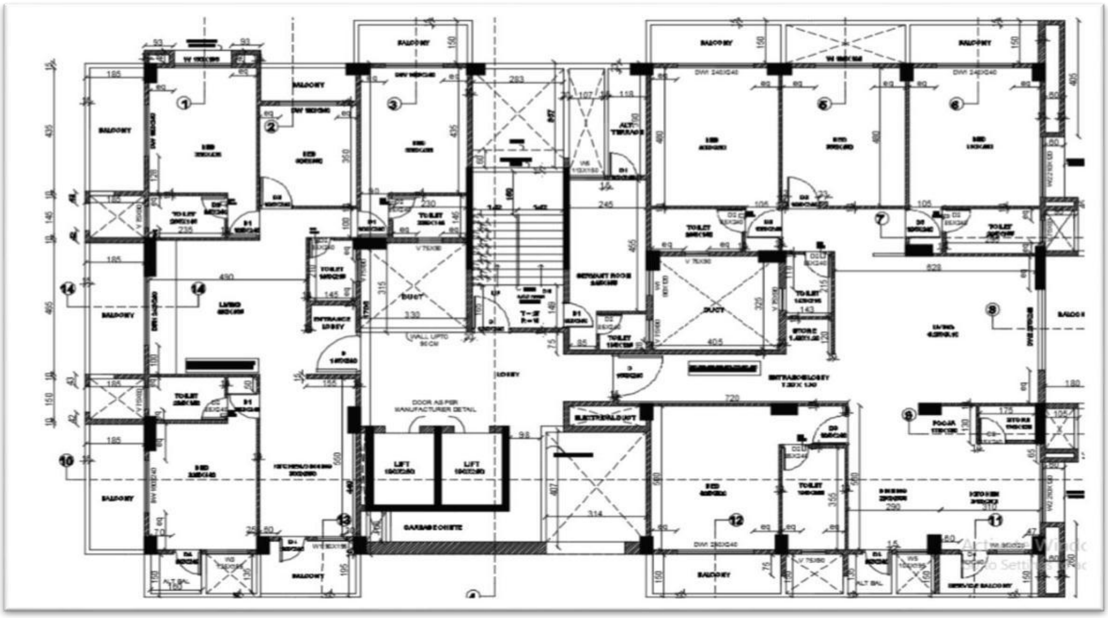
The preliminary model finalised for analysis is up to water tank top slab with presence of staircase alongwith columns and shear walls. The Details of Residential building are mentioned in below table. Architectural Plan and centre line to import in ETABS are shown in figure

Preliminary analysis

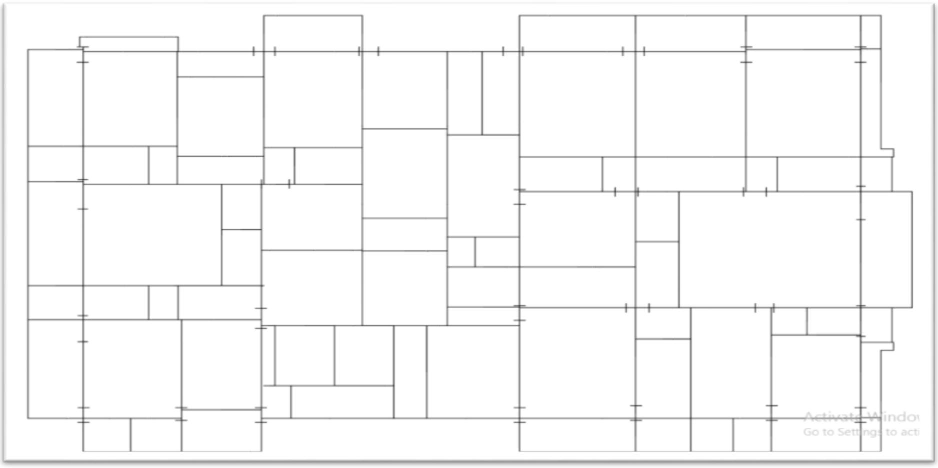
Data of Preliminary analysis (Commercial)

Sr. No	Particulars	Details
1	Model	G+15
2	Seismic Zone	III- Nashik Region
3	Storey height	3m
4	Plan size	30.5m x 20.05m
5	Size of columns	400mm x 600mm, 400mm x 680mm,400mm x 830mm, 400mm x 900mm
6	Size of beams	150mm x 600mm, 300mm x 675mm
7	Walls	External & Internal Partition Wall = 230mm Structural Wall(SW) = 200mm,230mm,300mm & 350mm
8	Thickness of slab	125mm,135 mm &150mm
9	Type of soil	Type-II, Medium soil as per IS1893 (Part) I: 2016
10	Material used	Concrete M-35 and ReinforcementFe-500
11	Static analysis	Equivalent Lateral Force Method
12	Dynamic analysis	Response Spectrum Method
13	Earthquake load	IS1893 (Part) I: 2016
14	Wind load	IS875 (Part 3) : 2015
15	Live load	IS875 (Part 2) : 1987
16	Specific weight of RCC	25 KN/m^2

17	Specific weight of infill	5 KN/m^3 (For AAC Blocks)
18	Software used	ETABS for both Static and DynamicAnalysis MS Excel for Wind load calculation



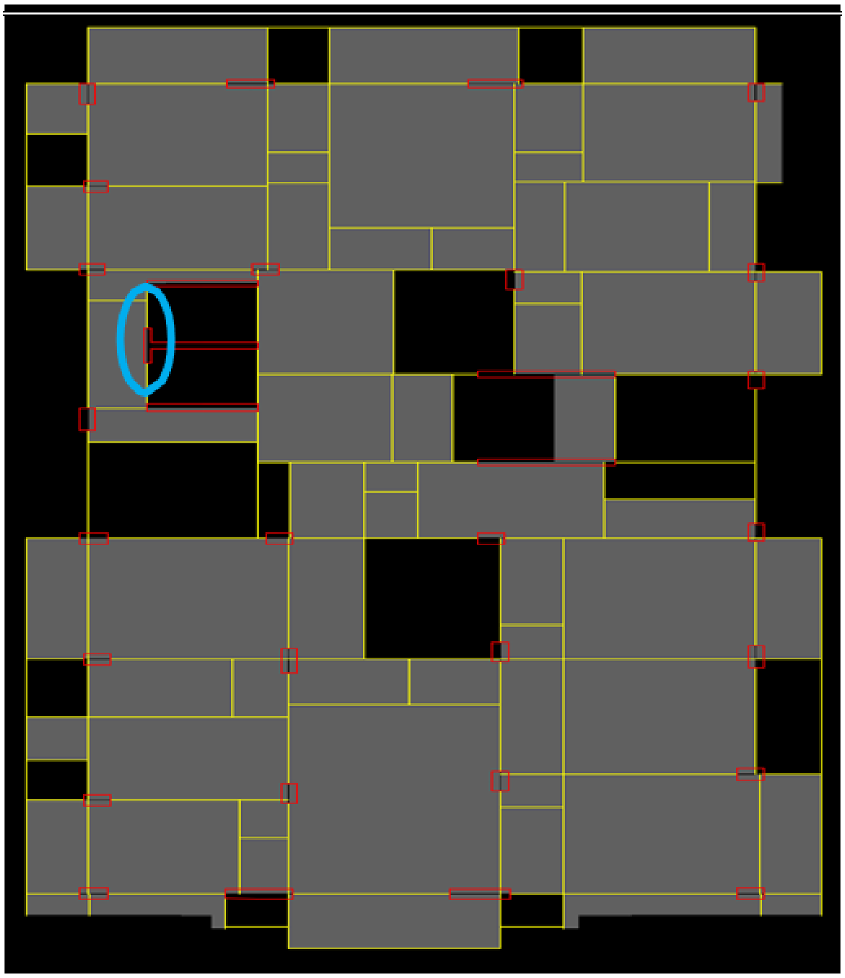
Architectural layout for typical floors (Residential)



Centre line Structural layout for import in ETABS (Residential)

After interpretation of results from i.e. by observing the plot of centre of mass and centre of rigidity it was noted that centre of rigidity was concentrated towards eccentric location of lift core which led a large eccentricity between centre of mass and rigidity in X and Y directions respectively which ultimately induced rotation in fundamental mode along principal plan directions. Hence it is a challenge to shift centre of rigidity towards centre of mass for which almost 10 more trials were did by inducing new shear walls along with rearranging the orientation of columns but this also didn't helped. To tackle this a conceptual thought was given that if the continuous 4.2m continuous common wall for 2 lift core is adjusted to such a length that the CR moves upward towards the CM. Hence a new structural layout by partial eliminating the 4.2m length to 1.2m along longer direction as highlighted in figure 9.3.1 is done.
All loads

i.e. Dead load, Live load, Wind load and earthquake loads are applied as mentioned in along with cracked section modifiers.



Modified structural layout for trial03 plan view (Residential)

After doing the analysis for trial03 to check whether the conceptual thought applied has led to any effective change or not, the plot for centre of mass and centre of rigidity was plotted as shown in figure 9.3.2, 9.3.3 for 1st and 15th floor respectively. From the plot it is clearly observed that there is considerable shift in CR towards CM in 1st floor eliminating large eccentricity as of in trial02 for 1st floor and the CR and CM almost coincides for 15th floor which is ideal expectation of every structural designer.

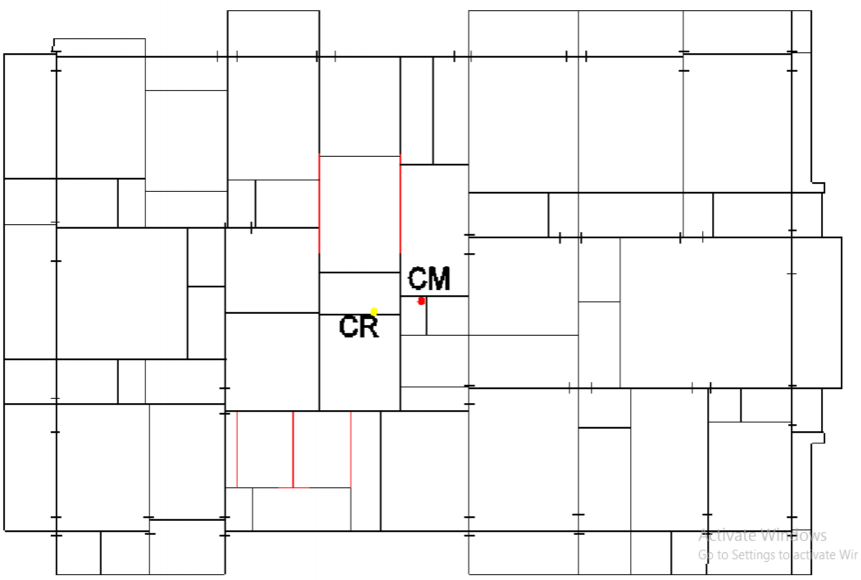


Figure 9.3.2 Plot of CM & CR at 1st floor level for trial03

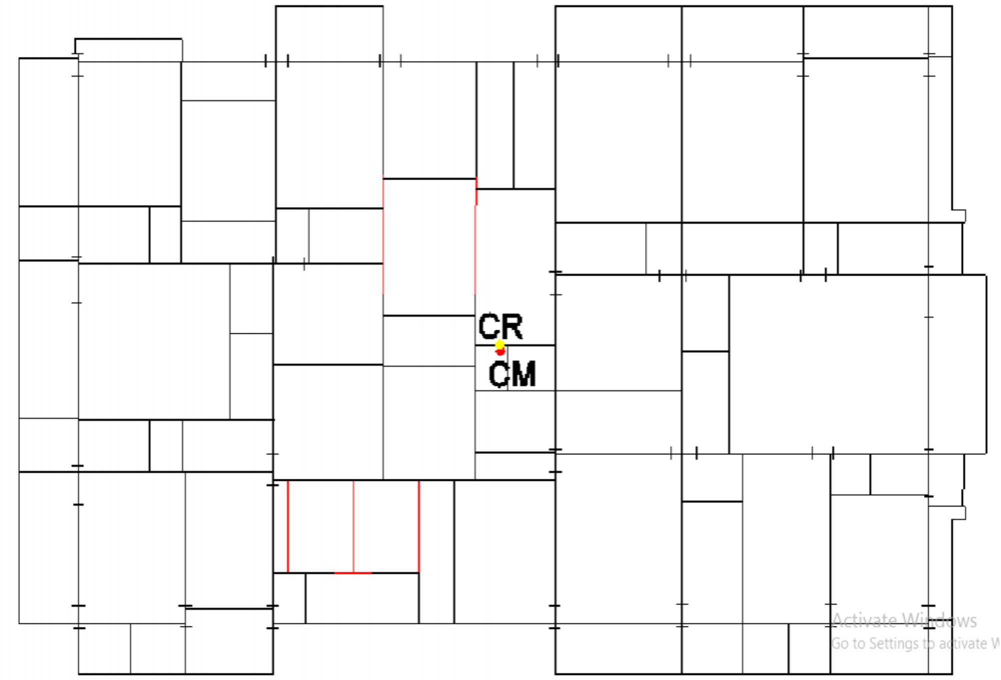


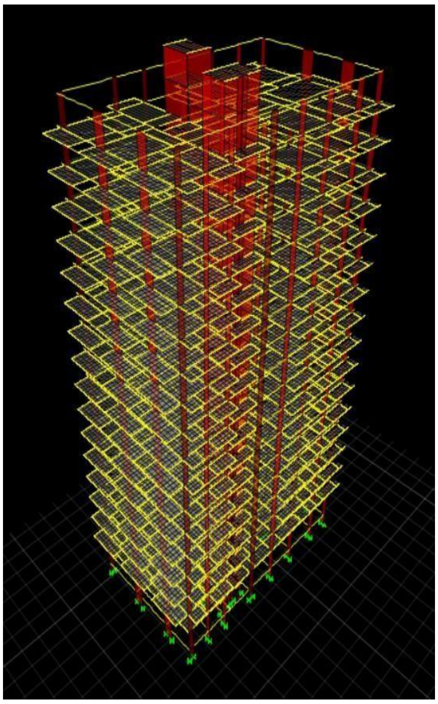
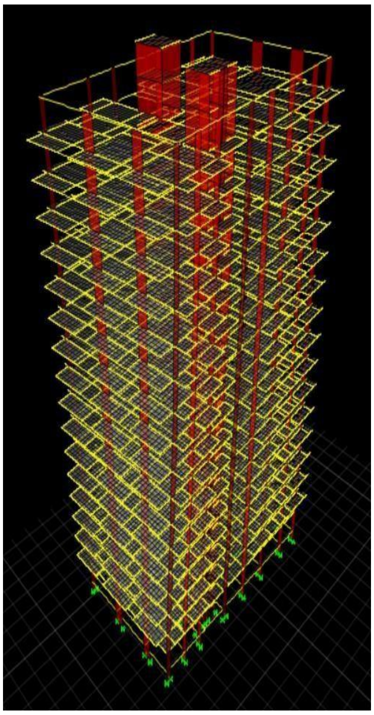
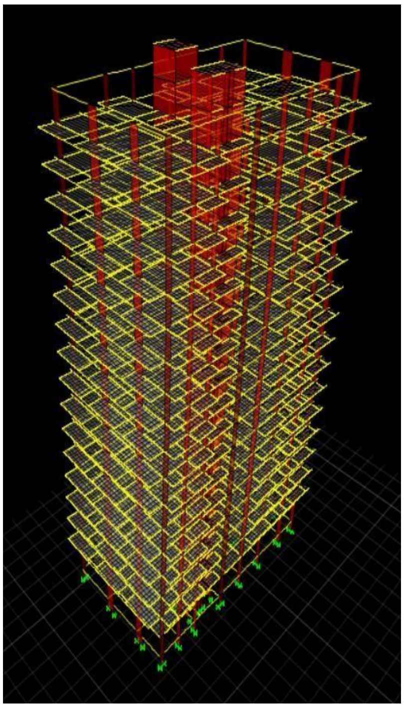
Figure 9.3.3 Plot of CM & CR at 15th floor level

The analysis results for are displayed in table and figure illustrates that satisfies all checklist concerned with IS codes and the structural stiffness along with lateral load resisting system is adequate enough to tackle all loads. Hence analysis for residential G+15 building can be concluded .

Dynamic parameters checklist

MODEL - G+23 WT					
Sr. no	**Description of check**	**Result of Analysis**	**Requirement**	**Reference**	**Status of Analysis**
1	Fundamental time periodfor mode 1	2.15	8s max	IS16700:2017Cl 5.5.2 pg 5	PASS
2	Fundamental time periodfor mode 2	1.92	8s max	IS16700:2017Cl 5.5.2 pg 5	PASS
3	Fundamental time periodfor mode 3	1.604	8s max	IS16700:2017Cl 5.5.2 pg 5	PASS
4	Behaviour in FundamentalMode 1	Translation	Pure Translation Expected	Columns behave in groupin pure translation	PASS
5	Behaviour in FundamentalMode 2	Translation	Pure Translation Expected	Columns behave in group in pure translation	PASS
6	Behaviour in FundamentalMode 3	Torsional	TorsionalExpected	Indirectly Linked with IS16700:2017Cl 5.5.1 pg 5	PASS
7	Torsional mode check	(0.9X1.92=1.728>1. 604)	0.9X1.92=1.72 8>1.604)	IS16700:2017Cl 5.5.1 pg 5	PASS
8	Modal mass participationin first 3 modes	SUM UX (3rd mode) = 85.69SUM UY (3rd mode) = 74.85	SUM UX (3rd mode) > 65% SUM UY (3rd mode) > 65%	IS1893(P1):201 6 Pg17 Table5	PASS
9	First 2 Translational mode's check	(0.9x2.15=1.935)>1 .92	(0.9x2.15=1.935)>1.92	IS1893(P1):201 6 Pg17 Table6	PASS
1 0	Lateral DriftRatio (Ϫmax/hi)	WLX+ = (0.0005/3)=0.00016WLY+ = (0.0004/3)=0.00013	Maximum permissible H/500 = (57.65/500) =0.11	IS16700:2017Cl 5.4.1 pg 5	PASS

11	Lateral Drift Earthquake(Drift)	RSX+ = 0.0051 RSY+ = 0.0046	Maximum permissible hi/250 = (3.0/250) =0.012	IS16700:2017Cl 5.4.1 pg 5	PASS
12	Torsional	WLX+ = 1 WLY+ = 1	Ref pt i) 2) intable 5	IS 1893(P1):2016 Cl 7 Table 5pg14	PASS

Mode shape 1 Translation along Y Mode shape 2 Translation along X Mode shape 3 Torsional

II. CONCLUSION

1. Base shear in building depends on the mass of building and Irregularity in plan results in eccentricity of centre of mass and centre of rigidity.
2. In commercial and residential both buildings it is observed that displacement of building is higher when direction of earthquake is perpendicular to longer face of building.
3. It is observed that torsional moment generated due to eccentricity in centre of mass and centre of rigidity is directly related to mass. As mass of building increases torsional movement increases and hence to tackle that torsional moment the mass and stiffness must be rearranged by considering the plot of centre of mass and centre of rigidity as done for residential building.
4. Torsional movement is comparatively more when direction of earthquake is perpendicular tothe shorter face of building.

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