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Structural Performance of High Rise Building

Er. Supriya Patil[1], Dr.M.N.Bajad[2]

[1]P.G.Student, Sinhgad College of Engineering Pune, Maharashtra State, India
[2]Professor, Dept. of civil Engineering, Sinhgad College of Engineering, Pune, Maharashtra State, India

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1. TEST RESULT AND DISCUSSION

In this context G+ 24 storey RC Structural wall system analysis and design output is considered. In this section results obtained by analysis and design are represented in comparative forms. The time period, storey Displacement, storey drift, storey shear are observed for different stories. The analysis is carried out using ETABS v2018 and database is prepared for different storey levels are as follows.

1.1Time period and Frequency

Table.1.1. Modes and Natural Period, Natural Frequency

Mode	Natural Frequency	Natural Period
1	2.827	0.3537
2	2.424	0.4125
3	2.309	0.4330
4	0.845	1.1834
5	0.536	1.8656
6	0.501	1.9960
7	0.434	2.3041
8	0.279	3.5842
9	0.23	4.3478
10	0.217	4.6083
11	0.199	5.0251
12	0.151	6.6225

Mode of structure is nothing but in which all points of structure moves harmonically at the same frequency to reach their individual maximum response. The number of modes to be used in analysis should be such that the sum of modal masses of all modes considered is at least 90% of the total seismic mass and missing mass correction beyond 33 %.According to this requirement of IS1893:2016 we had considered 12 modes. Generally first three modes are considered for corresponding Natural period. The frequencies at which at which normal mode vibrations are possible for a structure are called as natural frequencies of structure. Generally first three frequencies are considered for practice Natural frequency is maximum for mode 12 and minimum for mode 1.

1.2. Manually Computation of seismic weight

Dead Load

Slab = slab thickness x slab area x Density of Concrete
= 0.125 x 464 x 25= 1460 KN
Beam = Beam length x Beam size x Density of concrete= 203.062 x 0.6x0.23 x25=700.5639KN.
Walls
i) Structural walls = Wall length x Wall thickness x Density of concrete = 162 x 0.2 x 25 = 2349 KN
ii) Non-Structural walls = Wall length x Wall thickness x Density of concrete = 37.472 x 0.15 x 25 + 45.952 x 0.12 x 25= 278.376KN
Live Load = 25 % of total area = (25 x 46.4)/100= 115KN
Total weight per floor = Weight of slab + weight of beam +weight of walls= 1460 + 700.5639 +2349 +278.376 +115 = 4902.93KN
Total seismic weight of all floor = 4902.93 x 25 = 122573.4975 KN

1.3. Design Base Shear

Static base shear in X direction in KN
= Sa/g*I/R*/2*seismic weight
= (0.16 /2) * (1.0/4.0) * (1.326)* 122573.4975
= 3250.64 KN
Static base shear in X direction in KN
= Sa/g*I/R*/2*seismic weight
= (0.16 /2) * (1.0/4.0) * (0.754)* 122573.4975

= 1842.4 KN

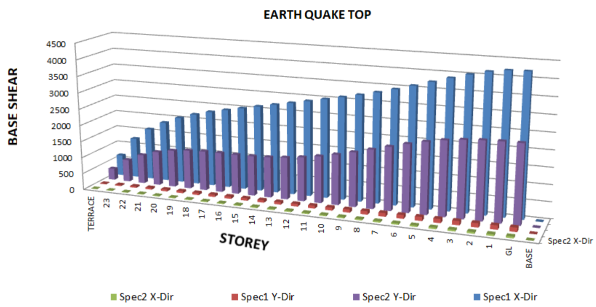

Figure .1.8. Base Shear Top – Earthquake Load Case

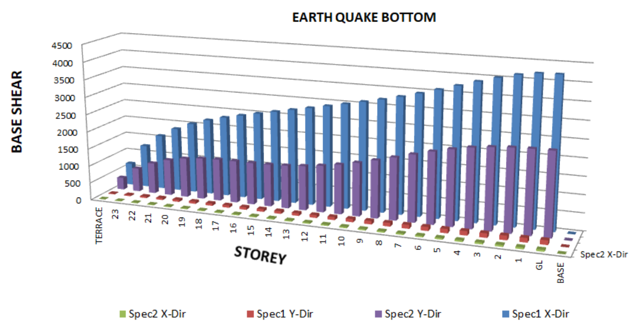

Figure.1. 9. Base Shear Bottom–Wind Load Case

1.4. Maximum Storey Displacement:

Storey displacement means the displacement which occurred at each storey level.

In multi- storied building maximum storey displacement will observed at the top stories.

As the height is increasing the storey displacement will have maximum value.

Horizontal limits on building displacement

Wind at service loads= H/ 500 , (H =Total height)

Storey Drift limitations = 0.004 h, (h= story height) ……IS1893:2016

Earthquake –Service state loads = H /250

(H =Total height)

Manual Calculation

Wind at service loads = H/500

= (71.6 * 1000) / 500

= 143.2 mm.

Earthquake –Service = H/250

State loads = (71.6*1000)/ 250

= 286.4 mm

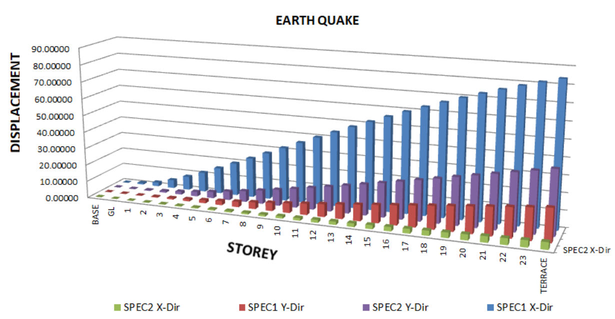

Figure.1.10. Maximum Storey Displacement – Earthquake Load Case

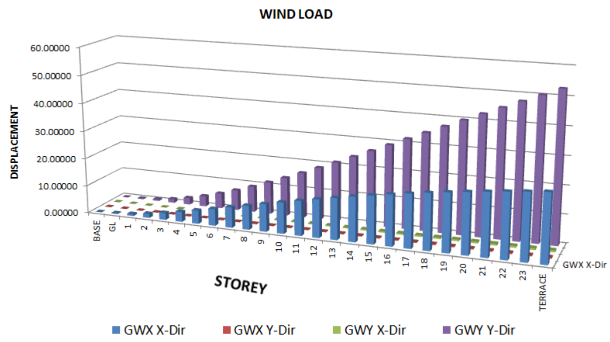

Figure.1.11. Maximum Storey Displacement – Wind Load Case

From output Etab and manual calculation it is verified that displacement of building under dynamic wind and earthquake is within the limit as per IS code.

1.5. Storey Drift:

Storey drift is relative displacement between any two levels of storey between the floor above and below the under consideration.
Drift causes horizontal displacement in high rise building. It affects movements of structural and non-structural elements under seismic and wind load.
During earthquake shaking, buildings sway laterally and excessive lateral displacement is not desirable. Large lateral displacements cause significant non-structural damage, structural damage.
Inter-storey drift ratio (IDR), defined as the relative

translational displacement between two consecutive

floors divided by the storey height.

Equations defining drift and drift index are,

Total drift of th i floor = Δi Inter-storey drift of i

floor (δ) i = Δ i −Δ (i−1)

Drift Index = deflection/height

Manual Calculation Storey drift

limitations =0.004h = 0.004 * 2.9*1000
= 11.6 mm As per the IS1893-2016

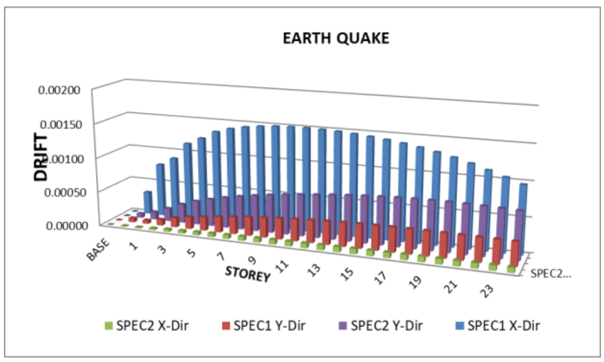

Figure.1.12. Storey Drift -Earthquake Load Case

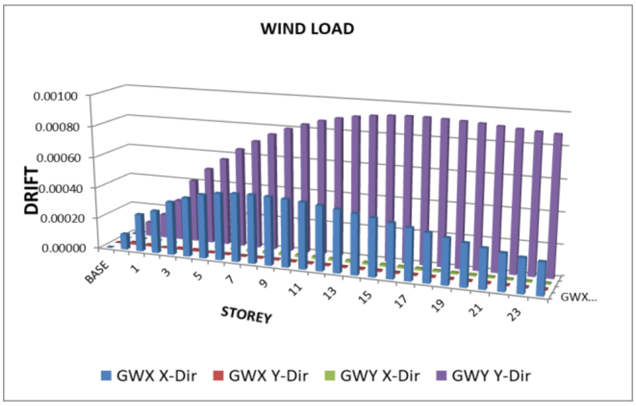

Figure.1.13. Storey Drift - Wind Load Case

Figure.1.12, 1.13 shows maximum storey drift for earthquake and wind load cases and it is verified with manually calculation maximum storey drift is within permissible limit under seismic and wind loading.

1.6 Torsional Irregularity:

If torsional rigidity of structure decreases then structure becomes sensitive to torsion.

Torsional irregularity should be considered when maximum story drift at one end of the structure transverse to an axis is more than 1.4 times the average of the story drift (or interstory drifts) at the two ends of the structure.i.e

max/ ΔAvg<1.4 then structure is regular

Where, Δmax is the maximum drift of a floor corner,

Δaverage is the average drift of the considered edge of the floor in the excitation direction

Maximum Deflection /Average Deflection<1.4 then structure is regular

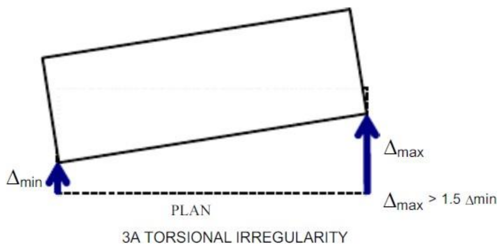

Figure.1.14-Torsional Irregularities

Figure-taken from IS1893-2016 clause no.7.1toshow the torsional irregularities.

Deflection (mm) on Terrace level from Etab

X-Direction l

Load Case –Earthquake		Wind
Corner 1	78.755	23.886
Corner 2	84.067	24.073
Corner 3	78.755	23.886
Corner 4	84.067	24.073

Maximum Deflection /Average Deflection<1.4

52.950/52.247 = 1.013 <1.4

24.073/ 23.979 <1.0038

Y-Direction l

Load Case –Earthquake		Wind
Corner 1	37.814	51.545
Corner 2	36.402	51.545
Corner 3	37.814	52.950
Corner 4	36.402	52.950

Maximum Deflection /Average Deflection<1.4

Earthquake:52.950/52.247 = 1.013 < 1.4

Wind: 37.814/37.108 =1.019 < 1.4

So, it is verified that structure is regular in X and Y direction

1.7 Stiffner Modifier

Generally it is used to reduce stiffness of concrete section in model for cracked behaviour of concrete. i.e. o stimulates structural behaviour of structure in cracked stage. Stiffeners modifiers have significant on behaviour of structure, in the absent of modifiers structure would be stiffer and attract higher lateral forces due to earthquake. So one can end up with heavy structural members and at the same time it also underestimates the drift. It also affects force distribution among different member of structure.

I. Stiffener Modifiers:

Stiffener modifiers are nothing but factors which is used to increase or to decrease the properties of concrete.

As per IS1893-2016 for structural analysis moment of inertia is taken as in Conventional column beam system

Walls 70% & for Beams 35 %

2. CONCLUSIONS

i) A high rise building of 24 floors subjected to seismic, wind and live loads were analyzed using ETAB 2018 software.

ii) Storey drifts, displacement are under dynamic wind load and seismic load are within permissible limit and it is manually verified as shown in table.

iii) The displacement is more in model 1 compare to other models,

iv) The displacement caused by dynamic earthquake and wind forces is minimum due to use of RC Shear Wall.

v) Structure is regular as it is in permissible limit of ΔMax / ΔAvg < 1.2 (as per IS 1893(part-1):2002).under dynamic wind and seismic load As High-rise building are sensitive to Wind forces, it is can summarized that use of structural shear wall performance is good, useful and efficient.

vi) By comparing manual design and software result, it is seen that software analysis is more convenient, required less time as compared to manual calculation, so far industrial practice it is always better to use software analysis for structural performance of high rise structure.

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