Lateral load comparison of G+12 storied steel structure in ETABS-2016

Rajai Jayesh¹, Dr. Sanghvi Chaitanya²

¹Post graduate student, applied mechanics department, L.D. College of engineering, Ahmedabad, 380015, India
²Professor, applied mechanics department, L.D. College of engineering, Ahmedabad 380015, India

Abstract - In India use of steel structure is very rare specially for residential and commercial purpose which covers most of construction work. For fast construction work initiative for use of steel structure on large scale is very much essential. Also it reduces the construction time, and time is money now a days, ultimately steel structure proves time saving and economic. By keep in mind that steel structure is future of construction in India, publishing this paper and shows the comparison of lateral load of G+12 storied steel structure building with different slab dimension of 3mX3m, 4mX4m and 6mX6m in ETABS-2016. Seismic loads and wind loads are applied on building as a lateral loads.

Key Words: Steel structure, Seismic load, Wind load, ETABS-2016.

1. INTRODUCTION

Steel structure is very fast construction type compare to RCC construction type. Also steel structure saves the construction time compare to RCC structure. To understand the behaviour of steel structure, analyzed the G+12 storied steel structure building in ETABS-2016 and understand the effect of lateral loading. For comparison of lateral loading 3 building with different slab dimensions are taken for analysis i.e. 3mX3m, 4mX4m and 6mX6m with 7 grids in X-direction and 5 grids in Y-direction, so final plan dimension of building will 18mX12m, 24mX16m and 36mX24m respectively. Seismic load applied as per IS 1893-part(1)-2001 and wind load is applied as per IS 875-part(3)- 1987.

Geometry and analysis data of building.

<table>
<thead>
<tr>
<th>Location</th>
<th>Ahmedabad</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBC</td>
<td>240 kN/m²</td>
</tr>
<tr>
<td>Grade of steel</td>
<td>250 MPa</td>
</tr>
<tr>
<td>Grade of concrete</td>
<td>20 MPa</td>
</tr>
<tr>
<td>Grade of reinforcement</td>
<td>415 MPa</td>
</tr>
<tr>
<td>Importance factor (I)</td>
<td>1</td>
</tr>
<tr>
<td>Response reduction factor (R)</td>
<td>5</td>
</tr>
<tr>
<td>Zone factor</td>
<td>Zone 3 (0.16)</td>
</tr>
<tr>
<td>Soil type</td>
<td>Medium</td>
</tr>
<tr>
<td>Wind speed</td>
<td>39 m/sec</td>
</tr>
<tr>
<td>Category of building</td>
<td>3</td>
</tr>
<tr>
<td>Class of building</td>
<td>Class B</td>
</tr>
<tr>
<td>Live load</td>
<td>2 kN/m²</td>
</tr>
<tr>
<td>Floor finish</td>
<td>1 kN/m²</td>
</tr>
</tbody>
</table>

Fig 1- Typical Plan of G+12 storied building

Fig 2- 3D view of G+12 storied building in ETABS-2016
2. Analysis G+12 storied building in ETABS-2016

Analysis the building based on data given above and assigning of member property done by auto select mode, in this mode of auto select in ETABS-2016 automatic member property is assigned to the member. After then run the program gives the actual moment and shear force on the member according to its property, if we design the building in ETABS-2016, we get final size of member and that sizes are obtained as below. Response spectrum analysis is considered for seismic loading.

Load combinations are applied to the structure are as follows.

\[
\begin{align*}
DL &= \text{Dead Load} \\
LL &= \text{Live Load} \\
EQX &= \text{Earthquake Load in X-direction} \\
EQY &= \text{Earthquake Load in Y-direction} \\
WX &= \text{Wind Load in X-direction} \\
WY &= \text{Wind Load in Y-direction}
\end{align*}
\]

1. \(1.5(DL+LL)\) \\
2. \(1.2(DL+LL+EQX)\) \\
3. \(1.2(DL+LL+EQY)\) \\
4. \(1.5(DL+EQX)\) \\
5. \(1.5(DL+EQY)\) \\
6. \(1.2(DL+LL+EQY)\) \\
7. \(1.2(DL+LL+EQX)\) \\
8. \(1.5(DL+EQY)\) \\
9. \(1.5(DL+EQX)\) \\
10. \(0.9DL + 1.5EQX\) \\
11. \(0.9DL - 1.5EQX\) \\
12. \(0.9DL + 1.5EQY\) \\
13. \(0.9DL - 1.5EQY\) \\
14. \((DL+LL)\) \\
15. \((DL+LL+EQX)\) \\
16. \((DL+LL+EQY)\) \\
17. \((DL+LL+EQY)\) \\
18. \((DL+LL+EQY)\) \\
19. \((DL+EQX)\) \\
20. \((DL+EQY)\) \\
21. \((DL+EQY)\) \\
22. \((DL+EQY)\) \\
23. \(1.2(DL+LL+WX)\) \\
24. \(1.2(DL+LL+WX)\) \\
25. \(1.5(DL+WX)\) \\
26. \(1.5(DL+WY)\) \\
27. \(1.2(DL+LL+WX)\) \\
28. \(1.2(DL+LL+WX)\) \\
29. \(1.5(DL+WY)\) \\
30. \(1.5(DL+WY)\) \\
31. \(0.9DL + 1.5WX\) \\
32. \(0.9DL - 1.5WX\) \\
33. \(0.9DL + 1.5WX\) \\
34. \(0.9DL - 1.5WX\)

Mass source is applied as \(DL+0.25LL\) to the building.

<table>
<thead>
<tr>
<th>Slab panel size</th>
<th>3mX3m</th>
<th>4mX4m</th>
<th>6mX6m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main beam size</td>
<td>ISLB 225</td>
<td>ISLB 300</td>
<td>ISMB 350</td>
</tr>
<tr>
<td>Secondary beam size</td>
<td>ISLB 125</td>
<td>ISLB 225</td>
<td>ISMB 350</td>
</tr>
<tr>
<td>Column size</td>
<td>ISWB 500</td>
<td>ISWB 550</td>
<td>ISWB 600</td>
</tr>
</tbody>
</table>

3. Lateral load calculation

1) Seismic load calculation

Horizontal seismic coefficient \(A_h = (Z/2) \times (I/R) \times (Sa/g)\)

Values of Z, I and R are already given above, now for value of (Sa/G), so from IS 1893-part(1)-2001 time period of building and (Sa/g) in X and Y direction given below.

Now base shear \(V_b = A_h \times W\), where \(W = \text{total weight of building (kN)}\).

<table>
<thead>
<tr>
<th>Dimension of building</th>
<th>18mX12m</th>
<th>24mX16m</th>
<th>36mX24m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.827</td>
<td>1.013</td>
<td>0.716</td>
</tr>
<tr>
<td></td>
<td>1.644</td>
<td>1.342</td>
<td>1.898</td>
</tr>
<tr>
<td></td>
<td>0.026</td>
<td>0.026</td>
<td>0.03</td>
</tr>
<tr>
<td>(W) (kN)</td>
<td>8206</td>
<td>12168</td>
<td>20569</td>
</tr>
</tbody>
</table>

2) Wind load calculation.

Design Wind Speed \(V_w = V_b \times k_1 \times k_2 \times k_3\) (IS 875-part (3)-1987)

\(V_w = \text{Basic wind speed = 39 m/sec for Ahmedabad}\) \\
\(k_1 = \text{Risk coefficient factor = 1}\)
Consider 5-20% permeability so internal pressure coefficient cpi = +0.5 and -0.5 (cl 6.2.3.2, IS 875-part (3))
External pressure coefficient cpe = 0.8 (table 4, 875-part (3)-1987)

\[ V_s = 39*1*1.057*1 = 41.223 \text{ m/sec} \]
And wind pressure \[ P_z = 0.6*V_s^2 \] = 0.6*41.223^2 = 1019.6 N/m^2

Wind force \[ P = (cpe + cpi) * A * P_z \]
Where \( A \) = surface area of structural element. Hence below given table shows the manual and ETABS Wind force comparison.

<table>
<thead>
<tr>
<th>Dimension of building</th>
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<th>36mX24m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mod ETAB</td>
<td>Manu ETAB</td>
<td>ETAB</td>
</tr>
<tr>
<td>X-dir</td>
<td>617.4</td>
<td>620.3</td>
<td>823.6</td>
</tr>
<tr>
<td>Y-dir</td>
<td>926.1</td>
<td>930.5</td>
<td>1234.1</td>
</tr>
</tbody>
</table>

4. CONCLUSIONS

In multi-storey RCC structure governing loads are generally Seismic, but here in case of steel structure wind load is governing factor. In most of case 1.5(DL+WY) is a governing load combination. As building dimension increases member property assigned to the building by auto select mode is going to higher. Lateral load values of seismic and wind loads are increase with increase the building dimensions. Time period reduces with increase the building dimensions. In both lateral load cases seismic and wind manual calculations and ETABS-2016 results are almost near to each other with maximum variation of 5%.

REFERENCES


[7] SP-16 (design aids for RCC)

[8] IS 800-2007 (GENERAL CONSTRUCTION IN STEEL)

[9] IS 15916-2010 (BUILDING DESIGN AND ERECTION USING PREFABRICATED CONCRETE)

[10] IS 875-1987/2016(part-3) (code of practice for design loads other than earthquake loads-wind loads)