Comparative Study of Flat Slab and Conventional Slab Structure Using ETABS for Different Earthquake Zones of India

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Abstract - In today’s construction activity the use of flat slab is quite common which enhances the weight reduction, speed up construction, and economical. Similarly from the beginning conventional slab has got place in providing features like more stiffness, higher load carrying capacity, safe and economical also. As the advancement era began practice of flat slab becomes quite common. In the present dissertation work a G+5 commercial multistoried building having flat slab and conventional slab has been analyzed for the parameters like base shear, storey drift, axial force, and displacement. The performance and behavior of both the structures in all seismic zones of India has been studied. In the present work the storey shear of flat slab is 5% more than conventional slab structure, the axial forces on flat slab building is nearly 6% more than conventional building, the difference in storey displacement of flat and conventional building are approximately 4mm in each floor. The present work provides reasonable information about the suitability of flat slab for various seismic zones without compromising the performance over the conventional slab structures.

Key Words: flat slab, drop, conventional slab, storey shear, storey displacement, axial forces.

1. INTRODUCTION

In this modern industrial era we can see huge construction activities taking place everywhere, hence there will be a shortage of land space, so construction of tall structures has been triggered up to overcome this problem. There are several elements are modified to make work faster and economical also like introducing flat slab construction which reduces dead weight, and makes beams invisible, enhances floor area. To know the performance of the structure it should be subjected to all type loadings, all seismic zones factors, various soil categories then only we can extract best choice or suitability parameter for the structures.
check for punching shear against software. Flat slabs are more vulnerable to punching shear because of the absence of beam. In direct design method following criteria must be satisfied for design of flat slab.
- The panel must be square or rectangle
- Ratio of longer span by shorter span not more than 2
- Live load should not be more than 3 times design dead load.

In the present work only manual design of flat slab taken and punching shear values of software is compared with manual calculated punching shear.

### Table 1: Structure Plan Details

<table>
<thead>
<tr>
<th>Number of stories</th>
<th>G+5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height of each storey</td>
<td>3.7m</td>
</tr>
<tr>
<td>Total height of building</td>
<td>25.9m</td>
</tr>
<tr>
<td>Number of bay's along X</td>
<td>7</td>
</tr>
<tr>
<td>Number of bays along Y</td>
<td>3</td>
</tr>
</tbody>
</table>

### Table 2: Structure Element Details

<table>
<thead>
<tr>
<th>columns</th>
<th>800x800, 300x900, 300x900, 300x900, 300x900</th>
</tr>
</thead>
<tbody>
<tr>
<td>beams</td>
<td>600x750, 500x750</td>
</tr>
<tr>
<td>Flat slab</td>
<td>200mm</td>
</tr>
<tr>
<td>Flat drop</td>
<td>450mm</td>
</tr>
<tr>
<td>Conventional slab</td>
<td>175mm</td>
</tr>
</tbody>
</table>

### 1.4 Earthquake and Wind Load Data

The structures are more vulnerable to lateral loads, as the height of building increases the structures becomes flexible and prone to damage. Hence lateral loads are mainly derived from seismic and wind loads for which structure needs to be analyzed.

### Table 3: Earthquake and Wind Load Data

<table>
<thead>
<tr>
<th>Seismic zone</th>
<th>II, III, IV, V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone factor Z</td>
<td>0.1, 0.16, 0.24, 0.36</td>
</tr>
<tr>
<td>Importance factor I</td>
<td>1</td>
</tr>
<tr>
<td>Response reduction factor</td>
<td>3</td>
</tr>
<tr>
<td>Damping ratio</td>
<td>0.05</td>
</tr>
<tr>
<td>Type of soil</td>
<td>medium</td>
</tr>
<tr>
<td>Basic wind speed $V_b$</td>
<td>33m/sec</td>
</tr>
<tr>
<td>Design wind pressure $P_d$</td>
<td>1.6kN/m²</td>
</tr>
</tbody>
</table>

### Load Calculation:

- Self weight: $0.65x1x25 = 16.25kN/m²$
- Live load: $5kN/m²$
- SDL: $3.5kN/m²$
- Total load = $24.75kN/m²$
- Ultimate load = $1.5x24.75 = 37.125kN/m²$
- Design load on the slab = $37.125x10x8 = 2970kN$

### Moment Calculation:

- $M_o = W_oL/8 = 2980kN\cdot m$
- $M_o = W_oL/8 = 3712kN\cdot m$

Check for depth of slab at drops:
Taking 49% of negative BM along x-direction
- $M_{u} = 0.49x2980 = 1460.2 \text{ kN} \cdot \text{m}$

- $D_{req} = \sqrt{M_u / 0.138 f_{ck} b} = 375 \text{ mm} D_{pro} = 450 \text{ mm}$, hence safe

Check for punching shear: $\tau_v = 1.07N/mm^2$ (manual), $\tau_v = 1.25N/mm^2 \tau_v = 1.12N/mm^2$ (ETABS value)

- $\tau_v < \tau_c$ hence safe in shear
2. Analysis of Flat and Conventional Slab Building using ETABS

The analysis of flat and conventional slab structure has been done by using ETABS software package. Before analysis all the required elements of the structure needs to be defined earlier like material properties, loads, load combinations, size of members, response spectrum etc. once the analysis has been done we can extract the results like displacement, storey shear, bending moment, drift ratio, axial forces for comparing the performance of flat and conventional slab building. The following flow chart shows the steps involved in the analysis by ETABS.

3. RESULTS AND DISCUSSIONS

In this section the results obtained from analysis of flat slab and conventional slab building using ETABS have been tabulated. The performance and behavior of both structures on different criteria like storey shear, storey displacement, drift ratio, and axial design forces has been analyzed and discussed as follows.

3.1 Storey Shear of FSB and CSB for SRSSX Load Case:

- Chart 1: Storey Shear of FSB Vs CSB Zone II
- Chart 2: Storey Shear of FSB Vs CSB Zone III
- Chart 3: Storey Shear of FSB Vs CSB Zone IV
The storey shear is maximum at ground level and keeps decreasing towards the top storey of the structure. From the chart it shows storey shear of flat slab structure is more than the conventional slab structure. And also as the seismicity level increases the storey shear intensity is also increases.

3.2 Axial forces on FSB & CSB 1.5(DL+LL+SDL)

Design axial forces in the zone II and zone III conventional slab has got more intensity compared to flat slab structure. There is a difference of 5% in between flat and conventional slab structure in zone II and zone III.
Axial forces are important in design of foundation elements, these forces are derived from live load, dead load, wind loads ad earthquake loads. From the above chart intensity of design reaction increases as the seismicity level increases as shown in from zone II to zone. From zone II and zone III conventional slab carryig more axial loads, where from zone IV to zone V flat slab is ahead of conventional slab structure. From zone II to zone V there is an increase of average 35% axial forces in both the structures.

3.3 Storey Displacement of FSB and CSB for SRSSX Load case

Storey displacement is Maximum at top storey and least at the base of structure. This criterion is important when structures are subjected to lateral loads like earthquake and wind loads. Displacement depends on height of structure and slenderness of the structure because structures are more vulnerable as height of building increases by becoming more flexible to lateral loads.

3.4 Drift Ratio Comparisons of FSB and CSB

Storey drift is defined as difference between lateral displacements of one floor relative to the other floor. Total
storey drift is the absolute displacement of any point relative to the base. As per IS.1893-2002 CL.7.11.1 the storey drift in any storey due to the minimum specified design lateral force with partial load factor 1.00 shall not be exceeding 0.004 times the storey height. In this case storey height is 3700 mm. Therefore limited storey drift is calculated as = storey drift /3700 =0.004

4. CONCLUSIONS

1. Storey shear of flat slab is 6% more compared to conventional slab structure, and storey shear is Maximum at base and least at top storey.

2. The design axial forces on flat slab are more compared to conventional structure the difference of forces is nearly 5.5%.

3. Storey displacement is Maximum at roof level than at base, and storey displacement of flat slab structure is greater than conventional structure, there will be an average 4mm displacement variation in each seismic zone for both structures.

4. As the seismic level increases all parameters like axial force, displacement, storey shear intensities are increases.

4.1 Scope of Future Work

- Comparisons of flat plate (without drop) and flat slab (with drop) can be studied for all seismic zones.

- Comparisons of pretension and post tensioned flat slab with or without drops.

- Cost comparisons of various types of slabs available.

REFERENCES


BIOGRAPHIES

MOHANA H.S, Resident of Hassan district. Received UG (civil) from MCE Hassan and PG (structures) from AIT chikmagalur.

KAVAN M.R (Assistant professor) in AIT chikmagalur, he has got 2 years of teaching experience and currently pursing PhD in structures.