Seismic Analysis Of Multistorey Building With Different Slab Type On Plain And Sloping Ground Using ETABS

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Abstract- Buildings present on sloping ground are very different from those on plain ground, on sloping ground the buildings are very irregular and unsymmetrical in both horizontal and vertical planes. The buildings on sloping ground causes more damage during earthquake, because on sloping ground the structure is constructed with different column heights. The object of the present work is to compare the behaviour of multi-storey buildings having flat slab and ribbed slab with that of conventional grid slab on plain ground and sloping ground. In the study 3D analytical model with the slope chosen in between 0 to 20 degree is taken .The response spectrum analysis is performed for all the models as per IS 1893-2002 using ETABS 2016 software. From the response spectrum analysis the properties of the building such as displacement, storey drift and storey shear have been studied for all the models.

keywords- sloping ground, flat slab, ribbed slab, grid slab, response spectrum

I. INTRODUCTION

Earthquake resistant design of RC buildings is a continuing area of research since the earthquake engineering has gained prominence across the globe. The seismic behavior of the structure during the earthquake depends critically on parameters like shape of the structure, size of the structure, intensity of the earthquake along with the type of slab. Structures designed for gravity loads in general may not be able to sustain the horizontal vibrations of the earth. With increase in height there is need for resisting lateral loads like earthquake load and wind load. Hence it is necessary to ensure the adequacy of the structure against horizontal vibration of the earth. Earthquake of different intensities can damage the building differently. So, it is necessary to analyze the various seismic behavior of multi storey building with different responses such as lateral displacement, storey drift and base shear. Thus a careful modeling is done for analyzing the seismic behaviour of structures. The buildings present on sloping ground are very different from those on plain ground, on sloping ground the buildings are very irregular and unsymmetrical in horizontal and vertical planes. The buildings on sloping ground causes more damage during earthquake, because on sloping ground the structure is constructed with different column heights. Flat slab is most widely used systems in reinforced concrete construction in offices, residential and industrial buildings in many parts of the world. In flat slab system, slab directly rested over the column in four corners. This can be done with or without drop and also with or without column head. This arrangement gives the advantage of reduced floor to floor height. Grid floor system consisting of beam spaced at regular intervals in perpendicular directions, monolithic with slab. They are generally employed for architectural reasons for large room such as, auditoriums, theater halls, show room of shops. Ribbed slab is a panel composed of a thin slab reinforced by ribs in one direction. Two way ribbed slab system is known as waffle system.

The seismic analysis is done for the structures which are prone to the seismic forces. Generally, analysis are classified as linear static analysis, linear dynamic analysis, non-linear static analysis and non-linear dynamic analysis. Linear static analysis or equivalent static analysis can be used for regular structures with limited height. Linear dynamic analysis can be performed by two ways, either by response spectrum method or by the elastic time history method. The significant difference between linear static and linear dynamic analysis is the level of the forces and their distribution along the height of the structure. Non-linear static analysis is simple to implement and provide information on the strength, deformation, and ductility of the structure, as well as the distribution of demands. Non-linear dynamic analysis or inelastic time history analysis is the only method to describe the actual behavior of a structure during an earthquake.

A. Objectives

1. To compare the performance of RC frame on Plain Ground & Sloping Ground with Flat Slab, conventional grid slab and ribbed slab Structure. In sloping ground the angles are 0 to 20 degrees along the horizontal length of the building.
2. Response spectrum analysis is carried out for critical zone (zone V) as per IS 1893 (Part1):2002 for medium soil type.
3. To study the effect of storey shear, displacement and storey drift.

B. SCOPE

In this study 3D analytical model with the slope chosen in between 0 to 20 degree is taken. The response spectrum analysis is performed for all the models as per IS 1893-2002 using ETABS 2016 software. From the response spectrum analysis the properties of the building such as displacement, storey drift and storey shear have been studied for all the models. The work will help greatly in achieving the better safety, economy and comfort in the design of the multistoried building (in the seismic zones of India) which is the need of the hour. Moreover, for the economic development of hilly areas, urbanization plays a very important role, so that there has been a great demand for the improvement of these areas by multi-storey building construction.

II. TYPES OF SLAB SYSTEMS

Flat slab- Commonly the reinforced concrete slab is supported directly by beams and beams are supported by columns this system is known as slab-beam construction. In slab-beam construction, beam decreases the available net clear floor height, hence in structures like offices, warehouses and public halls sometimes due to aesthetic view beams are not provided thus slabs are directly placed on columns. So these type of construction of slabs directly supported by columns are known as Flat slab. Flat slab can be constructed quickly due to their simple formwork and reinforcing bar arrangements. Building height can be reduced- As no beam is used, floor height can be reduced and consequently the building height will be reduced.

Grid slab- Grid floor systems consisting of beams spaced at regular intervals in perpendicular directions, monolithic with slab. They are generally employed for architectural reasons for large rooms such as auditoriums, vestibules, theatre halls, show rooms of shops where column free space is often the main requirement. The rectangular or square void formed in the ceiling is advantageously utilized for concealed architectural lighting. The sizes of the beams running in perpendicular directions are generally kept the same. Ribbed slab- Ribbed or waffle slab is a slab system which consists of series of parallel reinforced concrete T beams framing into reinforced concrete girders. The slab is the flange of the beam and the extended part is the web. The extended part is known as ribs. The spacing between the ribs should be in general 20-30 inch. The ribs are tapered in cross-section in its lower part.

TABLE 1. MEMBER DIMENSIONS

<table>
<thead>
<tr>
<th>Building Properties</th>
<th>Type of slabs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grid slab</td>
</tr>
<tr>
<td>Building height</td>
<td>39m</td>
</tr>
<tr>
<td>Floor height</td>
<td>3m</td>
</tr>
<tr>
<td>No of stories</td>
<td>13</td>
</tr>
<tr>
<td>Size of beam</td>
<td>0.3x0.5m</td>
</tr>
<tr>
<td>Size of column</td>
<td>0.65x.65m</td>
</tr>
<tr>
<td>Slab thickness</td>
<td>0.13m</td>
</tr>
<tr>
<td>Bay in x direction</td>
<td>6m</td>
</tr>
<tr>
<td>Bay in y direction</td>
<td>7m</td>
</tr>
</tbody>
</table>

C. BUILDING MODELS

1. Conventional grid slab building models
IV. RESULTS AND DISCUSSION

A. Displacement results [Model 1 to Model 3]

1. The displacement in X direction (shown in fig 4) is found to be maximum in model M1 and it is equal to 28.33mm at storey 13.
2. The displacement in Y direction is found to be maximum in model M1 and it is equal to 27.107mm at storey 13.
3. When all the models are compared, the maximum displacement is found in model M1 along X direction and is equal to 28.33mm at storey 13. The values of displacement are within the permissible limit as per IS 1893-2002.

B. Storey drift results

1. The storey drift in X direction (shown in fig 5) is found to be maximum in model M1 and it is equal to 0.001039 at storey 4.
2. The storey drift in Y direction is found to be maximum in model M1 and it is equal to 0.001088 at storey 4.

C. Storey Shear results

1. The storey shear in X direction (shown in fig 6) is found to be maximum in model M1 and it is equal to 0.001039 at storey 4.
2. The storey shear in Y direction is found to be maximum in model M1 and it is equal to 0.001088 at storey 4.
1. The storey shear in X direction (shown in fig 6) is found to be maximum in model M2 and is equal to 2372.4695 KN at storey 2.
2. The storey shear in Y direction is found to be maximum in model M2 and is equal to 2264.39KN at storey 2.
3. When all the models are compared, the maximum Storey shear is found in model M2 along X direction and is equal to 2372.4695kN at storey 2.

D. Displacement results [ Model 4 to Model 6 ]

1. The displacement in X direction (shown in fig 7) is found to be maximum in model M4 and it is equal to 672 mm at storey 13.
2. The displacement in Y direction is found to be maximum in model M4 and it is equal to 672 mm at storey 13.
3. When all the models are compared, the maximum displacement is found in model M4 and is equal to 672 mm at storey 13.

E. Storey drift results

1. The storey drift in X direction (shown in fig 8) is found to be maximum in model M4 and is equal to 0.0111 at storey 4.
2. The storey drift in Y direction is found to be maximum in model M4 and is equal to 0.0111 at storey 4.

F. Storey shear results

1. The storey shear in X direction is found to be maximum in model M6 and is equal to 2000kN at storey 4.
2. The storey shear in Y direction is found to be maximum in model M6 and is equal to 2000kN at storey 4.
3. When all the models are compared, the maximum Storey shear is found in model M6 and is equal to 2000kN at storey 4.

G. Storey Displacement results[Model 7 to 9]

1. The displacement in X direction (shown in fig 9) is found to be maximum in model M7 and it is equal to 450.51 mm at storey 13.
2. The displacement in Y direction is found to be maximum in model M7 and it is equal to 450.51mm at storey 13.
3. When all the models are compared, the maximum displacement is found in model M7 along X direction and is equal to 450mm at storey 13.

H. Storey Drift results

1. The storey drift in X direction (shown in fig 10) is found to be maximum in model M7 and is equal to 0.06 at storey 4.
2. The storey drift in Y direction is found to be maximum in model M7 and is equal to 0.06 at storey 4.
When all the models are compared, the maximum displacement is found in model M7 and is equal to 0.06 at storey 4.

I. Storey shear results

1. The storey shear in X direction is found to be maximum in model M9 and is equal to 1850kN at storey 3.
2. The storey shear in Y direction is found to be maximum in model M8 and is equal to 1810kN at storey 3.
3. When all the models are compared, the maximum Storey shear is found in model M9 along X direction and is equal to 1850kN at storey 3.

V. CONCLUSION

1. The displacement for model M1 (Grid slab model) is less when compared with the model M4 (Flat slab model). The storey displacement for model M4 (Flat slab model) is 50% more when compared with M7 (ribbed slab).
2. Storey drift is more on plain ground compared to sloping ground, this is due to increase in fixity of the structure.
3. The storey drift for model M1 (Grid slab model) is less when compared with the model M4 (Flat slab model) and model M7 (ribbed slab).
4. The storey drift in building with flat slab and ribbed slab construction was significantly more as compared to conventional slabs. As a result, additional moments were developed. Therefore, the columns of such buildings should be designed by considering additional moments caused by the drift.
5. The storey shear for model M1 (Grid slab model) is 18.62% more when compared with the model M4 (Flat slab model) and 28.21% more when compared with model M7 (ribbed slab).
6. The above results shows conventional slabs are more suitable for construction in seismic zones when compared to flat slab or ribbed slab system.

REFERENCES