A comparative study on seismic analysis of G+6 building with ribbed slab & conventional slab using SAP2000 software

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Abstract. The stability of structures mainly depends on the structural components like beams, columns and slab. Here in this study columns are reduced in the large open areas to access the whole room, which can be done by using the ribbed slab, grid slab and flat slab, which will help in minimizing the no. of columns which are required in the structure. A comparative study on seismic behaviour of G+6 school building is done with conventional slab and ribbed slab at seismic zone III and medium soil conditions by using SAP2000 software, it is found that in gravity analysis the maximum bending moments and shear force obtained for normal slab structure are 84.96 kN-m and 80.86 kN respectively, whereas for ribbed slab structure is 137.39 kN-m and 108.01 kN. The maximum storey stiffness of the ribbed slab structure is found to be 0.94 times of maximum storey stiffness of normal slab structure. It is found that the ribbed slab structure doesn’t perform well in moderate to high seismic areas. The stability of the ribbed slab structure can be enhanced by retrofitting the existing structure.

1. Introduction

An Earthquake is Earth's Shaking or the arrival of energy because of the movement of tectonic plates. This can be dangerous to slaughter a great many individuals and bring gigantic financial misfortune. Buildings are exceptionally influenced by a quake: and sometimes they are broken to the earth level. At the point when the ground shaking happens underneath the structure's establishments, they will get vibrated. There has been an extending enthusiasm for the development of seismic tremor safe structures; the fundamental target of this investigation is to get the behaviour of a structure with the ribbed slab. Also, the slab is a fundamental portion of the RCC type of structure which is intended to withstand both vertical and horizontal burden coming about during quakes. A ribbed slab is a lighter and stiffer slab when compared to the flat slab. They work very excellently where slab vibration is an issue, ribbed slab sections comprised of wide beams with narrow ribs crossing in a perpendicular direction to each other and a thin slab over it. Advantages of Ribbed type of slabs are it is flexible, moderately light, economical for a longer range of spans, construction is speed, thin floor depths, robustness, excellent vibration control.

Ribbed slab consists of parallel reinforced T shaped concrete beams which are framed into RCC girders. The slab is considered as the flange of the beam and extended parts as ribs. There are generally two types of ribbed slabs.

1. One way ribbed slab
2. Two-way ribbed slab (Waffle slab)
2. **Objective and Methodology**
   1. To identify the seismic performance of ribbed slab structures after the removal of obstructed columns in a hall or room of a building.
   2. To analyze and design the structure as per IS code recommendations.
   3. To analyze and compare the behaviour of structure with normal slab and ribbed slab.

![Flowchart of methodology](image)

**Fig 1: Flowchart of methodology**

3. **Structural modelling**

   3.1 **General properties**
   A G+6 building is modelled in SAP 2000 Software, with storey height of 3m, length of the structure in one direction is 25m and in other direction, it is 39m and the member sizes will vary according to design requirements. The thickness of the slab is 15cm; the thickness of the external and internal wall is 23cm and 11.5cm respectively. The model is analyzed with two different Structural elements one is Normal Slab Structure and the other is Ribbed Slab Structure and designed according to IS 456-2000.

Table 1: Material properties

| Name      | Type   | E MPa  | Unit Weight kN/m³ | Design Strengths          |
|-----------|--------|--------|-------------------|---------------------------|
| Concrete  | M30    | 27386  | 25                | Fc=30 MPa                 |
| HYSD415   | Rebar  | 200000 | 76.97             | Fy=415 MPa, Fu=485 MPa    |
| Mild250   | Rebar  | 200000 | 76.97             | Fy=250 MPa, Fu=410 MPa    |
3.2 Plan views of normal slab and ribbed slab structures

![Plan view of normal slab structure](image1)

![Plan view of ribbed slab structure](image2)

3.3 3D views of structures

![3D model of ribbed slab structure](image3)

![3D model of normal slab structure](image4)
4. Loading on structure

Loads are taken from Indian standard codebooks for dead loads we have IS 875 part 1, for Live loads IS 875 part 2 and seismic analysis is done according to the IS 1893 part 1 2016.

Table 2: Loading data

| Type of Load                | Intensity of Load                  |
|-----------------------------|-----------------------------------|
| Live load                   | 3 kN/m² (IS 875-Part 2)           |
| Floor finishing             | 1.1 kN/m² (IS 875-Part 1)         |
| Wall loads                  | External = 14 kN/m                |
|                             | Internal = 7 kN/m                 |
| Slab and Lift wall thickness| Slab = 150 mm                     |
|                             | Lift wall = 250mm                 |
| Seismic zone                | III                               |
| Type of soil                | Medium                            |

5. Results And Discussion

5.1 Results of gravity analysis

In gravity analysis, the maximum bending moments and shear force obtained for Normal slab are 84.96 kN-m and 80.86 kN respectively, whereas for Ribbed slab the gravity analysis result shows maximum bending moment as 137.39 kN-m and maximum shear force as 108.01 kN. In the table given below N.S.S stands for Normal Slab Structure whereas R.S.S stands for Ribbed Slab Structure.

Table 3: Maximum values of gravity analysis

| Type of member               | Load combination | Axial forces (kN) | Shear force (kN) | Bending Moment (kN-m) | Reinforcement (mm²) |
|-----------------------------|------------------|-------------------|------------------|-----------------------|---------------------|
| N.S.S Beam (400 x 300)      | 1.5(DL+LL)       | ------            | 80.86            | 84.96                 | 663                 |
| R.S.S Beam (400 x 300)      | 1.5(DL+LL)       | ------            | 108.0            | 137.39                | 1120                |
| N.S.S Column (350 x 300)    | 1.5(DL+LL)       | 2217.51           | 34.17            | 82.33                 | 4448                |
| R.S.S Column (400 x 350)    | 1.5(DL+LL)       | 2260.90           | 58.56            | 268.5                 | 7268                |

5.2 Results of seismic analysis

Seismic analysis is done by the linear static (equivalent static) method to get structural responses like lateral displacement, story drifts, overturning moment, story stiffness and base shear for both Normal Slab Structure and Ribbed Slab Structure.
Fig 6: Storey shears of normal slab structure

Fig 7: Storey shears of ribbed slab structure

Fig 8: Storey drifts of normal slab structure

Fig 9: Storey drifts of ribbed slab structure

Fig 10: Storey stiffness of normal slab structure

Fig 11: Storey stiffness of ribbed slab structure

Fig 12: Storey displacements of normal slab structure

Fig 13: Storey displacements of ribbed slab structure
From the above storey shear graphs, it is observed that lateral loads are more on ribbed slab structure when compared to normal slab structure, that means the ribbed slab structure has more self-weight.

For both types of structures, it is observed that storey drifts are in permissible limits as recommended by the IS 1893 code. There is a little amount of variation for storey drifts when both the structures are compared.

Storey stiffness is a bit more for normal slab structure as there are lesser columns in ribbed slab structure. In the software, storey stiffness will be calculated from storey1.

Storey displacements were found to have much less variation when both of the structures are compared to each other.

6. Conclusions

It can be concluded that ribbed slab structures compared to the normal slab structure in high seismic zones does not give a good performance because of lesser columns, whereas its performance can be enhanced by retrofitting the structure.

1. Maximum storey shear for ribbed slab structure is increased by 22% of normal slab structure.
2. Maximum Lateral displacement for the ribbed slab structure increased by 23% of normal slab structure.
3. Lateral loads on a ribbed slab structure are more when compared to the normal slab structure due to the increase of self-weight.
4. Storey drifts for normal slab structure are 20% less than the ribbed slab structure.
5. The maximum overturning moment for ribbed slab structure is 20% more than the normal slab structure.
6. Maximum storey stiffness of ribbed slab structure is found to be 0.94 times of maximum storey stiffness of normal slab structure.

The maximum overturning moment for ribbed slab structure was found to be 60321.2 kN-m whereas for normal slab structure it is 49888.4 kN-m.

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