Seismic Behaviour of Reinforced Concrete Flat Plate Systems

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Abstract - *It is very important in modern construction because flat slabs have so many advantages over traditional slabs that it is a very important part. Conventional slabs are being replaced by beamless slabs because they look better, take less time to build, are easier to form, and can be used in any room. Because the flat slabs are less stiff and have less shear strength, they can be more flexible than the traditional slabs, which are more rigid. When it comes to flat slabs, structural engineers say they aren't good for high-seismic areas. They need to be built up with shear walls or bracing. Or they need to be changed. The provision says that a structural engineer must do a linear static analysis for the design of a structure. Displacements, storey shears, and overturning moments are the main factors that cause a lot of damage to a building when there is an earthquake. In this study, RCC flat slab structures and traditional slab structures are used to compare a six-story building that is in an earthquake zone-II. For earthquake loading, the provisions of IS: 1893 (Part 1)-2002 are used. E-tabs 2021 software is used to make a three-dimensional model of the structure and to look at how it works. Linear Static Method of Analysis and Response Spectrum Analysis Method are used to look at both Flat slab structure and Conventional slab structure when they are being looked at. The forces and all of the relative displacements, storey shears, and overturning moments that happen in each of the structures are looked at, as well. The results of the analysis are talked about. It has also been used to figure out how flat slab structures and conventional ones work under lateral loads and earthquakes. The results are compared and it is found that the flat slab structure does better in earthquakes than the traditional slab structure.*

Key Words: Displacements, Storey Shears, Overturning Moments, Linear Static Analysis, Lateral Loads

1. INTRODUCTION

Earthquake is a natural phenomenon that happens when there are changes in the geotechnical activities in the layers of the Earth. It can be very hard to predict and can cause a lot of damage to both life and property if it happens in an area where people live. Earthquakes don't kill people, but they do damage the buildings. For this reason, it is the job of a structural engineer to draw out the parameters from their past work and think about all the hazards that the structure might face in the future, so that it can be built in a way that is as safe as possible.

There are a lot of ways to look at the structure and figure out how well it will work under a certain load, but the best one is called Non-Linear Time history Analysis. Non-Linear Static methods have been used for structures that aren't very important or that have a lot of seismic risk (NSPs). The results from these procedures may or may not be correct. In general, slabs can be one-way or two-way. One-way slabs are slabs that mostly move in one direction. When slabs are supported by columns that are arranged in rows so that the slabs can move in two directions, they are called two way slabs. beams can be added between the column and the slab to make it more stable. The slabs can also be strengthened by thickening them around the columns (drop panels) and by flaring their columns under the slabs (column capitals)

Flat plates are concrete slabs that are the same depth all the way across. They don't need beams, capitals, or drop panels to transfer the weight of the load to the supporting columns. Flat plates can be made quickly because of their simple formwork and bar reinforcements. They need the smallest overall storey heights to meet their head room needs. Then, they are the most flexible when it comes to how columns and partitions are put together. They also let in a lot of light and are very fire-resistant. There aren't many sharp corners where concrete could split. Most of the time, flat plates are used to build multi-story reinforced concrete hotels, flats and houses. They are also used in hospitals, dormitories, and other places where people live. Flat plates could make it hard to move the shear around the outside of the columns. There is a risk that the columns could break through the slabs. People often need to make columns bigger or thicker, use shear heads, or do both. They are made up of I or channel shapes that are cut into the slab above each column. However, it should be noted that the simple formwork needed to make flat plates is usually so cheap that the extra costs for shear heads are more than covered. There may be times when a different type of floor is needed for heavy industrial loads or long spans of space, though. Concrete slabs are often used to carry vertical loads straight to walls and columns without the need for beams and girders, so they don't need to be built. Flat plates are used when spans aren't very long and the loads aren't very heavy, like in apartment and hotel buildings.

When there are no column flares or drop panels, the term "flat plate" is used. Column patter is usually done on a rectangular grid, but flat plates can be used with column layouts that aren't all the same size. They have worked well with columns, triangle grids, and other ways to build them. Here, the floor slab is held in place by the columns without the help of stiffening beams, except at the edges. About 125-250mm thick for spans of 4.5-6m. Because it has limited shear strength and hogging moment capacity at the column supports, it can't carry as much weight as it should. Due to the fact that it's not too thick or flat on top, it is called a "flat plate." It has a lot of architectural appeal. Designs for Flat Plates or Flat Slabs assume that the slab will be split into three strips in each direction. There are two types of strips: one is called a column strip, and the other is called a middle strip. In slabs without drops, the width of the column strip should be half the width of the panel. In slabs with drops, the width of the column strip should be the same width as the drops. As a rule, if there are no drops in a slab of stone, its middle strip should be equal to half its width. The Direct Design Method, or the Equivalent Frame method, is the best way to figure out Bending Moment and Shear Force. The main objectives of the study are as follows to evaluate the seismic behavior of different regular RC moment resisting flat slab and conventional slab structure. And to evaluate base shear, storey displacement, overturning moments.

2. METHODOLGY

1. The Building is assumed to be in Zone-II (moderate zone for Earthquake)
2. Analysis of Conventional Slab of Building using ETABS.
3. All building is being designed as per IS 456:2000 & IS 1893:2002.
4. The Building is assumed to be in Zone-II (moderate zone for Earthquake)
5. Analysis of Flat Slab of Building using ETABS.
6. All building is being designed as per IS 456:2000 & IS 1893:2002.
7. Base Shear, overturning moments, Displacement and Time Period Performance of the structure undergoing the seismic behavior at zone-II of different storey levels were obtained.
8. Comparison of conventional Slab structure and Flat Slab Structure has been done in order to determine the difference between performances of both Slabs.

3. ANALYTICAL DATA OF BUILDING

3.1 General

The main objective of performance based response spectrum analysis of buildings is to avoid total catastrophic damage and to restrict the structural damages caused, to evaluate the performance limits of the building. For this purpose response spectrum analysis is used to evaluate the real strength of the structure and it promises to be a useful and effective tool for performance based design.

3.2 Description of building Frames

In the present work, six storied (conventional and flat slab) reinforced concrete frame buildings situated in Zone II, is taken for the purpose of study. The number of bays in each direction and height at each floor are given below, the buildings is symmetrical about both the axis. The total height of the building is 18 for six storied. The building is considered as Special Moment Resisting Frame.

3.3 Geometrical data of the structure

The conventional slab structure and flat slab Structure are considered to have the same geometrical data.

Table -1: Geometrical data of the structure

S.No	Variable	Data
1	Number of stories	6
2	Number of bays in x-direction	4
3	Number of bays in y direction	4
4	Bay length	5m
5	Height of the floor	3m

3.4 Preliminary data for the conventional slab

Table -2: Preliminary data for the conventional slab

S.No	Variable	Data
1	Type of structure	Moment resisting frame
2	Live load	3 kN/m^2
3	Floor finish load	1.0 kN/m^2
4	Wall load (external)	11 kN/m^2
5	Wall load(internal)	4.5 kN/m^2
6	Materials	Concrete (M25) and Reinforced with HYSD bars
7	Size of columns	350X350
8	Size of beams	230x300
9	Depth of slab	120mm thick
10	Specific weight of RCC	25 kN/m^3
11	Zone	II
12	Type of soil	Medium
13	Response reduction factor	5
14	Importance factor	1
15	Zone factor	0.10

3.5 Preliminary data for flat slab:

Table -3: Preliminary data for the conventional slab

S.No	Variable	Data
1	Type of structure	Moment resisting frame
2	Live load	3 kN/m^2
3	Floor finish load	1.0 kN/m^2
4	Materials	Concrete (M25) and Reinforced with HYSD bars(Fe500)
5	Size of columns	350X350
6	Depth of slab	150mm thick
7	Depth of drop	150mm thick
8	Specific weight of RCC	25 kN/m^3
9	Zone	II
10	Type of soil	Medium
11	Response reduction factor	5
12	Importance factor	1
13	Zone factor	0.10

4. RESULTS AND DISCUSSIONS

A six storied building with RCC structure with conventional slab and flat slab was analyzed in ETABS and results are obtained and calculating Displacement, Storey shear and Overturning moment compared as follows:

Structure 1: In this model I building with six stories is modeled as a "'RCC conventional slab structure". The dead loads are calculated by ETABS itself. The wall load is considered as uniformly distributed load on beams. Structure 2: In this model II building with six stories is modeled as “RCC flat slab structure”. The dead loads itself calculated by ETABS.

4.1 Model I & model II:

RCC conventional slab structure and flat slab structure

Building is modeled as RCC conventional slab structure and flat slab structure. For the Analysis, a typical six storied structure with 4 bays in both X-direction and Y- direction with 5m bay length and a typical height 18m is considered.. The height of all the stories is taken as 3m. The column size is taken as 350mmx350mm for all the storey’s, the beam cross section is taken as 230mmx300m.The floor slabs are modeled as membrane element of 120mm thickness for conventional slab structure and 150mm thickness for flat slab structure. The drop thickness is taken as150mm. All the supports are modeled as fixed supports. Linear static analysis is conducted on each of these models. The unit weight of concrete is taken as 25kN/m3., assuming steel in the reinforced concrete Fe 500 & M24.

Conventional slab structure

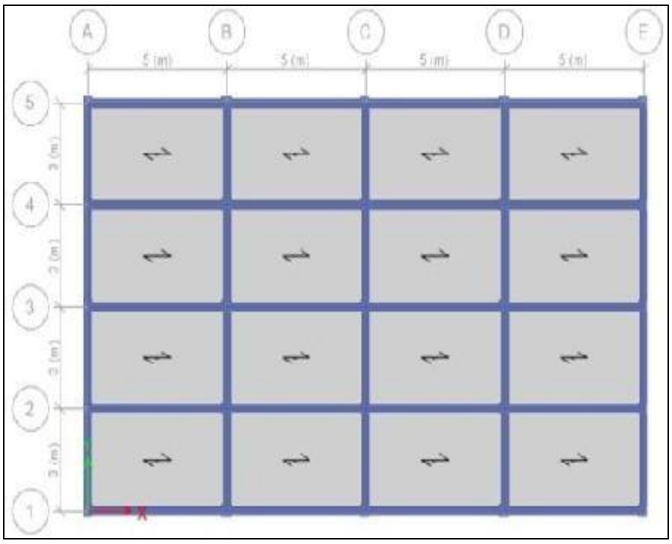


Fig -1: 2D (plan) model of conventional slab structure

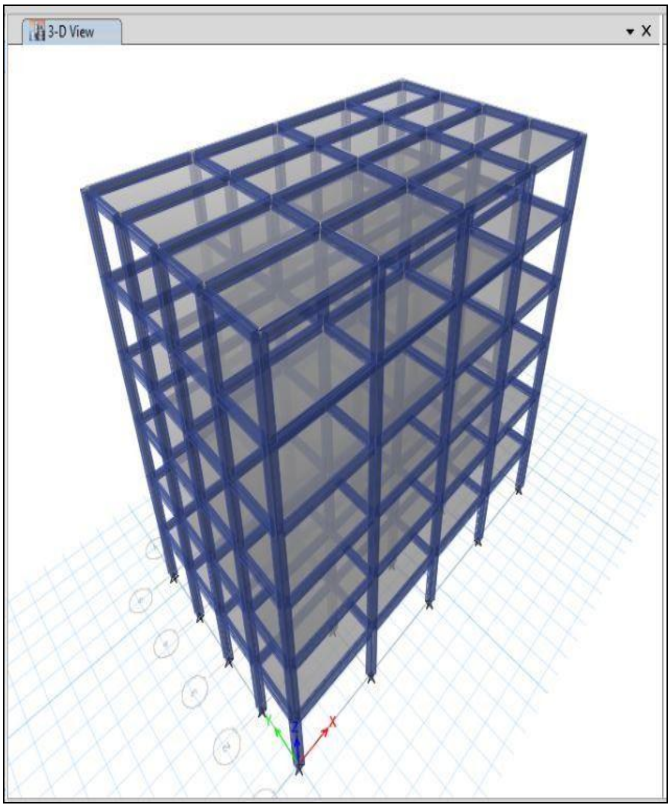


Fig -2: 3D Model of conventional slab structure

Flat slab structure

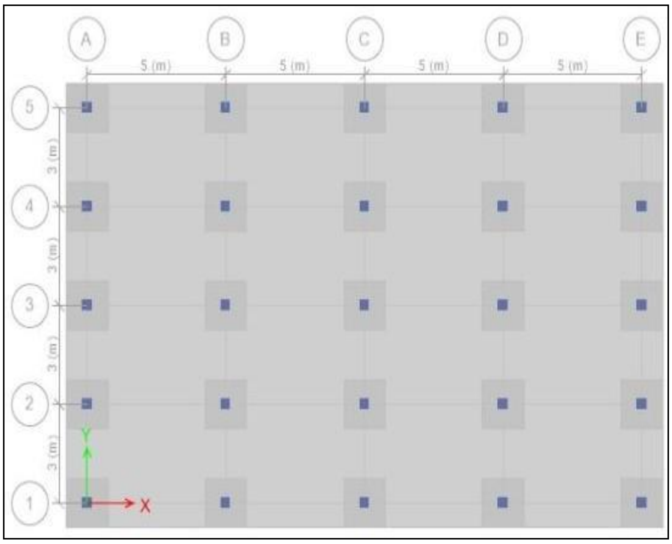


Fig -3: 2D (plan) of flat slab structure

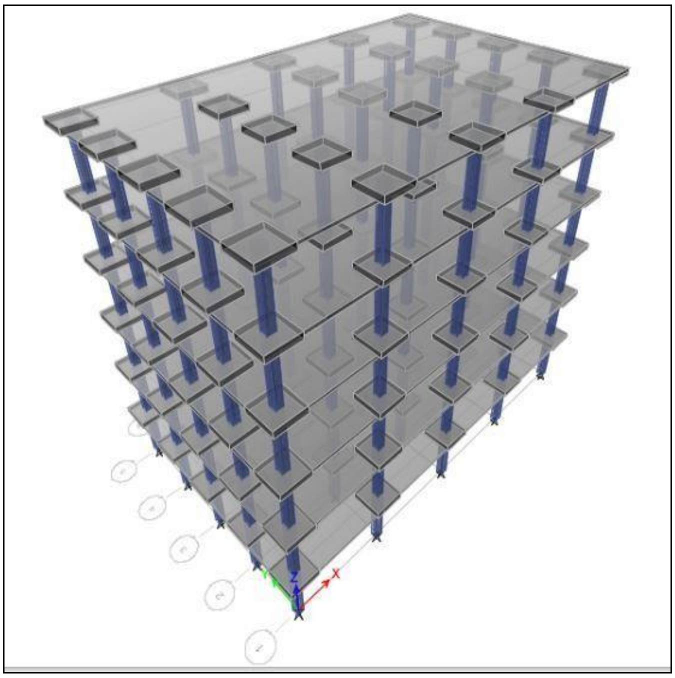


Fig -4: 3D model for flat slab structure

4.2 Comparison between conventional slab structure and flat slab structure

From the figures we got to know that the displacements in conventional slab are more when compared with the displacements in flat slab structure for both earthquake loading in x- direction and y- direction. For example the value of displacement for storey 6 is 7.3mm and 6.2mm for conventional slab structure and 3.39mm and 2.68mm for flat slab structure.

Displacement

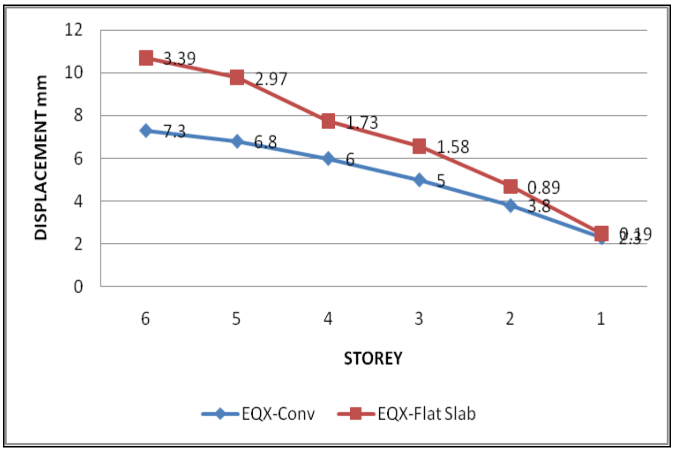


Fig -5: Comparison graph for earthquake load in x-direction

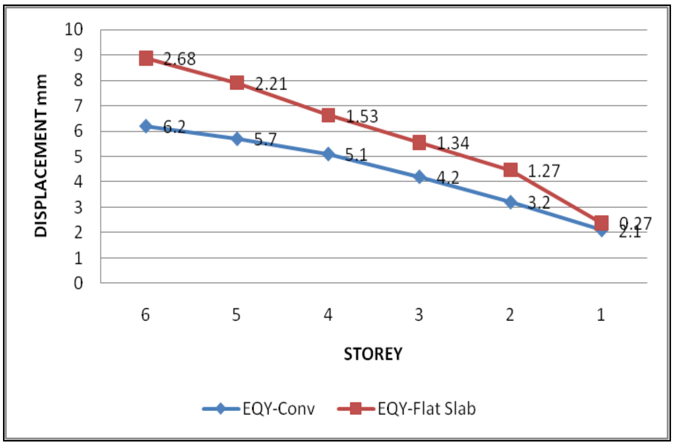


Fig -6: Comparison graph for earthquake load in y-direction

Storey shear

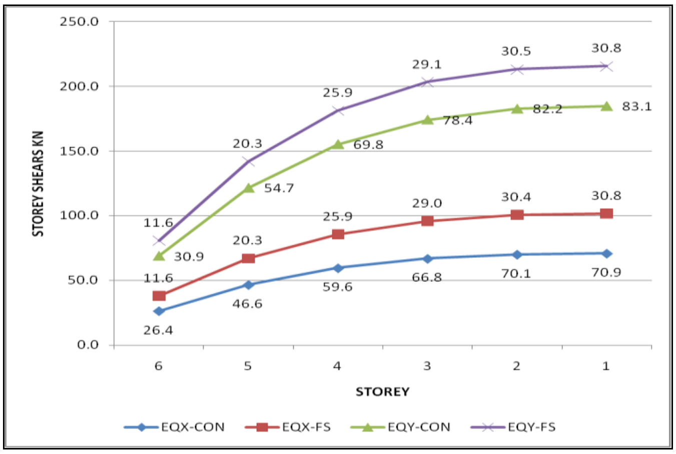
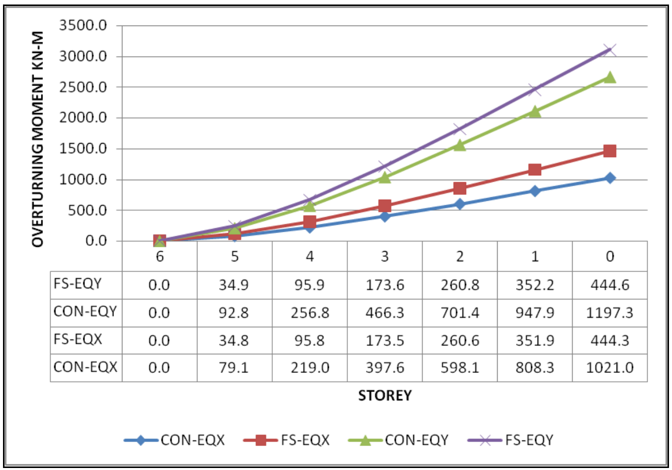


Fig -7: Comparison graph of storey shear for earthquake load in x-direction and y-direction

Figure 7 shows the comparison of storey shear of earthquake loading in x- direction and y-direction.

From the above table and figures we got to know that the storey shear in conventional slab are more when compared with the storey shear in flat slab structure for both earthquake loading in x- direction and y-direction. For example the value of storey shear for storey 6 is 26.3771kN and30.9317kN for conventional slab structure and 11.609kN and 11.6072kN for flat slab structure.

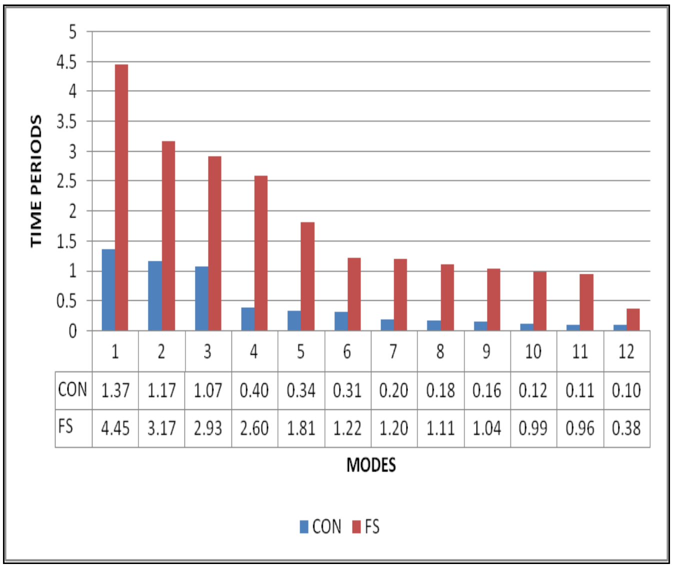
Overturning moments



	6	5	4	3	2	1	0
FS-EQY	0.0	34.9	95.9	173.6	260.8	352.2	444.6
CON-EQY	0.0	92.8	256.8	466.3	701.4	947.9	1197.3
FS-EQX	0.0	34.8	95.8	173.5	260.6	351.9	444.3
CON-EQX	0.0	79.1	219.0	397.6	598.1	808.3	1021.0

Fig -8: Comparison graph of overturning moment for earthquake load in x-direction and y-direction

Time periods for conventional slab and flat slab structure



	1	2	3	4	5	6	7	8	9	10	11	12
CON	1.37	1.17	1.07	0.40	0.34	0.31	0.20	0.18	0.16	0.12	0.11	0.10
FS	4.45	3.17	2.93	2.60	1.81	1.22	1.20	1.11	1.04	0.99	0.96	0.38

Fig -9: Graph of time periods

As shown in above graph it can be said that the time periods for conventional slab is more than the time periods for flat slab.

5. CONCLUSIONS

The following conclusions are made from the present study

1. The displacement is maximum in conventional slab structure when compared with flat slab structure.
2. The storey shear is maximum in conventional slab structure than in flat slab structure.
3. The overturning moments of conventional slab are higher than that of flat slab structure.
4. The time period of flat slab structure is less than the conventional slab structure.
5. In earthquake condition the flat slab structure will perform well for earthquake loads than the conventional slab structure.

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