A Comparison of Flat Slab And Conventional Slab Structures Considering Seismic Behavior

Mr. Hrishikesh Kiwale[1], Ms. Jyoti Chavan[2], Mr. Gaurav Tayade[3], Prof. Aparna Gaikwad[4]
[1, 2, 3] Dept of Civil Engineering
[4]Associate Professor, Dept of Civil Engineering
[1, 2, 3, 4] Dr. Dy Patil College Of Engineering Akurdi

Abstract- *As being one of the special reinforced concrete structural forms, flat-slab systems need further attention. Architects can use them to be more flexible, use more space, make easier forms, and build faster. When there is a lot of shaking, a horizontal structure isn't very strong.. In this work a comparative study of conventional beam-column building and a flat slab building subjected to seismic forces is carried out. The main objective of study is to understand the behavior of flat slab buildings under seismic loading. Based on this analytical study. Although the acceleration in flat slab structures are reduced due to its flexibility, the storey drift increases significantly and are many times exceed the permissible limits specified by the code. This may make the flat slab structure unserviceable during earthquakes. The natural time period increases as the height of building (No. of stories) increases, irrespective of type of building viz. conventional structure, flat slab structure. For all the structure. The base shear of a regular Rc columns is the same as the base shear of a base isolation building. Flat slab construction has a lot more storey drift than RCC construction. As a result, there are more opportunities. Therefore, the column of such a highrise should have been designed to account for the extra time prompted either by shifting. The moment in column of conventional RCC building is less than the flat slab RCC building. The of a traditional Rc wall is far less than flat slab of the same size.*

bends in the traditional RCC building are reduced by 30-60% as compared to the flat slab building. Also in validation of model staad pro values of base shear satisfactorily matches with analytical value

Keywords- Flat slab, Conventional slab, Seismic behavior, Comparison, Time history.

I. INTRODUCTION

GENERAL:

As being one of the special reinforced concrete structural forms, flat-slab systems need further attention. Architects can use them to be more flexible, use more space, make easier forms, and build faster. Because it doesn't work well under earthquake pressure, a smooth construction isn't as strong as it should be for a building. Because the flat-slab system doesn't have deep waves and braced frames, it doesn't have enough lateral resistance. This leads to excessive curvatures that can damage non-structural parts even in quakes of higher pace.

Flat slabs of wood are economical since they have no beams and hence can reduce the floor height by 10-15%. Further, a precast would be easier and the structure looks good. Parabolic dish pile building is used in the western world for decades. Material advances in concrete quality available for construction, improvement in quality of construction; easier design and numerical techniques has contributed to the rapid growth of the technology in India.

It is widely known that the slab-column connection is a critical component in the slab-column frame system as shown in Figure 1.1. This is the part of the slab right next to the block that will have to pass a lot of twisting, shearing, and bending forces between the slab and the column. This part of the slab is very vulnerable to jabbing shear failure.

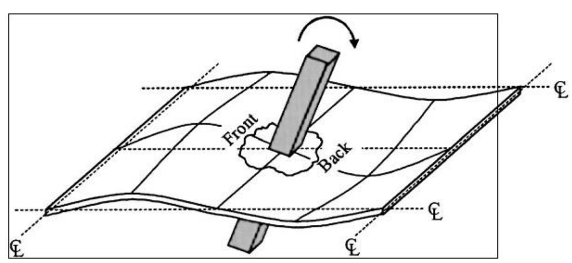


Fig 1: Behavior of Slab-Column Connection in Flat Slab Structure

1.1 NECESSITY

Because although base isolation building been around for a looooong time in India, the wide - spread utilisation Comment Strain (Hrs) is a new thing. This is especially true in areas of the country that have a lot of earthquakes. Structural Engineers who work in areas with a lot of earthquakes have been wary of this type of construction and operation because there aren't any Indian standards on the subject. Modern Special Moment Resisting Frames (SMRF) have been used for concrete construction in high-seismic areas of India for a long time. With or without shear walls, these frames have been used in the past. The columns are made to be more strong than the beams, so they can hold more weight. Ductile detailing rules in IS (13920-1993) make sure this happens. After the earthquake in Bhuj in 2001, people are more likely to follow these rules. If a building has both horizontal forces and SMRF, the response modification factor factor (R) can be as greater as 5 for Infills and as low as 4 for houses with retaining wall alone that take more than 75% of the shear force. When there are no structures, flat slab structures don't fall into the category of frames, at least as far as Indian standards go. Hence Buildings must have shear walls in order to take all of the lateral seismic force. Flat slab design, on the other hand, is said to be based on a "equivalent frame" in x direction of the building, which makes it a frame for earthquakes as well. Some codes, such as ACI-318 05 and ASCE 41-06, have rules that are predicated on more latest studies on how to deal with this.subject.

1.2 OBJECTIVE

These following are really the precise aims of this research.

1. To analyze the reinforced concrete building systems.
2. To compare the seismic behavior of two types of multistoried buildings, one is conventional building i.e. slab, beam & column the other one is flat slab building.
3. To construct building of different number of story for analyzing and to perform comparative analysis.
4. To compare the axial force, bending moment, base shear, time period of RCC and flat slab.

II. LITERATURE REVIEW

Sagar Jamle et. Al., 2017

Additionally, the impacts of seismic forces in zone V on these structures are examined in this article. Additionally, the purpose is to demonstrate the behaviour of several frames when the structure's length exceeds its breadth. G+9, G+18, G+27, and G+36 Storeyed models, each with a plan size of 20X50m, were chosen for this. Shear walls are supplied at various points to stabilise the changing parameters. To investigate the influence of alternative shear wall locations on flat slab multi-story buildings, static analysis (Equivalent Static Analysis) is performed in the programme STAAD Pro for zone V. Lateral displacement, storey drift, drift reduction factor, and contribution factor are all included in the seismic parametric investigations.

Mahesh Bakale et. Al., 2017

The goal of this project is to find out how different slab systems react to earthquakes in different situations. seismic zones, taking into account the varied number of stories. The article discusses four distinct slab systems: conventional beam slabs, flat plate slabs, flat slabs with drops, and ribbed slabs. The seismic behaviour of these slab systems is investigated using the ETABS software tool to simulate the G+6, G+9, and G+12 multi-story structures. The research compares tale displacement and shear.

M. Altug Erberik et. Al., 2004

The benefits of flat-slab RC structures over traditional moment-resisting frames are many. However, flat-slab construction's structural efficacy is harmed by its purported lower performance under seismic loads. Although flat-slab systems are frequently employed in earthquake-prone parts of the globe, there are no published fragility curves for this style of construction. The purpose of this work is to derive such fragility curves for medium-rise flat-slab structures with masonry infill walls. The research used a collection of earthquake recordings that were consistent with the design spectrum chosen to reflect ground motion variability. Inelastic response-history analysis was utilised to assess a random sample of structures exposed to a suite of displacement spectral ordinates-scaled recordings while monitoring four performance limit states. The fragility curves obtained in this research were compared to those obtained for moment-resisting RC frames. According to the research, earthquake losses for flat-slab buildings are comparable to those for moment-resisting frames. However, distinctions occur. Additionally, the investigation demonstrated that the discrepancies between the two structural forms were justified in terms of their structural response characteristics.

Ema COELHO et. Al., 2004

At the ELSA Laboratory, an experimental programme was conducted with the goal of determining the seismic behaviour of flat-slab structures. The programme included pseudo-dynamic testing on a three-story RC flat-slab building structure that was typical of flat-slab structures in seismic zones around Europe. The article describes the experimental findings from two tests conducted using Eurocode 8-compliant accelerograms of increasing intensity, as well as a comparison to analytical analyses. Some observations are made on the shortcomings of these structures' behaviour.

III. METHODOLOGY

3.1 ANALYSIS AND DESIGN OF FLAT SLAB FOR SEISMIC LOAD

According to the Indian Standard Seems to be 1893 (Factors for Quake Resilient Layout of Framework), lateral force approach relies on these rules. due to non-clarity of IS1893 designer, in addition may have to Other codes, including the UBC-2000 (National Structural Password), can also be used to design a good sideways framework. Premised upon those guidelines, it's common to figure out lateral force by either using static or a dynamic procedure.

Once the lateral forces are found, flat plate/slab structures in areas of low seismicity (Zone1& 2) can be designed as permitted by code to resist both vertical and lateral loads. However, for areas of high seismicity (Zone3, 4 & 5) code does not permit flat slab construction to resist earthquake lateral load, hence lateral load resisting system has to be designed separately in addition to flat plate/slab gravity system. The ability of flat plate/slab gravity system to support vertical load when subjected to lateral load should be checked (deformation compatibility check). Flat Plate/slab floor slabs are typically considered as a rigidity diaphragm to distribute in plane lateral loads to the lateral load resisting system. In case of flat plate/slab resisting lateral loads, floor slab will transfer lateral loads at each column and therefore all slab column connections should be checked for additional force resulting from lateral loads. In addition, all columns should be checked for additional bending resulting from lateral shear. When flat slab is used in combination with shear walls for lateral load resistance, the columns can be designed for only 25% of the design force.

For example, think about a horizontal tower with shear walls that protect it from lateral loads. In this case, a wood scheme just isn't very strong against side loads. Many times, these are only made to handle gravity loads, but the stiffeners can handle all of the earthquake load. It doesn't matter that lintels but also sections aren't entitled to discuss the lateral forces, because they still deform including the entire building.lose its vertical load capacity.

3.2 ACI-318 PROVISIONS FOR FLAT SLAB

ACI considers design of flat slab from two distinct viewpoints. One Under these kinds of changes, the tile framework must not be able to support itself. This is the "Intermediate Frame." They also have flat slabs to columns that don't fight against earthquakes. A system like shear walls is used to begin taking every one of the horizontal force that come from outside the structure. In other words, it isn't always possible to think of a plain concrete and section configuration as an Advanced Frame. There aren't any places where these kinds of buildings can be built. The amount of steel reinforcement (mainly non) in a classic bay to handle these forces is also very strict.Intermediate frame rules say that a certain amount of rebar must pass through the paragraph cage as well as the PT tendons. This is so important that ASCE-41-03 "Seismic evaluation of Existing Buildings" says that if a building doesn't have continuous bottom steel, it can't be called "Immediate Occupancy" or "Life Safety." if there are no bottom bars or PT TENDONs going through the COLUMN CAGE, the ductile roster capacity and yield stress of a connection are both zero. There isn't much use of intermediate frames in practise in the US, and even in places like New York, where there aren't very many earthquakes, shear walls are used. Another way to think about the lateral load system is to not think about the flat slab as part of it. It's more famous and strongly supported by the authors. In this method, the state of the jabbing shear stress in the written description is used to figure out how the storey will move (that is un-reinforced for punching). Notice that ACI says that the column's moment is converted to the slab by bending as well as eccentric punching shear, which is why the slab bends. Further, the total jabbing shear stress (direct and eccentric) must also take into account the moment at the steel joint. For rising punching tensile stress (with no reinforcement for punching shear), the storey offset is allowed to be a little less than before. This means that anyone who is planning to use this method would need to consider making the steel structures stiffer so that the storey drift would be less. In turn, the shear reinforcement would not be needed in the joint. Shear reinforcement can be issued in the form of "shear stud rails." This is better than the traditional stirrup reinforcement because it doesn't work well with thin slabs. Conventional stirrups should not be provided in slabs thinner than 250 mm thick.

IV. PERFORMANCE ANALYSIS

4.1 GENERAL

The main goal of the study is to look at how a flat slab structure behaves when it is hit by earthquakes and how it compares to how it behaves with a conventional beam-column structure. The analysis is carried out in STAAD Pro 2007 software.

To achieve the objective Static loads are simulated and analysed for different R.C.C. and flat slab structures of different heights. In this example, we're going to compare the standard R.C.C. structure ad flat slab structure situated in seismic zone II & III.

4.2 PROBLEM STATEMENT

In present work, G+5 and G+10 building frame models with conventional beam-column and flat slab will be analyzed by using STAAD PRO software. For seismic zone-II and zone-III.

Plan and Data to be assumed are as follows:

Plan Area: 24m x 37.5m
Building: G+5 And G+10 RC Building
Size of beam: B1=250 x 500 mm
B2=290 x 600mm
Size of column: 230 x 750 mm
Slab thickness: 150 mm for conventional slab
125 mm for flat slab.
Live load: 4 KN/m2
Seismic load as per IS 1893- 2012
M20 Grade Concrete, Fe 500 steel

4.3 MODELING OF BUILDING

For the study, two types of hypothetical RCC buildings are considered without infill. Mass of infill and slab is considered on beam element as uniformly applied load and floor load respectively. Stiffness of infill and slab is not considered.

The buildings which are used in this report are (G+5) and (G+10). The total dimension of building is 24m x 37.5m. The above building are analyzed for firstly with beam-column structure, and then these buildings are analyzed as flat slab buildings. Following are the designation of the six models used in this study.

Assumptions:

- All materials are homogenous and isotropic
- For modeling of flat slab plate element is used
- For modeling of beam and column beam element is used
- The load from slab directly transferred to column

Model 1 A 5 story conventional R.C.C. structure (ZONE 2)
Model 2 A 5 story flat slab R.C.C. structure (ZONE 2)
Model 3 A 5 story conventional R.C.C. structure (ZONE 3)
Model 4 A 5 story flat slab R.C.C. structure (ZONE 3)
Model 5 A 10 story conventional R.C.C. structure (ZONE 2)
Model 6 A 10 story flat slab R.C.C. structure (ZONE 2)
Model 7 A 10 story conventional R.C.C. structure (ZONE 3)
Model 8 A 10 story flat slab R.C.C. structure (ZONE 3)

In this study, Slab is modeled by finite element approach using 441 elements. The Table 4.1 shows total number of nodes and line element used in all buildings for modeling. It clearly shows there is less number of elements in flat slab building due absence of beam but total number of nodes are same in both buildings.

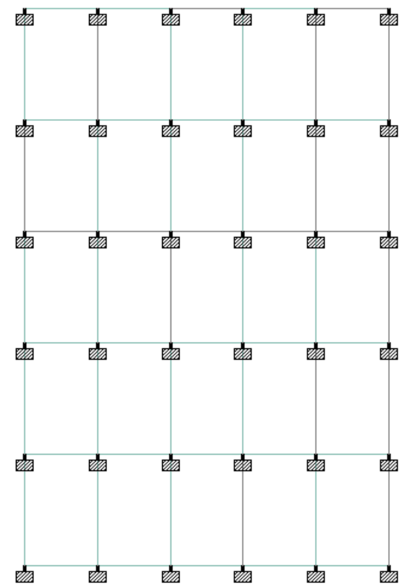


Fig 2 : Plan of all Models

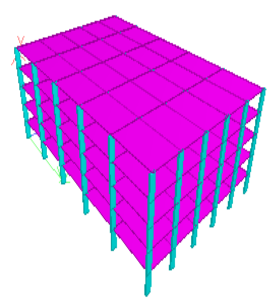


Fig 3 : 3 D View of 5 Storey Flat Slab

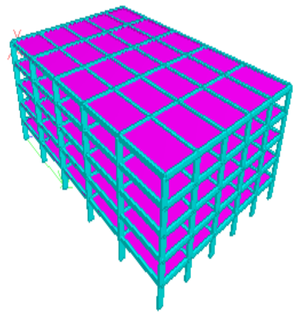


Fig 4: 3 D View of 5 Storey Conventional Slab Conventional Slab

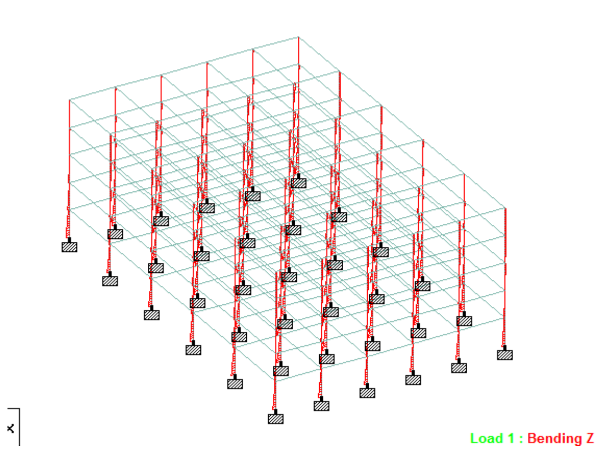


Fig 5 : BMD of 5 Storey Flat Slab

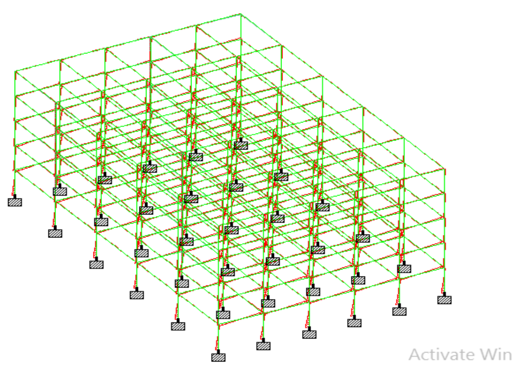


fig 6: BMD of 5 Storey Conventional Slab

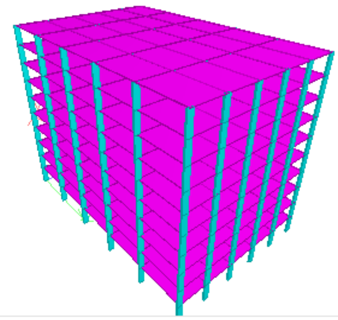


Fig 7: 3 D View of 10 Storey FS

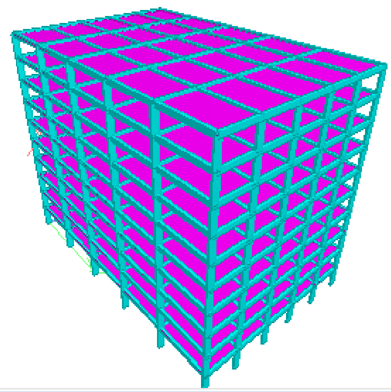


Fig 8: 3 D View of 10 Storey CS

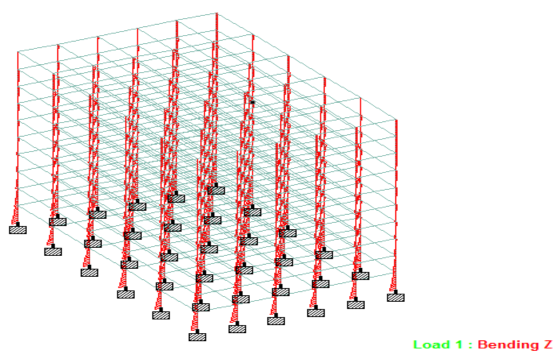


Fig 9 : BMD of 10 Storey FS

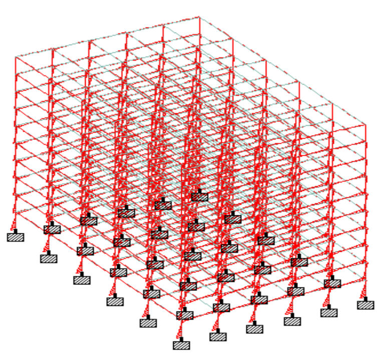


Fig 10: BMD of 10 Storey CS

VI. RESULT AND DISCUSSION

5.1 BASE SHEAR

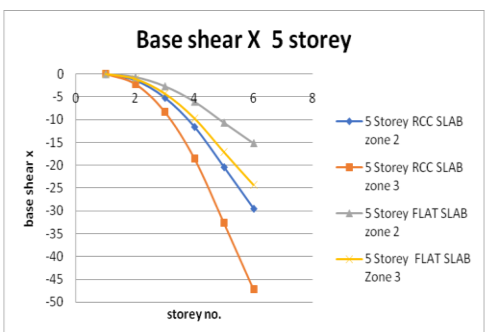
Two types of buildings are analyzed i.e. conventional beam-column building and building with flat slab for two different zones (II, III) using code response spectrum. The maximum base shears for different structures by SRSS method are given in Table 4.4.

Fig 4.20 represents the base shear for different types of structures. It is observed that base shear of conventional R.C.C building is more than of the flat slab building.

For all the structures, base shear increases as the height increases. It is observed that magnitude of base shear is significantly affected by flat slab structure. This is due to the flexibility of flat slab structure.

Table 1: Base shear X 5 story

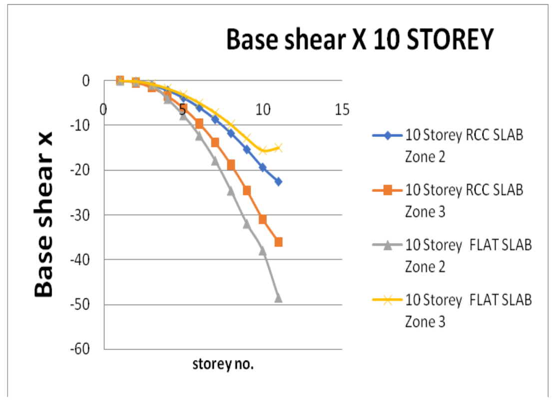
Name	5 Story RCC SLAB	5 Story RCC SLAB	5 Story FLAT SLAB	5 Story FLAT SLAB
	zone 2	zone 3	zone 2	Zone 3
base	0	0	0	0
storey 1	-1.39	-2.222	-0.686	-1.097
storey 2	-5.216	-8.345	-2.692	-4.307
storey 3	-11.578	-18.525	-6.056	-9.689
storey 4	-20.4	-32.651	-10.666	-17.066
storey 5	-29.49	-47.191	-15.153	-24.245



Graph 1: Base shear X 5 story

Table 2: Base shear X 10 story

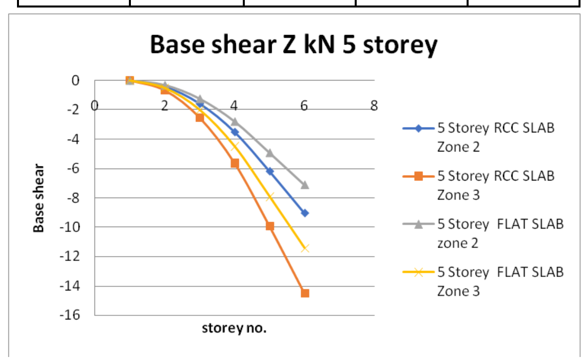
Name	10 Story RCC SLAB	10 Story RCC SLAB	10 Story FLAT SLAB	10 Story FLAT SLAB
	Zone 2	Zone 3	Zone 2	Zone 3
base	0	0	0	0
Story 1	-0.261	-0.418	-0.18	-0.206
Story 2	-0.983	-1.573	-0.9	-0.809
Story 3	-2.181	-3.489	-4.118	-1.81
Story 4	-3.858	-6.17	-7.78	-3.211
Story 5	-6.014	-9.622	-12.282	-5.013
Story 6	-8.649	-13.838	-17.885	-7.215
Story 7	-11.764	-18.823	-24.638	-9.854
Story 8	-15.368	-24.589	-31.996	-12.94
Story 9	-19.37	-30.995	-38.025	-15.601
Story 10	-22.56	-36.097	-48.579	-15.003



Graph 2: Base shear X 10 story

Table 3: Base shear Z kn 5 story

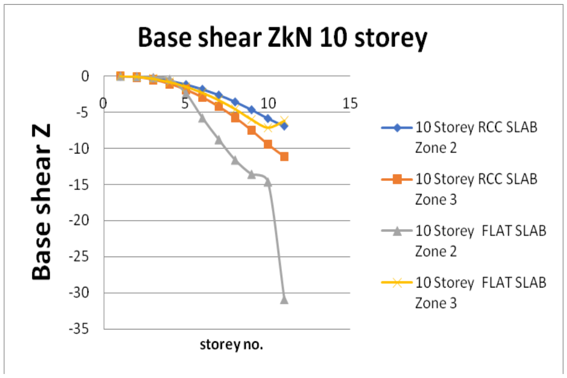
Name	5 Story RCC SLAB	5 Story RCC SLAB	5 Story FLAT SLAB	5 Story FLAT SLAB
	Zone 2	Zone 3	zone 2	Zone 3
base	0	0	0	0
Story 1	-0.425	-0.68	-0.322	-0.516
Story 2	-1.588	-2.541	-1.25	-2
Story 3	-3.521	-5.634	-2.805	-4.488
Story 4	-6.204	-9.927	-4.937	-7.9
Story 5	-9.058	-14.492	-7.128	-11.405



Graph 3: Base shear Z kn 5 story

Table 4: Base shear Z kn 10 story

Name	10 Storey RCC SLAB	10 Storey RCC SLAB	10 Storey FLAT SLAB	10 Storey FLAT SLAB
	Zone 2	Zone 3	Zone 2	Zone 3
base	0	0	0	0
Storey 1	-0.08	-0.128	-0.045	-0.097
Storey 2	-0.299	-0.479	-0.1875	-0.375
Storey 3	-0.663	-1.061	-0.419	-0.838
Storey 4	-1.173	-1.876	-2.395	-1.486
Storey 5	-1.828	-2.925	-5.778	-2.319
Storey 6	-2.629	-4.206	-8.782	-3.338
Storey 7	-3.575	-5.721	-11.6	-4.562
Storey 8	-4.671	-7.473	-13.565	-5.998
Storey 9	-5.887	-9.419	-14.637	-7.109
Storey 10	-6.934	-11.094	-30.899	-6.179



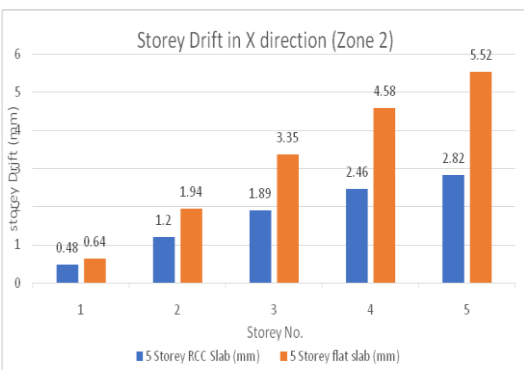
Graph 4: Base shear Z kn 10 story

5.2 STOREY DRIFT & LATERAL DISPLACEMENT

Story is defined as the space between two adjacent floors and story drift is defined as the displacement of one level relative to the other level above or below. Figure 4.27 shows typical story drift Pattern in building.

Table 5: Story Drift in X direction (Zone 2)

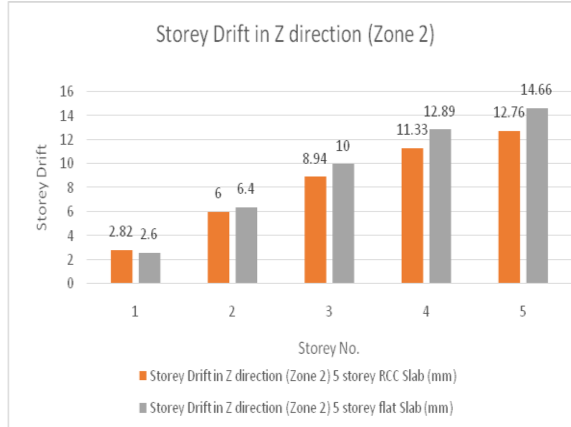
Story Drift in X direction (Zone 2)		
Story No.	5 Story RCC Slab (mm)	5 Story flat slab (mm)
1	0.48	0.64
2	1.2	1.94
3	1.89	3.35
4	2.46	4.58
5	2.82	5.52



Graph 5: Story Drift in X direction (Zone 2)

Table 6: Story Drift in Z direction (Zone 2)

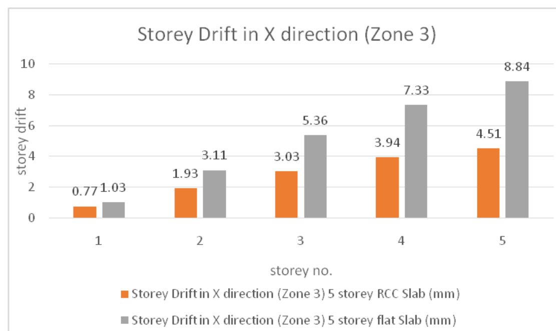
Story Drift in Z direction (Zone 2)		
Story No.	5 story RCC Slab (mm)	5 story flat Slab (mm)
1	2.82	2.6
2	6	6.4
3	8.94	10
4	11.33	12.89
5	12.76	14.66



Graph 6: Story Drift in Z direction (Zone 2)

Table 7: Story Drift in X direction (Zone 3)

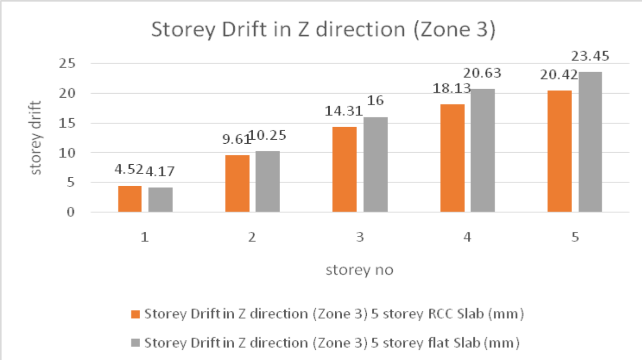
Story Drift in X direction (Zone 3)		
Story No.	5 story RCC Slab (mm)	5 story flat Slab (mm)
1	0.77	1.03
2	1.93	3.11
3	3.03	5.36
4	3.94	7.33
5	4.51	8.84



Graph 7: Story Drift in X direction (Zone 3)

Table 8: Story Drift in Z direction (Zone 3)

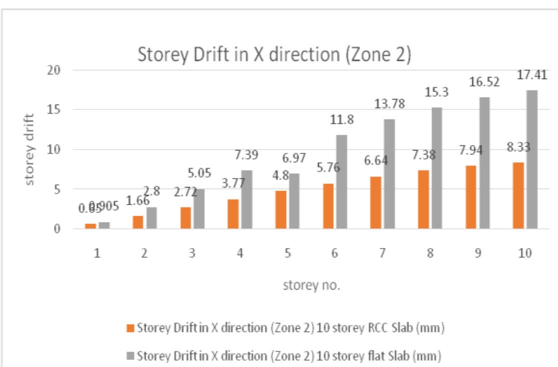
Story Drift in Z direction (Zone 3)		
Story No.	5 story RCC Slab (mm)	5 story flat Slab (mm)
1	4.52	4.17
2	9.61	10.25
3	14.31	16
4	18.13	20.63
5	20.42	23.45



Graph 8: Story Drift in Z direction (Zone 3)

Table 9: Story Drift in X direction (Zone 2)

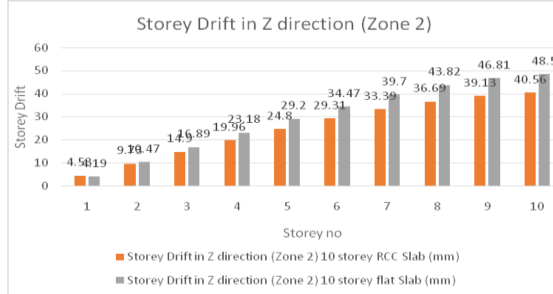
Story Drift in X direction (Zone 2)		
Story No.	10 story RCC Slab (mm)	10 story flat Slab (mm)
1	0.65	0.905
2	1.66	2.8
3	2.72	5.05
4	3.77	7.39
5	4.8	6.97
6	5.76	11.8
7	6.64	13.78
8	7.38	15.3
9	7.94	16.52
10	8.33	17.41



Graph 9: Story Drift in X direction (Zone 2)

Table 10: Story Drift in Z direction (Zone 2)

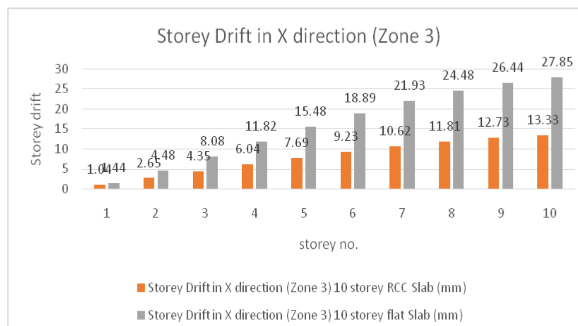
Story Drift in Z direction (Zone 2)		
Story No.	10 story RCC Slab (mm)	10 story flat Slab (mm)
1	4.53	4.19
2	9.73	10.47
3	14.9	16.89
4	19.96	23.18
5	24.8	29.2
6	29.31	34.47
7	33.39	39.7
8	36.69	43.82
9	39.13	46.81
10	40.56	48.5



Graph 10: Story Drift in Z direction (Zone 2)

Table 11: Story Drift in X direction (Zone 3)

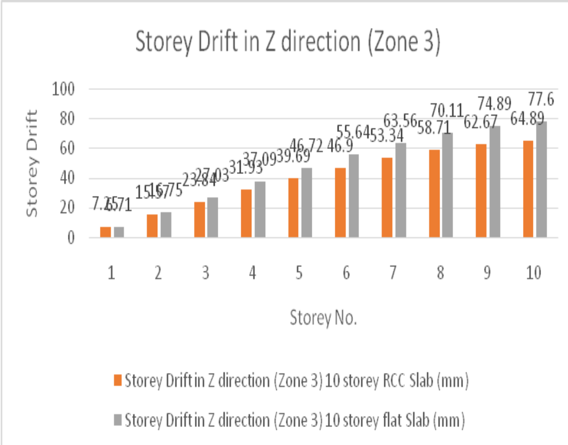
Story Drift in X direction (Zone 3)		
Story No.	10 story RCC Slab (mm)	10 story flat Slab (mm)
1	1.04	1.44
2	2.65	4.48
3	4.35	8.08
4	6.04	11.82
5	7.69	15.48
6	9.23	18.89
7	10.62	21.93
8	11.81	24.48
9	12.73	26.44
10	13.33	27.85



Graph 11: Story Drift in X direction (Zone 3)

Table 12: Story Drift in Z direction (Zone 3)

Story Drift in Z direction (Zone 3)		
Story No.	10 story RCC Slab (mm)	10 story flat Slab (mm)
1	7.25	6.71
2	15.57	16.75
3	23.84	27.03
4	31.93	37.09
5	39.69	46.72
6	46.9	55.64
7	53.34	63.56
8	58.71	70.11
9	62.67	74.89
10	64.89	77.6



Graph 12: Story Drift in Z direction (Zone 3)

5.3 RESULT AND DISCUSSION OF TIME HISTORY ANALYSIS

Acceleration and displacement are two important parameters which should be taken in to account while comparison. This time history data is used for analysis of building. Top node of (G+5) and (G+10) building for Koyna earthquake is observe for comparison.

Table 13: Frequency Vs Time Period F2

Mode	Frequency Hz	Period seconds
1	0.464	2.156
2	0.912	1.097
3	0.953	1.049
4	1.389	0.72
5	2.313	0.432
6	2.786	0.359

VII. CONCLUSION

In this work a comparative study of conventional beam-column building and a flat slab building subjected to seismic forces is carried out. The main objective of study is to understand the behavior of flat slab buildings under seismic loading. Based on this analytical study following conclusion can be drawn:

1. Although the acceleration in flat slab structures are reduced due to its flexibility, the storey drift increases significantly and are many times exceed the permissible limits specified by the code. This may make the flat slab structure unserviceable during earthquakes.
2. The natural time period increases as the height of building (No. of stories) increases, irrespective of type of building viz. conventional structure, flat slab structure.
3. For all the structure, base shear increases as the height increases.
4. The base shear of a conventional Rc columns is more than the base shear of a flat slab building.
5. In a building of flat slab construction, there is a lot more storey drift than there is in a building with RCC. As a result, there are more opportunities. Because of this, the column of this kind of constructing must be made with more weight in mind because of the drift.
6. The juncture in the section of both a conventional Rc columns is below the moment in the column of a flat slab Rc wall.
7. The bending moments in the in the conventional RCC building are reduced by 30-60% as compared to the flat slab building.
8. The natural time period increases as the height of building (No. of stories) increases, irrespective of type of building viz. conventional structure, flat slab structure.
9. In comparison with the conventional RCC building to flat slab building, the time period is more for flat slab building than conventional building.
10. For all the structure, base shear increases as the height increases.
11. Base shear of conventional RCC building is more than the flat slab building
12. Storey drift in building with flat slab construction is significantly more as compared to conventional RCC building. As result of this, additional moments are developed. Therefore, the column of such building should be designed by considering additional moment caused by the drift.
13. The moment in column of conventional RCC building is less than the flat slab RCC building.
14. The bending moments in the in the conventional RCC building are reduced by 30-60% as compared to the flat slab building.
15. In validation of model staad values of base shear satisfactorily matches with analytical value

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