COMPARATIVE SEISMIC ANALYSIS OF CONVENTIONAL SLAB AND FLAT SLAB WITH AND WITHOUT SHEAR WALL

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Abstract - *Modern trends towards high rise buildings increases recently due to the high increase in the number of tall buildings, both residential and commercial. In every parts of the world flat slab construction are widely used in reinforced concrete structures because; this system reduces the costs of form work and construction time and easy installation. Without beams floor slab system directly supports columns. In comparison with earlier high rise buildings, today's tall buildings are becoming more and more slender and leading to the possibility of more sway. From lateral loads such as wind, seismic loads shear walls provide the stability to the structure. These shear walls transfer the lateral loads to the foundation by their shearing resistance and resistance to overturning. In the present work, summarized the importance of flat slab construction and revealed the relevance of shear wall in a flat slab multi-storied building.*

Key Words**: Flat slab, shear walls, seismic analysis, base shear**

1. INTRODUCTION

From last two decades there is a high increase in the high rise buildings and modern trend is towards high rise structures. In tall buildings with increase in height lateral loads have prime consideration. From the effect of gravity resulting most common loads are dead load, live load and snow load. Buildings are also subjected to lateral loads caused by wind and earthquake. Due to the lateral loads develop high stresses, produce sway movement or vibrations.

Flat slab are used to avoid the beam-column clogging, and it is very economical. Flat slabs directly transfer the loads to columns without beams. But flat slabs are not efficient in transfer the lateral loads. Punching shear strength around the column-slab connections always possess a problem. Punching shear is a type of failure of reinforced concrete slabs subjected to high localized forces. When the total shear force exceeds the shear resistance of the slab, the slab will be pushed down around the column is termed as punching shear in flat slabs. This results in the column breaking through the portion of the surrounding slab. As a solution of seismic load resistance, time and cost effective construction shear walls are most effective one method.

C.A.P Turner constructed flat slabs in U.S.A. in 1906 mainly using intuitive and conceptual ideas, which was start of this type of construction. Many slabs were load-tested between 1910- 20 in U.S.A. It was only in 1914 that Nicholas proposed a method of analysis of flat slabs based on simple statics. This method is used even today for the design of flat slabs and flat plates and is known as the direct design method. Structural engineers commonly use the equivalent frame method with equivalent beams such as the one proposed by Jacob S. Grossman in practical engineering for the analysis of flat plate structures. Floor systems consisting of flat slabs are very popular in countries where cast-in place construction is predominant form of construction because of many advantages in terms of architectural flexibility, use of space, easier formwork, and shorter construction time. Flat slabs are being used mainly in office buildings due to reduced formwork cost, fast excavation, and easy installation.

Fig 1. Typical flat slab construction

2. LITERATURE REVIEW

Lan N Robertson (1997) [1]

In this study the analysis of flat slab structures subjected to combined lateral and gravity loads. Using a three dimensional model, analysis of a flat slab building can have done when it subjected to vertical and lateral loads which includes both slab column frame elements and the lateral framing system (shear wall) if present. This study reviews two structural analysis models and compares them to experimental test results. A two-beam analytical model more accurately predicts the test results with respect to slab moment distribution and lateral drift.

M A Rahman (2012) [2]
He conducted a study on effect of openings in shear wall on seismic response of structures. In this paper, finite element modeling in analyzing and exploring the behavior of shear wall with opening under seismic load actions, an attempt is made to apply the finite element modeling.

Navyashree K (2014) [3]
Introduced use of flat slabs in multi-storey commercial building situated in high seismic zone. The proposed work compared the behavior of multi-story commercial buildings having two way slabs with beams and with that of having conventional RC frame and flat slabs, then studied the effect of height of the building.

Lakshmi K O (2014) [4]
In this journal find the effect of shear wall location in buildings subjected to seismic loads. A symmetric sixteen story residential building considered for the analysis. The finite element analysis software ETABS is used to create the 3-D model and run the analysis by pushover method. Eight different models were considered

Sachin P Dyavappanavar (2015) [5]
In this journal they has done seismic analysis of RC multi-storied structures with shear walls at different locations. For the investigation of the structure twenty storied building is considered. Building assumed to be situated in zone IV. Analysis has done by changing the positions of shear walls symmetrically by considering different shape and locations of shear walls in buildings.

K G Patwari (2016) [6]
In this they has done a comparative study of flat slab building with and without shear wall to earthquake performance. The work deals, with or without shear wall of flat slab building on the seismic behaviour of high rise building with different position of shear wall. For the analysis fifteen storey model is selected. Time history analysis in software ETABs is carried out to study the effect of different location of shear wall on high rise structure.

Dr. K. Naresh (2019) [7]
The comparative analysis and study has been carried out in this paper between G+14 multistoried commercial building with conventional slab and the same building with flat slab in terms of base shear, story drift, story stiffness and displacement using ETABS.

3. METHODOLOGY

Equivalent Static load analysis of building Design seismic Base shear as per IS 1893 (Part I):2002

Table 1: Preliminary Data for 4-story Conventional slab building.

SL.NO	PARAMETERS	
1	Length in X-direction	25m
2	Length in Y-direction	20m
3	Floor to floor height	3m
4	No of stories	4
5	Total height of the building	15m
6	Slab thickness	150mm
7	Grade of concrete	M30
8	Grade of steel	HYSD 415,500
9	Wall size	230mm
10	Column size	230mmX450mm
11	Beam size	230mmx350mm
12	Shear wall thickness	150mm
13	Live load in Floors	$5kN/m^2$
14	Live load in Terrace	$2kN/m^2$
15	Floor finish	$1.5kN/m^2$

Table 2: Preliminary Data for 4-story Flat slab building

SL.NO	**PARAMETERS**	
1	Length in X-direction	25m
2	Length in Y-direction	20m
3	Floor to floor height	3m
4	No of stories	4
5	Total height of the building	15m
6	Slab thickness	200mm
7	Drop thickness	300mm
8	Grade of concrete	M30
9	Grade of steel	HYSD 415,500
10	Wall size	230mm
11	Column size	230mmX450mm
12	Shear wall thickness	150mm
13	Live load in Floors	$5kN/m^2$
14	Live load in Terrace	$2kN/m^2$
15	Floor finish	$1.5kN/m^2$

Table 3 Preliminary Data for Seismic Load Parameters

SL.No	**Seismic load parameters**	**Zone 3**
1	Zone factor	0.16
2	Response reduction factor	3
3	Importance factor	1

4	Type of soil strata	2(Medium)
5	Damping	5%

Table 4 The list of design load combinations considered during the analysis as per 1893(Part-1):2002.

Type	Design Load Combinations
Gravity analysis	1.5 (Dead Load + Live Load)
Equivalent Static Analysis	1.2 (Dead Load + Live Load + EQX)
	1.2 (Dead Load + Live Load - EQX)
	1.2 (Dead Load + Live Load + EQY)
	1.2 (Dead Load + Live Load - EQY)
	1.5 (Dead Load + EQX)
	1.5 (Dead Load - EQX)
	1.5 (Dead Load + EQY)
	1.5 (Dead Load - EQY)
	0.9 (Dead Load + EQX)
	0.9 (Dead Load - EQX)
	0.9 (Dead Load + EQY)
	0.9 (Dead Load - EQY)

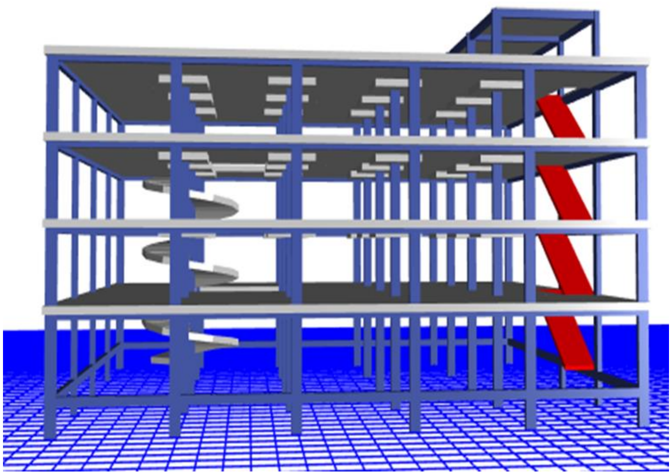

Fig 2. Rendered view of flat slab structure without shear wall

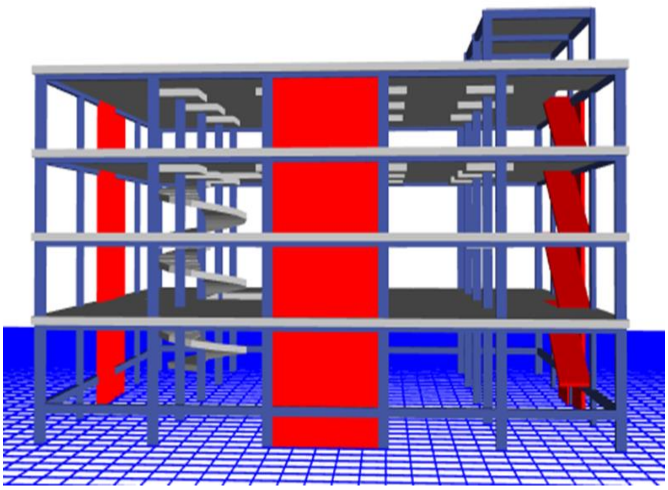

Fig 3. Rendered view of flat slab with shear wall structure.

4. RESULTS & DISCUSSIONS

4.1 Story Displacement:

By studying the results and comparing their values in below figures, we can see that displacement increases as storey height increases. We can clearly see that there is decrease in lateral displacement with consideration of shear wall for the structure with flat slab. And maximum displacement for conventional slab structure without shear slab.

From the obtained results we can say that structure with flat slab gives better resistance for displacement.

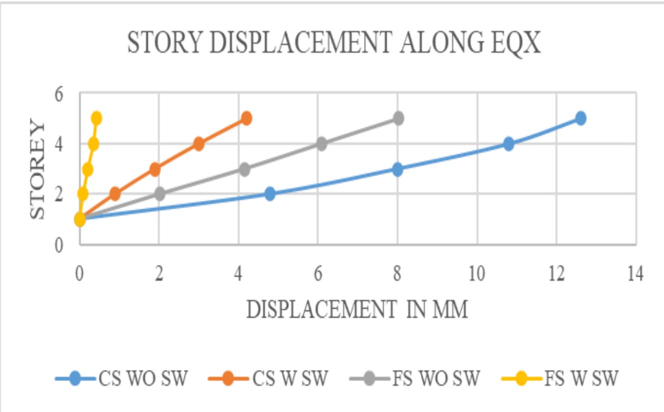

Chart -1: Storey vs displacement for structure along EQX.

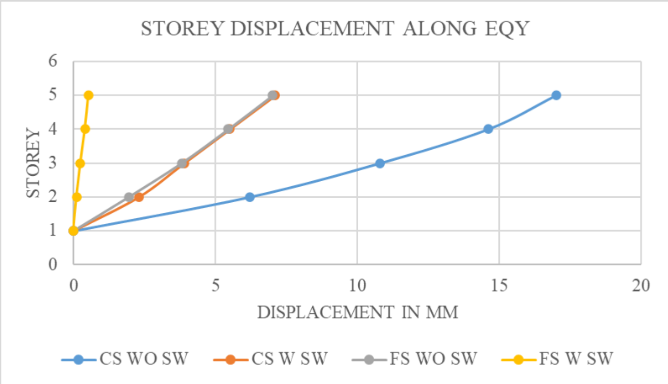

Chart -2: Storey vs displacement for bare frame structures with seismic

4.2 Story Drift

By studying from results and comparing their values in figures below we can see that variation in drift as storey height increases. We can clearly see that there is a reduction of lateral drift for flat slab with shear wall for structure along both X and Y direction respectively for equivalent static analysis.

From the graph we can see that conventional slab without shear wall have maximum drift compare to flat slab with shear wall.

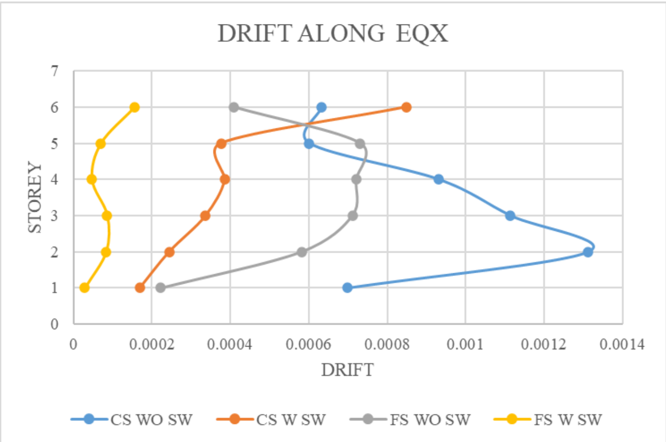

Chart -3: Storey vs drift for structures along EQX.

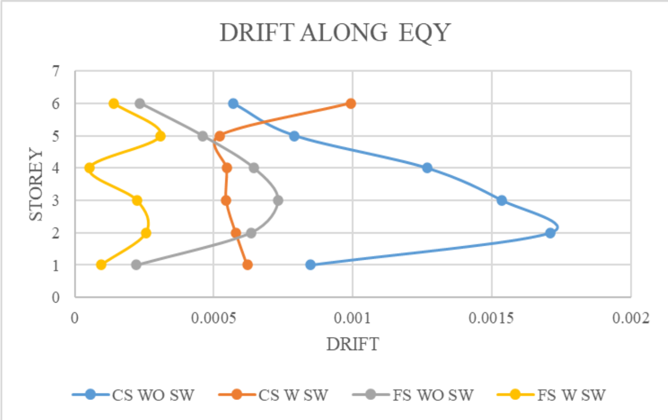

Chart -4: Storey vs drift for structures along EQY.

4.3. Storey Shear

By studying from results and comparing their values in figures below we can see that variation in shear as storey height increases. We can clearly see that there is a reduction of storey shear for Flat slab structure and more for conventional structure along both X and Y direction respectively for equivalent static analysis.

Here the storey shear depends on the weight of the storey so conventional slab shear wall has maximum shear along X and Y directions.

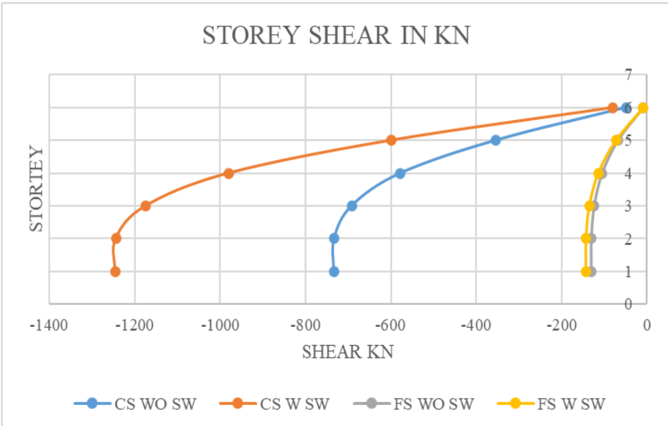

Chart -5: storey vs storey shear for structures along EQX.

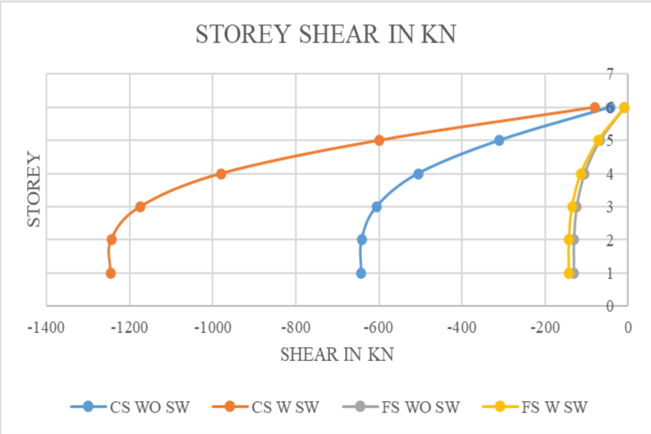

Chart -6: Storey vs storey shear structures along EQY.

4.4. Natural Time Period:

By studying from results and comparing their values in figure below we can see that variation in Time period according to the type of slab configuration, by default software will consider 12 mode shapes in which first three modes are considered for analysis.

Also it is observed that the value of Time period is more for flat slab frame structures compared to conventional slab structures here the flat slab with opening gives maximum time period and its exceeding maximum limit.

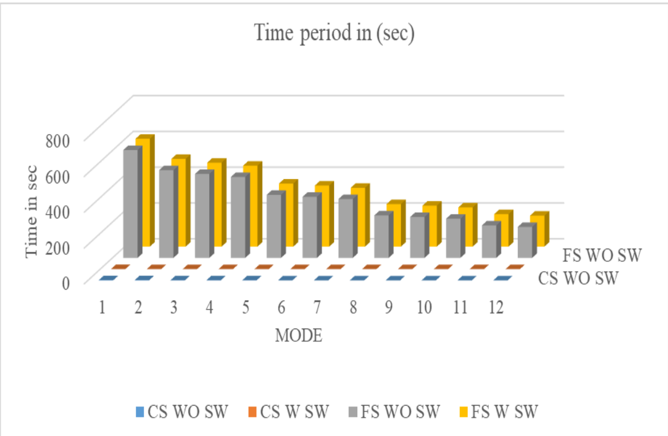

Chart -7: Time vs mode for structures with seismic

4.5. Base Shear:

By studying from results and comparing their values in figures below we can see that variation in base shear value compared to conventional and flat slab structure.

Base shear depends on the total weight of the structure so when we compared with conventional slab structure flat slab structure have minimum weight.

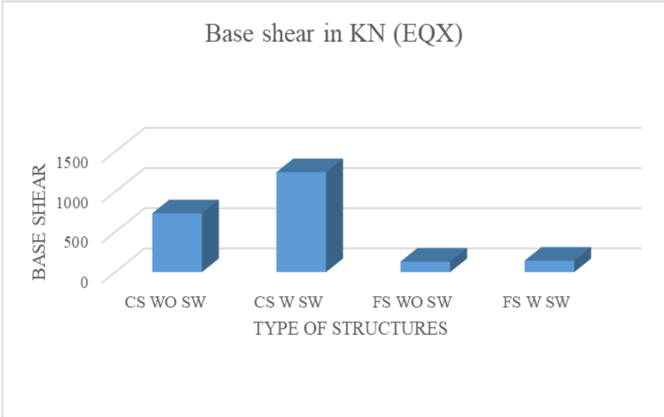

Chart -8: Base shear vs type of structure.

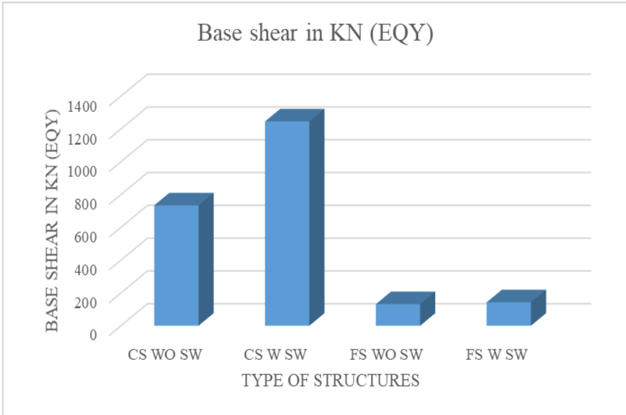

Chart -9: Base shear vs type of structure along EQY.

4.6. Comparison of Story Stiffness:

By studying from results and comparing their values in figures below we can see that variation in stiffness as storey height increases. We can clearly see that there is a reduction of stiffness for without shear wall has maximum along both X and Y direction respectively for equivalent static analysis. Also it is observed that the value of stiffness for structure with shear wall has maximum value compared to structure without wall.

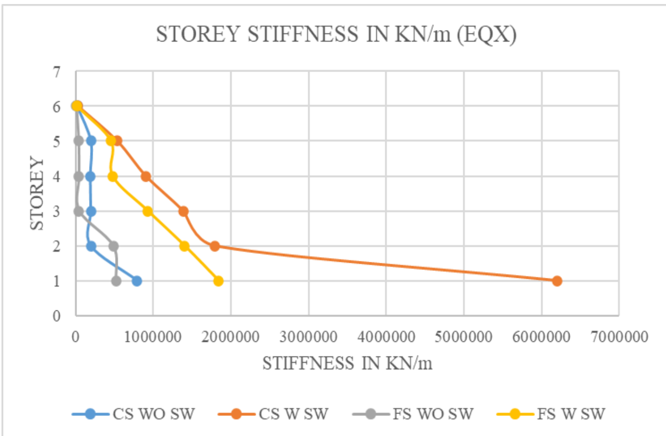

Chart -10: shear vs stiffness for structures along EQX.

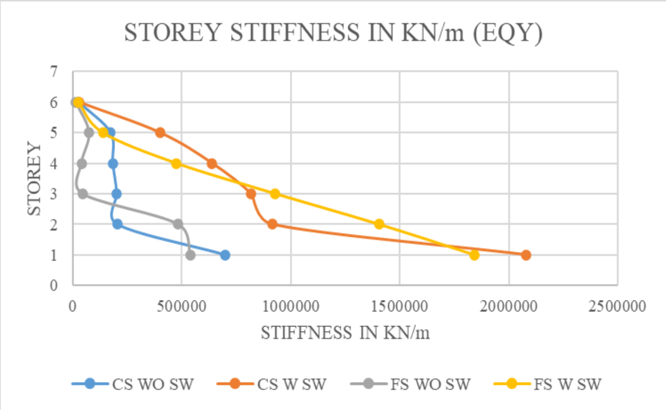

Chart -11: shear vs Stiffness for structures along EQY.

5. CONCLUSIONS

1. Displacement of industrial and commercial structure constructed using flat slab system is more than the conventional slab system. Here we can say that flat slab with shear wall gives better displacement resisting.
2. With the increase in height of structure displacement is also goes on increasing.
3. Story shear of Flat slab building is less than conventional slab building in Y-direction.
4. Story shear is maximum at base level and it decreases as height of structure increases.
5. Base shear of flat slab building is less than the base shear in conventional slab building in both X and Y directions
6. It is seen that story drift is maximum for the conventional slab compared to flat slab and very less for the flat slab with shear wall.
7. Story stiffness of conventional slab building is stiffer than Flat slab building. As the story no decreases stiffness goes on increasing

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