A PARAMETRIC STUDY ON THE SEISMIC BEHAVIOUR OF FLAT SLAB MULTI-STORIED BUILDING WITH SHEARWALL SUBJECTED TO IRREGULARITIES

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Abstract - *During an earthquake, failure of structure progresses at weak point. location of such weak point is due to discontinuity in mass, stiffness, and geometry of structures. Structures exposed to such discontinuity is termed as irregular structures. Presences of such building in high seismic regions region the design and analysis becomes too complex. Stiffness change of structure in height and mass condense the dynamic characteristics of buildings different from the regular building. The core objective of analysis is to conduct the study on the performance of the flat slab multi-storey building with shear wall subjected to different irregularities i.e. vertical geometric irregularity, stiffness irregularity, torsional irregularity The analysis carried out in ETABS 2017 software by using linear dynamic analysis (Response spectrum method) for 10-storey building. Height of each storey being 3.5m. Total 4 models with different irregularities are been compared on bases of parameter's storey displacement, storey stiffness, storey drift, & time period.*

Key Words: Flat slab, Shear wall, Time period, Stiffness, Torsional, Response Spectrum.

1. INTRODUCTION

1.1 PREFACE

An earthquake is natural disaster that the world is facing which is the consequential of the unexpected release of energy in the earth's crust, it is usually initiated by the movement that take place along the plane of fault which leads to produce a seismic wave that causes the destruction. Earthquakes are usually impulsive in natural surroundings. the amount of the earthquake is determined from the relations to the energy that is released at the specific position at ground fault, its severe effect towards the structure is found out by moments due to seismic forces acing at the location of structure. The resultant movement is generally impacted by the structures which leads to the loss of human life and possessions of the national budget. Seismic tremor is one of the catastrophic events which the world is confronting time to time.

In view of past quake information, forfeiture of human lives and properties which eventually influences the national economy.

The structure ought to have, to be specific basic and normal arrangement, sufficient sidelong quality, firmness and flexibility to achieve well under quake.

Structure with straightforward normal shape and uniform distributed mass and having regular symmetric plan are considered to endure a lot lesser harm than structures with unpredictable structure. However, these days, unpredictable structures are favoured due to their useful and stylish contemplations is obvious from instances of reasonable existing sporadic structures.

1.2 PHILOSOPHY OF SEISMIC DESIGN

The essential design earth quake safe structure reasoning might be outlined as given beneath:

- Under lesser however repeating movements, the essential members of the structure should withstand both vertical and horizontal forces.
- Under dynamic but rarely movement of ground, the vital members may bear genuine harm, though the structure must not deteriorate.

1.3 OBJECTIVE OF THE STUDY

1. To compare the behaviour of various structures subjected to different irregularities.
2. The analysis is carried out between the flat slab structure of G+9 storey by means of shear wall being subjected to the different irregularities such as vertical geometric irregularities, torsional irregularity, stiffness irregularity.

2. LITERATURE REVIEW

2.1 REVIEW

The following are the past research carried out based on the structure subjected to irregularities.

"Priyanka Vijaykumar Baheti, D.S. Wadje, G.R. Gandhe" (2017) [1] studied about behaviour of the building with shear wall & infill panel at center and at corner are analyzed by Etabs software through static analysis. To achieve the objective flat slab with peripheral beam and infill wall panel & shear wall for the different height of the structures i.e. G+ 4, G+8, G+12 are modelled and analyzed by static method to study the behaviour of structure till collapse & weakness is identified under seismic loading. Time period is proportional to the numbers of storeys. zone V and medium soil condition is considered for examination.

"Amrut Manvi" (2015) [2] examined the cost examination of flat slab and conventional RC slab structure having B+G+3 storey in seismic zone 2 using analysis software ETABS. This investigation found that the RC beam structure is heavier than the flat slab structures. The expense of the flat slab structure was 15.8% less than the reinforced concrete structure. In term of the cost of the material the flat slab structure is best solution for the multi-storey building w.r.t. the conventional RC structures.

"Sumit Pahwa" (2014) [3] directed the case study for the assessment of various structural parameters of the RC structure and flat slab without provision of shear wall for the following seismic zone III, IV & V &with variable height of 21m, 27m, 33m, and 39m. This research also stated about the seismic behaviour of heavy slab lacking end restrained. These study statuses that for all the cases considered the parabolic path is followed by the drift values along the height of the storey with the maximum value being near mid-storey. Flat slab with drop are within permissible limits in zone III without shear-wall.

3. METHODOLOGY

3.1. MODEL GEOMETRY

Model consists of 5 Bay in each vertical & Horizontal direction, each bay having constant Panel Dimensions of 5mX5m.

Building Height:

Building is Modelled for G+9 Storey each of height 3.5m, Making of Total 35m as building height Except for the Stiffness Irregularity Model G+8 storey with Soft Storey of 7m at storey level 4, making Similar height of the Building i.e. 35m.

Table -3.1: Material Properties

DESCRIPTION	VALUES
GRADE OF CONCRETE	M20
GRADE OF STEEL	Fe415
DENSITY OF RCC	25KN/m^3
COLUMN SIZE	600mm X 600mm
SHEARWALL THICKNESS	200mm
SLAB THICKNESS	200mm
DROP THICKNESS	75mm
DROP SIZE	2.5m X 2.5m
IMPOSED LOAD	4 KN/m^2
FLOOR FINISH	2KN/m^2
SEISMIC ZONES	III
RESPONSE REUDCTION FACTOR	3 (OMRF)
IMPORTANCE FACTOR 'I'	1.5
SOIL CATEGORY TYPE	II (MEDIUM)
DAMPING RATIO	0.05

3.2. LOAD CALCULATIONS

Load Calculations: -
system of the structure is allied with three kinds of primary load cases as per Indian standard provisions: -

- Dead Load (IS:875.(Part I)-1987)
- Live Load (IS:875.(Part II)-1987)
- Seismic Load (IS:1893.(Part III)-2002)

Dead Load: -
The total dead weight of the assembly is calculated by software on the bases of Sections property of the materials & the constant of materials.

3.3. MODEL LAYOUT

Model layout to be Modeled out in ETABS is briefly descriped below.

- **MODEL-B1**(REGULAR FLAT SLAB)
- **MODEL-B2** (GEOMETRIC IRREGULARITY). Geometric irregularity is provided at storey 5, offset is provided on both the side by 5m on each side.
- **MODEL-B3** (STIFFNESS IRREGULARITY). Stiffness irregularity is provided by incorporating the soft storey by increasing the height of storey7m).
- **MODEL-B4** (TORSIONAL IRREGULARITY). Torsional irregularity acts into play when the shear wall is placed at one edge corner.

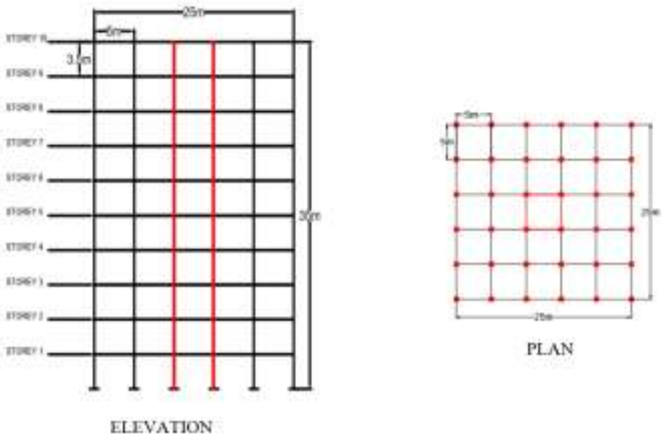

Fig -3.2: MODEL-B1 (REGULAR FLAT SLAB WITH SHEARWWALL)

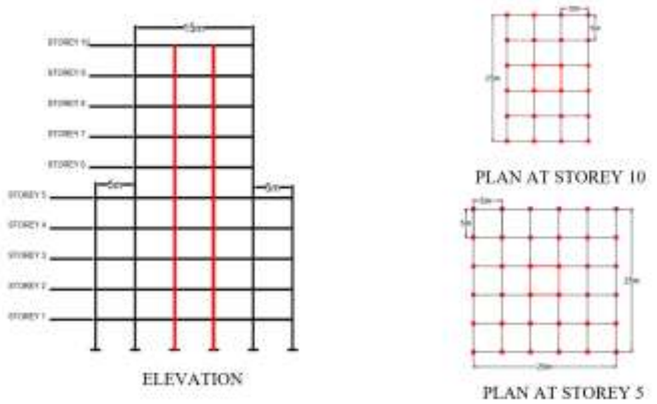

Fig -3.3: MODEL-B2 (GEOMETRIC IRREGULARITY-FLAT SLAB WITH SHEAR WALL)

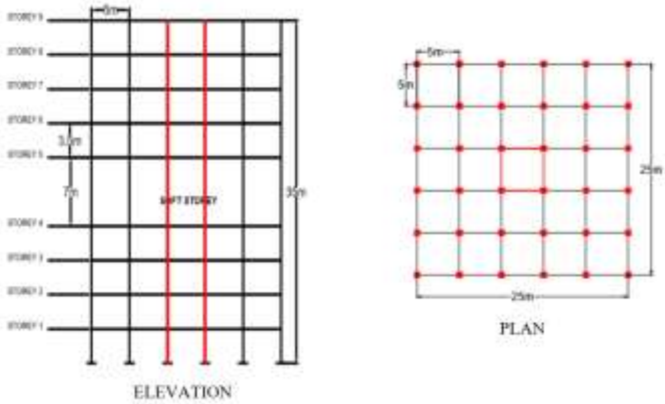

Fig -3.4: MODEL-B3 (STIFFNESS IRREGULARITY-FLAT SLAB WITH SHEAR WALL)

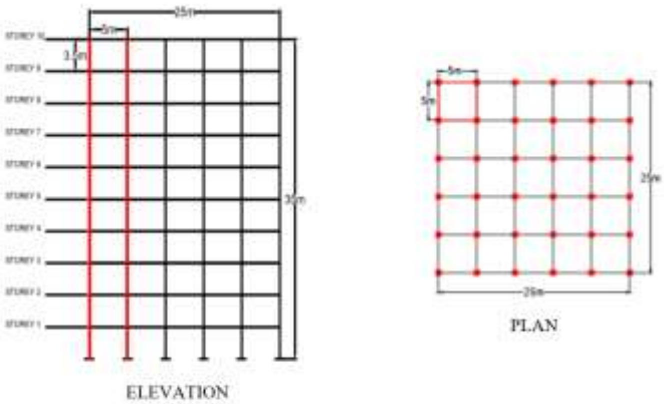

Fig -3.5: MODEL-B4 (TORSIONAL IRREGULARITY-FLAT SLAB WITH SHEARWALL)

3.4 ETABS MODEL

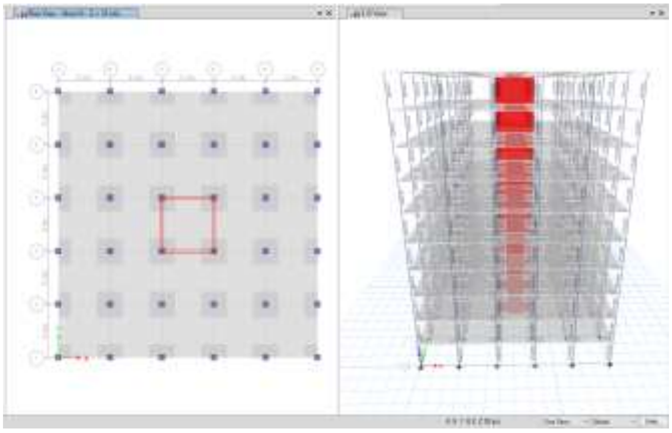

Fig -3.6: MODEL-B1 (REGULAR FLAT SLAB WITH SHEARWWALL)

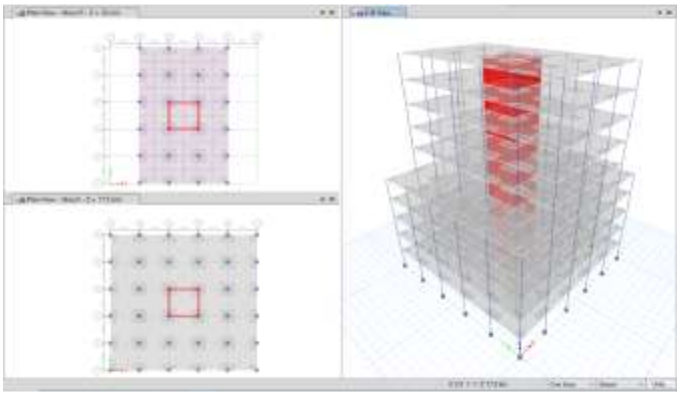

Fig -3.7: MODEL-B2 (GEOMETRIC IRREGULARITY-FLAT SLAB WITH SHEAR WALL)

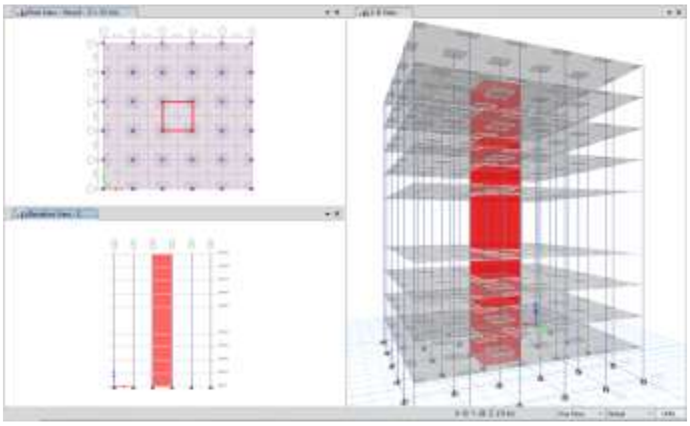

Fig -3.8: MODEL-B3 (STIFFNESS IRREGULARITY-FLAT SLAB WITH SHEAR WALL)

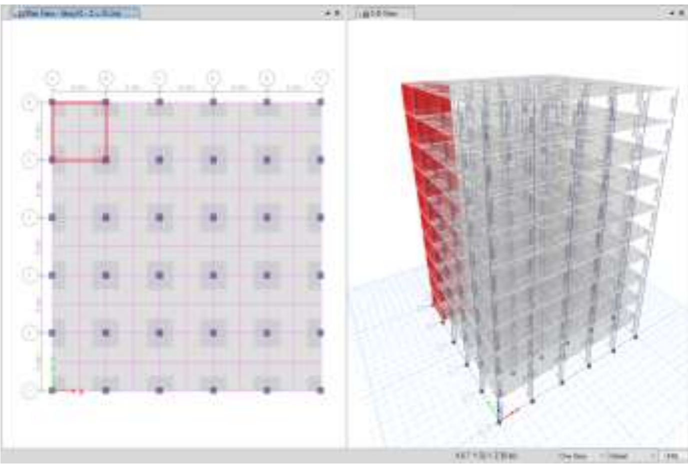

Fig -3.9: MODEL-B4 (TORSIONAL IRREGULARITY-FLAT SLAB WITH SHEARWALL)

4. RESULTS & DISCUSSION

STOREY DISPLACEMENT:

Table -4.1: Maximum storey displacement of flat slab with shear wall.

STOREY	ELEVATION	MODEL-B1	MODEL-B2	MODEL-B3	MODEL-B4
	in meters	in mm	in mm	in mm	in mm
STOREY10	35	20.844	19.309	17.699	24.517
STOREY9	31.5	18.425	16.985	15.682	23.147
STOREY8	28	15.906	14.592	13.565	21.394
STOREY7	24.5	13.343	12.181	11.399	19.292
STOREY6	21	10.781	9.795	9.227	16.905
STOREY5	17.5	8.284	7.503	.	14.271
STOREY4	14	5.927	5.377	5.053	11.382
STOREY3	10.5	3.801	3.454	3.264	8.237
STOREY2	7	2.015	1.836	1.747	4.92
STOREY1	3.5	0.685	0.627	0.603	1.768
Base	0	0	0	0	0

Chart -4.1: storey displacement of flat slab with shear wall.

Storey Displacement: -

- Storey displacement varies linearly for all models, max can been seen in MODEL-B4.
- The Storey displacement is increased by 17.6% in MODEL-B4 when compared to MODEL-B1. The storey displacement in MODEL-B2 & MODEL-B3 are decreased by 7% & 15% respectively w.r.t. MODEL-B1.
- Storey displacement increases when the shear wall is shifted at the one end corner.
- Shear wall proves to be more effective in resisting lateral forces in vertical geometric irregularity and soft storey model because of lesser weight of structure.

STOREY DRIFT:

Table -4.2: Maximum storey drift of flat slab with shear wall.

STOREY	ELEVATION	MODEL-B1	MODEL-B2	MODEL-B3	MODEL-B4
	in meters	in mm	in mm	in mm	in mm
STOREY10	35	0.000691143	0.000664	0.000576286	0.000391429
STOREY9	31.5	0.000719714	0.000683714	0.000604857	0.000500857
STOREY8	28	0.000732286	0.000688857	0.000618857	0.000600571
STOREY7	24.5	0.000732	0.000681714	0.000620571	0.000682
STOREY6	21	0.000713429	0.000654857	0.000596286	0.000752571
STOREY5	17.5	0.000673429	0.000607429	-	0.000825429
STOREY4	14	0.000607429	0.000549429	0.000511143	0.000898571
STOREY3	10.5	0.000510286	0.000462286	0.000433429	0.000947714
STOREY2	7	0.00038	0.000345429	0.000326857	0.000900571
STOREY1	3.5	0.000195714	0.000179143	0.000172286	0.000505143
Base	0	0	0	0	0

Chart -4.2: Storey drift of flat slab with shear wall.

Storey Drift:-

- In MODEL-B1, B2 & B3 the variation in storey drift is uniform when two adjacent storeys are taken into consideration.
- storey drift is less in MODEL-B2 & B3 when compared to MODEL-B1(regular flat slab building). Shear wall in building with irregularities proves to be more effective due to reduction in weight.
- For MODEL-B3 there is not any sudden change in storey Drift at the levels where the soft storey is located.
- In MODEL-B4 Larger storey drift is observed at the lower level and its reduces at top marginally due to torsional irregularity.

BASE SHEAR:

Table -4.3: Maximum Base shear of flat slab with shear wall.

RESULTS: -	MODEL-B1	MODEL-B2	MODEL-B3	MODEL-B4
BASE SHEAR IN KN	2862.4796	2666.8325	2223.9258	1638.8847

Chart -4.3: Base Shear of Flat Slab with Shearwall.

Base Shear:

- Maximum expected lateral force is high in MODEL-B1 as the Base Shear Develop in that model is high.
- Least base shear is observed in MODEL-B4 due to the torsional irregularity.
- There is decrease in base shear by 7%, 22% & 42% respectively in MODEL B2, B3, &B4 w.r.t MODEL-B1.
- From MODEL-B1 & B4, location of shear wall plays a vital part in terms of the base shear. Shear wall at the centre of building will have higher base shear compared to shear wall at the one end corner.

STOREY STIFFNESS:

Table -4.4: Maximum storey stiffness of flat slab with shear wall.

STOREY	ELEVATION	MODEL-B1	MODEL-B2	MODEL-B3	MODEL-B4
	in meters	KN/M	KN/M	KN/M	KN/M
STOREY10	35	271170.393	220850.324	273526.26	231701.983
STOREY9	31.5	462179.096	784647.032	449513.451	354313.437
STOREY8	28	584015.682	1018472.968	545342.245	409998.007
STOREY7	24.5	679827.423	1202212.527	615023.678	446324.056
STOREY6	21	786719.937	331259.238	366269.7	486920.411
STOREY5	17.5	927182.099	872356.026	-	537497.901
STOREY4	14	1130619.309	1099767.368	963328.982	596825.399
STOREY3	10.5	1461393.829	1460037.231	1281743.018	670122.934
STOREY2	7	2088031.782	2118831.282	1860788.758	802219.455
STOREY1	3.5	4181644.379	4252529.373	3688568.404	1493761.04
Base	0	0	0	0	0

Chart -4.4: storey stiffness of flat slab with shear wall.

Storey stiffness: -

- In MODEL -B1 & B4 the story stiffness pattern observed is uniform. The large stiffness variation is seen in MODEL-B2 & B3 at site of change in vertical geometry and at the location of soft storey.
- From MODEL-B2& B3 it is witnessed that, the stiffness of the structure is decreased due to soft storey and change in vertical geometry.
- Storey stiffness of floor at the level of change in vertical geometry of MODEL-B2 is less than 78% w.r.t to the adjacent upper storey.
- For MODEL-B3 the Lateral stiffness at the level of location of soft storey is increased because of shear wall.
- MODEL-B4 has the lowest story stiffness which varies uniformly. Hence its more prone to the seismic effects. Due to torsional irregularity the stiffness of the structure is decreased.

TIME PERIOD:

Table -4.5: Maximum Time period of flat slab with shear wall.

TIME PERIOD	MODEL-B1	MODEL-B2	MODEL-B3	MODEL-B4
Modal case	Period	Period	Period	Period
	sec	sec	sec	sec
1	1.065	0.901	1.113	1.654
2	1.065	0.898	1.112	1.143
3	1.051	0.776	1.112	0.728
4	0.345	0.304	0.353	0.505
5	0.248	0.231	0.245	0.288
6	0.248	0.23	0.245	0.268
7	0.202	0.171	0.219	0.19
8	0.139	0.12	0.135	0.167
9	0.113	0.102	0.123	0.135
10	0.113	0.102	0.123	0.123
11	0.103	0.091	0.112	0.102
12	0.081	0.071	0.075	0.08

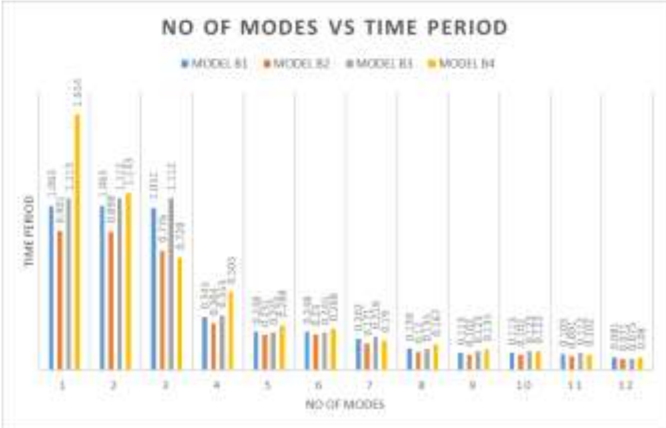

Chart -4.5: No of Modes Vs Time Period chart of Flat Slab with Shear wall.

Time Period: -

- Fundamental natural period T of a normal single storey structure to 20 storey buildings are usually in the range 0.05-2 sec.
- Time period(T) increases with the flexibility, flexible building be likely to undergo larger relative horizontal displacement it may results in destruction to countless non-structural building component and the content.
- MODEL-B2 has the lowest time period of 0.9sec lesser the mass lesser is the time period.
- MODEL-B4 has time period is 1.654 sec because of torsional irregularity.
- MODEL-B1& B3, has nearly equal Time period in the range of 1 to 1.15 sec.

5. CONCLUSIONS

- Base shear of the model with lateral load resisting system provisions at one end of the corner is less compared to the other models.
- Shear wall increases the base shear of the structures which is the estimation of the expected lateral forces that a structure can resist.
- Large variations in Story drift due to the geometric irregularities and stiffness irregularities can be reduced by use of shear wall.
- When the plan and vertical geometry of the building configurations are asymmetric, then the building will be exposed to torsion.

6. SCOPE FOR FURTHER STUDIES

- Flat slab structure subjected to irregularities by using different way of analysis i.e. time history & push over analysis.
- To study the Behaviour of multi-storey Flat slab building subjected to irregularities w.r.t. different seismic zones.

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