Seismic Response of Vertically Irregular and Regular RC Structure with Stiffness Irregularity at Different Level

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Abstract: Nowadays, as in the urban areas the availability of space for the construction of buildings is less , thats why we can construct vertically irregular or regular building. So in limited space we have to construct such type of buildings which can be used for multiple purposes such as lobbies, car parking, reception hall etc. To fulfill the demand, buildings with irregularities is the only option available for construction. During an earthquake, failure of structure starts at weak points, and this weakness arises due to irregularity in mass, stiffness and geometry of structure. During an earthquakes, vertical irregularities are one of the major reasons of failures of structures.To study the behaviour of the building having various vertical irregularities at different floor level with stiffness irregularity at different level and the modelling is done by using the software SAP2000. The methods use for analysis are static analysis and response spectrum analysis. Comparison has done for vertically irregular and regular building by considering various parameters like storey drift, displacement, base shear, and storey stiffness.

Keywords*: Stiffness irregularities, vertical irregularities, soft storey, storey drift.*

I. INTRODUCTION

Irregular buildings consist of a big portion of the modern urban infrastructure. The people involved in constructing the building facilities, including owner, architect, structural engineer, contractor and local authorities, contribute to the overall planning, selection of structural system, and to its configuration. This may lead to structures with irregular distributions in their stiffness, mass and strength along the height of building. When such buildings are located in a high seismic zone, the structural engineers role becomes more challenging for the construction. Therefore, the structural engineer needs to know the seismic response of irregular structures. In recent past years,several studies have been carried out to analyze the seismic response of vertically irregular buildings.

Structures with soft storey were the most notable structures which is collapsed. Therefore , the effect of vertically irregularities in the seismic performance of structures becomes really more important. Vertically or heightwise changes in stiffness and mass under the dynamic characteristics of irregular buildings are different from the regular building. As per IS 1893 vertical irregularity in the structures may be due to irregular distributions in their mass, strength and stiffness along the height of building. When such buildings are constructed in high seismic zones, the analysis and design becomes more challenging There are various types of irregularities in the buildings depending upon their location and characteristics but mainly, they are divided into two parts, plan irregularities and vertical irregularities.

II. LITERATURE REVIEW

1. M. R. AMIN, P. HASAN, " EFFECT OF SOFT STOREY ON MULTISTORIED REINFORCED CONCRETE BUILDING FRAME"

In this paper, the effect of soft storey for multistoried reinforced concrete building frame, four building models (3, 6, 9 and 12 storey) with identical building plan were analyzed. Equivalent diagonal struts were provided, as suggested in , in place of masonry to generate infill effect. Earthquake load was provided at each diaphragm' s mass centre as a source of lateral load as set forth by the provision (1993). Soft storey level was transferred from ground floor to top floor for each model and equivalent static analysis was carried out using ETABS 9.6.0 analysis package.

2. P. B. LAMB, DR. R. S. LONDHE, " SEISMIC BEHAVIOR OF SOFT FIRST STOREY"

In this paper, the study of a building with the help of different models considering different methods for improving the seismic performance of the building with soft first storey. Analytical models represent all existing components which determine the mass, strength, stiffness and deformability of structure. The equivalent static and dynamic analysis is carried out on 3d model using the software SAP2000 and the comparisons of these models are presented. Lastly, the performance of all the building models is observed in high seismic zone v.

The use of masonry infill is found to be not effective in decreasing the strength demand on the first storey columns, though they considerably reduce the stiffness irregularity. In this case the stiffness of first storey is 45% of second storey stiffness. The use of cross bracings importantly increases the first storey stiffness. Light weight infill is found to be quite effective in increasing the stiffness of first storey, storey drift and marginally reduces the strength demand in first storey columns.

3. RAKSHITH GOWDA, K. R AND BHAVANI SHANKAR, " SEISMIC ANALYSIS COMPARISON OF REGULAR & VERTICALLY IRREGULAR RC BUILDING WITH SOFT STOREY AT DIFFERENT LEVEL"

In this paper, the study of behavior of multi storyed RC 3-d frame regular building and vertically irregular (stepped) building is done, in which soft storeys are provided at different level for different load combinations. Staad pro is used for modelling and

analysis RC buildings. It is necessary to study and to survey various alternative models of reinforced concrete moment resisting frame building with soft storey at different level, the performance of all the building models is observed in seismic zone v which is very high. In an investigation has been made to study the behavior of RC frames when subjected to static and dynamic earthquake loading. The result of bare frame, frame with infill, and different location of soft storey provided are compared and result are made in view of is code. It is observed that, providing infill increase earthquake resistant behavior of the structure when compared to soft storey provided. If the frame cannot be provided with complete infill, the soft storey can be provided in the 5th floor as this model shows relatively less displacement and inter storey drift and 10th floor shall be ignored as this model had maximum displacement and inter storey drift in comparison with the models with soft storey in other locations.

4. DR. SARASWATI SETIA AND VINEET SHARMA, " SEISMIC RESPONSE OF R.C.C BUILDING WITH SOFT STOREY"

This paper includes, the influence of some parameters on behaviour of a building with soft storey. The modelling of building is carried out using the software STAAD.Pro 2006. Parametric studies on storey shear , inter storey drift and displacement have been carried out using equivalent static analysis to explore the influence of these parameter on the behaviour of buildings with soft storey. The selected building analyzed through five numerical models.

III. GAPS IN LITERATURES

After the study of various national and international research papers on the performance of seismic analysis of vertically irregular and regular building , the problems and gap which are studied above is mentioned below,

- From earlier research work till now, Various researches have carried out work on seismic analysis of vertically irregular and regular building with stiffness irregularity at ground soft story, but there are very few scientific research dealing with the comparison of vertically irregular and regular rc frame with stiffness irregularity at different level. In this paper the study of vertically irregular and regular building with stiffness irregularity at different level will be carry out.
- There are mostly seismic analysis is done on zone IV and zone V. In this paper analysis is done under seismic zone V.
- There is need to know which structure is economical for design the structure by using modern software SAP2000 is discussed in this paper.

IV. MODELING & ANALYSIS OF STRUCTURES

In this study, five models will be analyze for irregular and regular building by using the software SAP2000. And soft storey is provided at different level in vertically irregular and regular building. The categorization of model is as follows:

1. Without soft story in vertically irregular and regular building.
2. Soft storey at ground level in vertically irregular and regular building.
3. Soft storey at 5th floor in vertically irregular and regular building.
4. Soft storey at 9th floor in vertically irregular and regular building.
5. Soft storey at 13th floor in vertically irregular and regular building.

IV.1: Material Properties

M-25 grade of concrete and Fe-415 grade of reinforcing steel are used for all the frame models used in this study. Elastic material properties of these materials are taken as per Indian Standard IS 456 (2000). The short-term modulus of elasticity (EC) of concrete is taken as:

$EC = 5000\sqrt{Fck}$

IV.2: Building Description

The SAP2000 software is used to develop 3D model and to carry out the analysis. The study is carried out on reinforced concrete moment resisting frame. with regular and irregular structure of different wall thickness combination and provide soft storey at different floor level. The soft storey position is at ground floor, fifth floor, ninth floor and thirteen floor level in regular and irregular buildings. The plan layout of the building is shown in Figure 3.1. The building considered is the general building having G+15 stories. The detail description of structure considered for analysis is given in Table 3.1.

Table 3.1:Structural Details.

TYPE OF STRUCTURE	SMRF
NO.OF STORIES	G+15
PLAN DIMENSION	24 X 36M
STOREY HEIGHT	3M

THICKNESS OF SLAB	0.150M
BEAM SIZE	0.3X0.5M
COLUMN SIZE	0.8X0.4M
SEISMIC ZONE	V
HEIGHT OF BUILDING	48M
DENSITY OF BRICK	20KN/M2
LIVE LOAD	3KN/M2
ROOF LOAD	1.5KN/M2
SOIL CONDITION	MEDIUM SOIL[TYPE II]
ZONE FACTOR	0.36
RESPONSE REDUCTION FACTOR	5
IMPORTANCE FACTOR	1
WALL THICKNESS	230MM

IV.3: Modelling

IV.3.1 Discription of all Buildings.

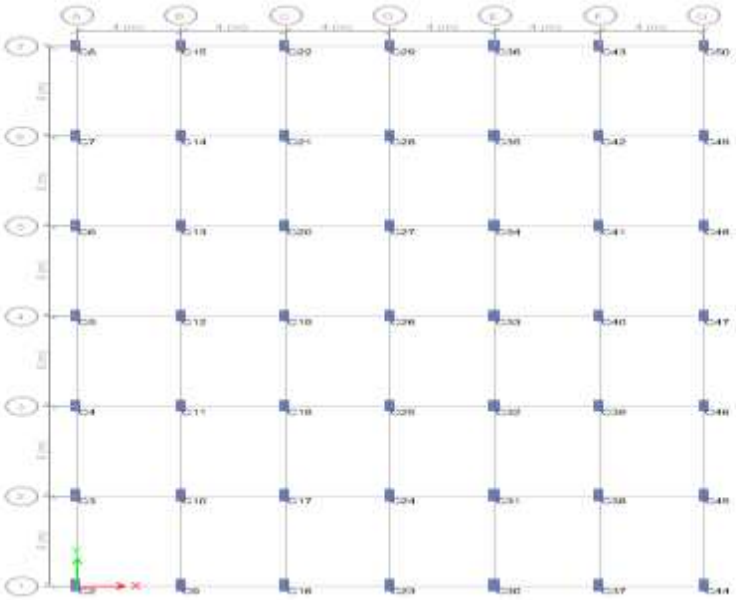
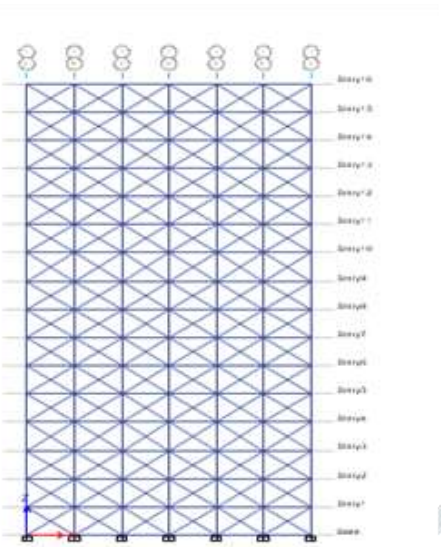


Fig. 3.1: plan of structure

IV.3.2 : Elevation of regular and irregular building



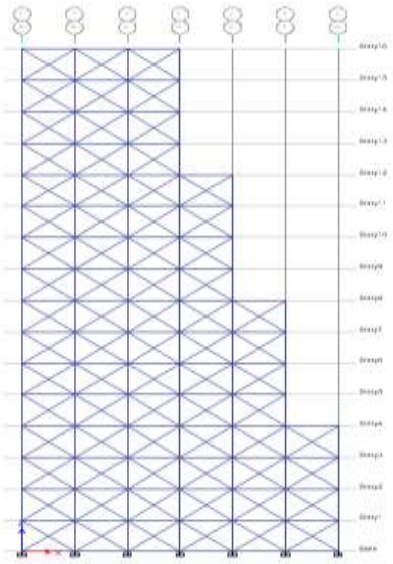


Fig3.2: Elevation of regular building **Fig.3.3:Elevation of irregular building**

IV.4 : Analysis of building

Seismic codes are unrepeatable to a particular region or country. In India, Indian Standard Criteria for Earthquake Resistant Design of Structures IS 1893 (Part-I): 2002 which provides outline for calculating seismic design force. This force turn on the mass and seismic coefficient of the structure and depends on properties like seismic zone in which structure lies, importance of the structure, its stiffness, the soil properties and its ductility. The code recommends following methods of analysis.

IV.4.1 Equivalent static analysis

Equivalent static analysis is performed on all the models, which is given below.
The total design lateral force or design seismic base shear (VB) along any principal direction shall be determine by the following expression using IS: 1893 (Part 1)-2002.
The design horizontal seismic coefficient (Ah) is given by,
The fundamental natural period (Ta) is taken for moment resisting frame building without brick infill panels as And then Distribution of design force (Qi)

$$Qi=VB$$

The fundamental natural period (Ta) is taken for moment resisting frame building without brick infill panels as And then Distribution of design force (Qi)

where,
Qi = Design lateral force at floor i,
Wi = Seismic weight of floor i,
hi = height of floor i which measure from base, and
n = Number of stories.
The results obtained from analyses are compared with respect to the following parameters.

IV.4.2 Response spectrum analysis

Response Spectrum analysis allows to analyze the structure for seismic loading. For any supplied response spectrum (either acceleration v/s period or displacement v/s period) joint displacements, member forces and support reaction may be calculated. Model response may be combined either square root of sum of squares (SRSS) or complete quadratic combination (CQC) method to obtain the resultant response, as given in clause 7.8.4.4 of code IS1893(Part I):2002.

Building with regular or irregular plan configuration may be modeled as the system of masses lumped at the floor levels with each mass having one degree of freedom, that of lateral displacement in the direction under consideration.
In the present work, the Response spectra of IS1893:2002 is used. The method of Square root of sum of square (SRSS) is used for combining modal response. Damping factor is taken as 1, this corresponds to the 5% damping ratio. Spectra is applied in both X and Y direction. For the analysis, following load combinations specified by the IS 1893: 2002 as per clause 6.3.1.2 are used.
1.1.5 (DL+ LL)
2.1.2 (DL + LL ± EL)
3.1.5 (DL EL)
4.0.9 DL ± 1.5EL

With the available data about the structure; plan, elevation, section details, grade of steel and concrete, etc. a three dimensional modeling of the structure is done. There are 6 initial basic load cases; their directions with respect to the plan orientation are as given below. They are,

1. Dead Load (DL)
2. Live Load (LL)
3. Earthquake Load in X-Direction (EQX)
5.Response spectrum analysis in X-Direction (RSAX)

IV.5 : Objectives of this study-

1) To determine the best and the appropriate structural system for the different type of buildings and to understand irregular and regular shape building.

2) To analyze irregular and regular structural systems using SAP2000 software for vertical irregularity.

3) To compare the performance of the building with irregular and regular shape under seismic loading.

4) To obtain the response in terms of parameter such as storey displacement, storey drift, storey shear.

V.RESULT

After analyzing and designing of all models for regular and irregular building in SAP2000 Software, the results obtained in terms of storey drift, base shear, displacement, storey stiffness. The comparison between regular and irregular building model shown below in terms of graphical representation.

V.1. Displacement –

The value of storey displacement is shown in Table 1 and Table 2, displacement value in X-direction for regular and irregular building are given.

Table 1: Displacement for regular shape building in X-Direction.

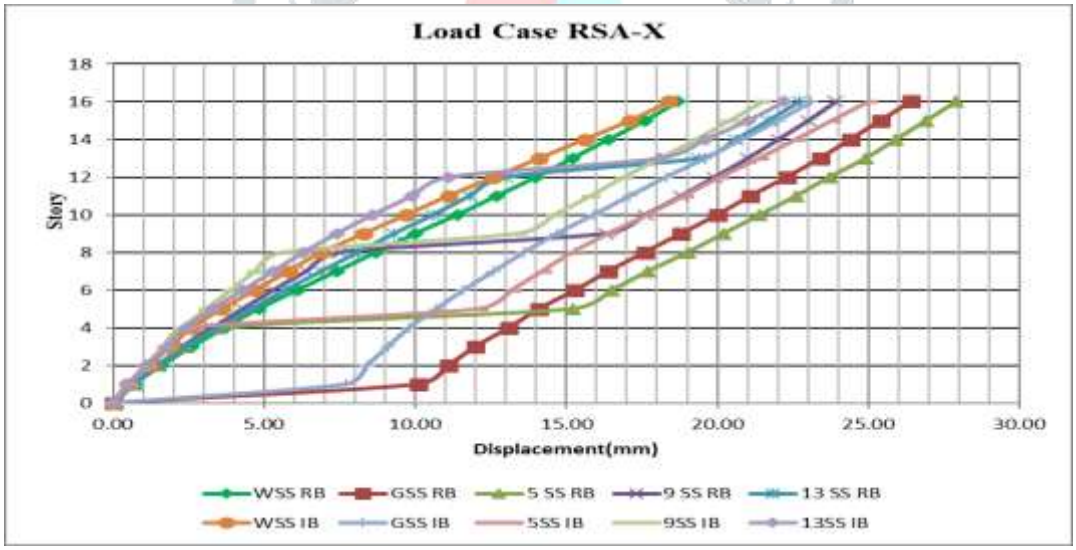
DISPLACEMENT						
REGULAR						
Sr. No.	*Direction*	*X direction (RSAX)*				
	Story's	*without soft storey*	*ground soft stoery*	*5th soft storey*	*9th soft storey*	*13th soft*
16	**Story 16**	18.70	26.40	27.90	23.90	22.70
15	**Story 15**	17.60	25.40	26.90	23.00	21.70
14	**Story 14**	16.40	24.40	25.90	22.00	20.60
13	**Story 13**	15.20	23.40	24.90	21.00	19.40
12	**Story 12**	14.00	22.30	23.70	19.90	13.00
11	**Story 11**	12.70	21.10	22.60	18.80	11.80
10	**Story 10**	11.40	20.00	21.40	17.60	10.60
9	**Story 9**	10.00	18.80	20.20	16.30	9.30
8	**Story 8**	8.70	17.60	19.00	7.50	8.10
7	**Story 7**	7.40	16.40	17.70	6.40	6.90
6	**Story 6**	6.10	15.30	16.50	5.30	5.70
5	**Story 5**	4.80	14.10	15.20	4.30	4.60
4	**Story 4**	3.70	13.10	3.50	3.30	3.50
3	**Story 3**	2.60	12.00	2.40	2.30	2.40
2	**Story 2**	1.60	11.10	1.50	1.50	1.50
1	**Story 1**	0.70	10.10	0.70	0.70	0.70
0	**Story 0**	0.00	0.00	0.00	0.00	0.00

Table 2: Displacement for irregular shape building in X-Direction.

IRREGULAR						
Sr. No.	*Direction*	*X direction (RSAX)*				
	Story's	*without soft storey*	*groud soft stoery*	*5th soft storey*	*9th soft storey*	*13th soft*
16	**Story 16**	18.40	23.10	25.00	21.50	22.20
15	**Story 15**	17.10	22.00	23.80	20.40	21.00
14	**Story 14**	15.60	20.80	22.60	19.30	19.60
13	**Story 13**	14.10	19.60	21.40	18.10	18.10
12	**Story 12**	12.60	18.30	20.10	16.90	11.10
11	**Story 11**	11.10	17.10	18.90	15.80	9.90
10	**Story 10**	9.70	15.90	17.70	14.60	8.60
9	**Story 9**	8.30	14.70	16.40	13.40	7.40
8	**Story 8**	6.90	13.60	15.20	5.60	6.30
7	**Story 7**	5.80	12.60	14.20	4.70	5.30
6	**Story 6**	4.70	11.60	13.20	3.90	4.30
5	**Story 5**	3.60	10.70	12.10	3.10	3.30
4	**Story 4**	2.60	9.80	2.50	2.30	2.40
3	**Story 3**	1.90	9.10	1.70	1.70	1.80
2	**Story 2**	1.20	8.40	1.10	1.10	1.10
1	**Story 1**	0.50	7.70	0.50	0.50	0.50
0	**Story 0**	0.00	0.00	0.00	0.00	0.00

From the table it is observed that,

- Displacement in regular building is more as compare to irregular building in x direction.
- Displacement is more where the soft storey is provided for both regular and irregular building.



Graph 1: Displacement in regular and irregular building in x direction

Graph 1 represents the value of storey displacement. In graph x-axis represents the displacement occured in building after application of lateral force and y-axis represents the increasing number of storeys. As we saw in graph displacement is more for 5th soft storey regular building..

V.2: Base shear-

Table 3 and Table 4 represents the value of base shear in vertically regular and irregular building.

Table 3: Base shear for regular building in X-direction.

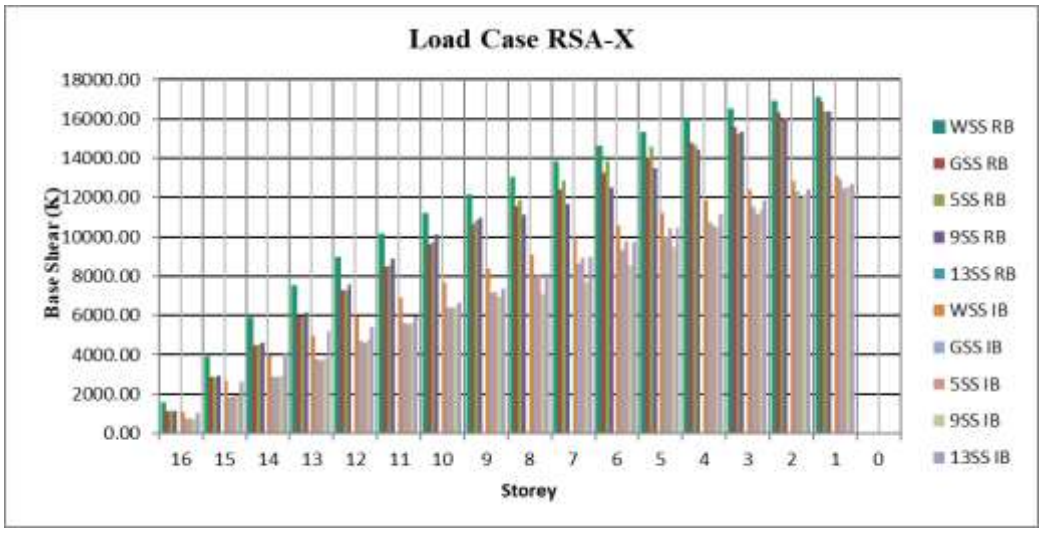
BASE SHEAR						
REGULAR						
Sr. No.	*Direction*	*X direction (RSAX)*				
	Story's	*without soft storey*	*groud soft stoery*	*4th soft storey*	*8th soft storey*	*12th soft*
16	**Story 16**	1555.59	1117.70	1132.07	1129.91	1557.59
15	**Story 15**	3864.03	2860.54	2886.76	2921.95	4035.42
14	**Story 14**	5841.49	4470.30	4494.74	4602.73	6380.85
13	**Story 13**	7506.27	5944.79	5962.00	6161.99	8141.98
12	**Story 12**	8914.15	7287.79	7306.84	7596.47	8483.63
11	**Story 11**	10124.51	8507.88	8552.14	8909.80	9275.68
10	**Story 10**	11184.14	9617.24	9718.09	10113.87	10217.58
9	**Story 9**	12131.92	10630.60	10819.22	10994.99	11167.75
8	**Story 8**	13002.93	11564.31	11865.98	11103.26	12072.78
7	**Story 7**	13820.49	12435.12	12867.50	11645.59	12925.43
6	**Story 6**	14588.97	13258.87	13834.82	12511.17	13722.64
5	**Story 5**	15299.47	14049.21	14581.20	13487.73	14458.33
4	**Story 4**	15937.77	14816.83	14700.61	14452.47	15127.74
3	**Story 3**	16479.71	15568.55	15243.40	15331.72	15712.83
2	**Story 2**	16882.46	16308.70	15945.96	16025.15	16162.57
1	**Story 1**	17094.15	16883.98	16405.08	16405.08	16405.08
0	**Story 0**	0.00	0.00	0.00	0.00	0.00

Table 4: Base shear for irregular shape building in X-direction.

IRREGULAR						
Sr. No.	*Direction*	*X direction (RSAX)*				
	Story's	*without soft storey*	*groud soft stoery*	*4th soft storey*	*8th soft storey*	*12th soft*
16	**Story 16**	1100.57	728.70	753.17	769.33	1030.23
15	**Story 15**	2679.09	1849.44	1880.73	1932.85	2641.57
14	**Story 14**	3958.81	2856.38	2859.30	2950.62	4129.14
13	**Story 13**	4970.18	3749.37	3707.70	3823.73	5216.19
12	**Story 12**	5970.07	4715.00	4638.21	4741.49	5389.13
11	**Story 11**	6881.85	5619.61	5555.57	5603.50	5936.21
10	**Story 10**	7673.16	6423.40	6415.36	6389.34	6647.09
9	**Story 9**	8365.77	7139.09	7213.90	6968.74	7360.48
8	**Story 8**	9109.25	7898.96	8085.99	7080.48	8158.83
7	**Story 7**	9859.10	8640.97	8951.55	7676.32	8977.16
6	**Story 6**	10563.06	9343.67	9787.53	8563.35	9750.16
5	**Story 5**	11199.42	10015.87	10434.89	9493.20	10454.66
4	**Story 4**	11842.41	10762.55	10559.42	10493.73	11183.14
3	**Story 3**	12425.16	11531.31	11179.09	11439.39	11865.99
2	**Story 2**	12864.25	12293.21	11966.52	12177.35	12396.21
1	**Story 1**	13095.47	12885.29	12470.72	12575.99	12681.27
0	**Story 0**	0.00	0.00	0.00	0.00	0.00

From the table it is observed that,

- Base shear is maximum in regular building than irregular building.
- Base shear is more for wss building as compare to all the soft storey building for regular and irregular building.



Graph 2: Base Shear in regular and irregular building in x direction.

Representation of base shear value is shown in graph 1 for regular and irregular building. In graph x-axis represents the number of storeys and y-axis represents the value of base shear.

V.3: Storey Drift-

The value of storey drift is given in table 5 and table 6. In this table, story drift value for vertically regular and irregular building are given.

Table 5: Storey Drift for regular building in X-direction.

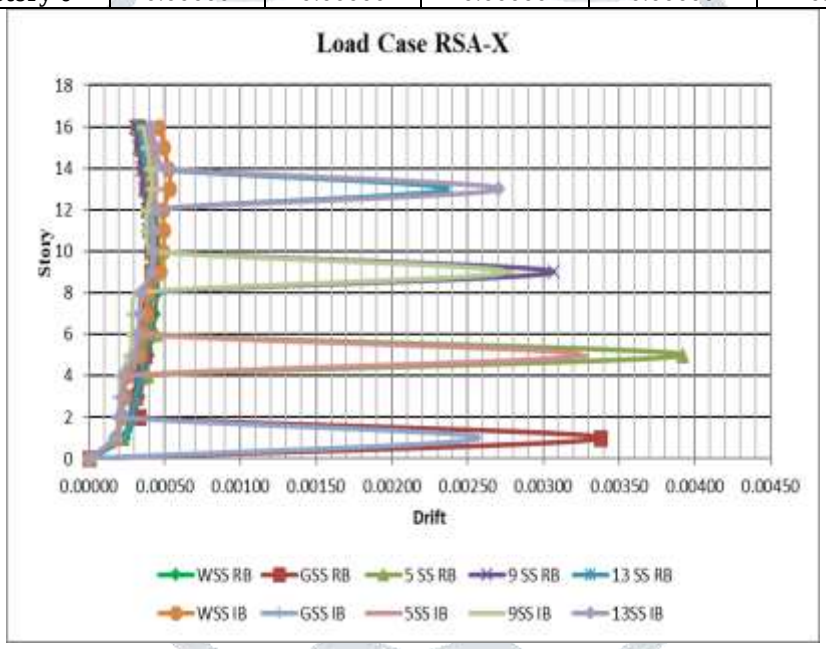
DRIFT						
REGULAR						
Sr. No.	*Direction*	*X direction (RSAX)*				
	Story's	*without soft storey*	*groud soft stoery*	*5th soft storey*	*9th soft storey*	*13th soft*
16	**Story 16**	0.00036	0.00032	0.00032	0.00031	0.00034
15	**Story 15**	0.00039	0.00034	0.00034	0.00033	0.00037
14	**Story 14**	0.00041	0.00036	0.00036	0.00035	0.00042
13	**Story 13**	0.00043	0.00038	0.00038	0.00036	0.00237
12	**Story 12**	0.00044	0.00039	0.00039	0.00038	0.00044
11	**Story 11**	0.00045	0.00040	0.00040	0.00039	0.00042
10	**Story 10**	0.00046	0.00041	0.00041	0.00043	0.00042
9	**Story 9**	0.00046	0.00041	0.00041	0.00307	0.00042
8	**Story 8**	0.00045	0.00041	0.00041	0.00042	0.00042
7	**Story 7**	0.00044	0.00040	0.00040	0.00037	0.00041
6	**Story 6**	0.00042	0.00039	0.00044	0.00036	0.00039
5	**Story 5**	0.00040	0.00037	0.00392	0.00034	0.00037
4	**Story 4**	0.00037	0.00035	0.00039	0.00032	0.00034
3	**Story 3**	0.00033	0.00031	0.00030	0.00030	0.00031
2	**Story 2**	0.00029	0.00033	0.00027	0.00027	0.00028
1	**Story 1**	0.00024	0.00338	0.00023	0.00022	0.00023
0	**Story 0**	0.00000	0.00000	0.00000	0.00000	0.00000

Table 6: Storey Drift for irregular building in X-direction.

From the table it is observed that,

- Drift in regular building is more as compared to drift in irregular building in x direction.
- Drift is more where the soft storey is provided.
- Drift in fifth storey is more.

IRREGULAR						
Sr. No.	*Direction*	*X direction (RSAX)*				
	Story's	*without soft storey*	*groud soft stoery*	*5th soft storey*	*9th soft storey*	*13th soft*
16	**Story 16**	0.00046	0.00039	0.00039	0.00036	0.00042
15	**Story 15**	0.00050	0.00042	0.00041	0.00038	0.00045
14	**Story 14**	0.00052	0.00044	0.00043	0.00040	0.00051
13	**Story 13**	0.00054	0.00045	0.00044	0.00042	0.00271
12	**Story 12**	0.00049	0.00042	0.00041	0.00038	0.00046
11	**Story 11**	0.00049	0.00042	0.00042	0.00039	0.00043
10	**Story 10**	0.00049	0.00042	0.00042	0.00043	0.00043
9	**Story 9**	0.00047	0.00041	0.00041	0.00275	0.00041
8	**Story 8**	0.00039	0.00035	0.00035	0.00033	0.00034
7	**Story 7**	0.00038	0.00034	0.00034	0.00029	0.00034
6	**Story 6**	0.00036	0.00033	0.00037	0.00029	0.00032
5	**Story 5**	0.00034	0.00031	0.00325	0.00027	0.00030
4	**Story 4**	0.00025	0.00023	0.00026	0.00021	0.00023
3	**Story 3**	0.00024	0.00022	0.00021	0.00020	0.00022
2	**Story 2**	0.00021	0.00024	0.00020	0.00019	0.00020
1	**Story 1**	0.00018	0.00257	0.00017	0.00017	0.00017
0	**Story 0**	0.00000	0.00000	0.00000	0.00000	0.00000



Graph 3: Storey Drift in regular and Irregular buildings in X Direction.

Graph 3 represents the value of storey drift. In graph x-axis represents the change in storey drift value and y-axis represents the number of storeys.

V.4: Storey Stiffness -

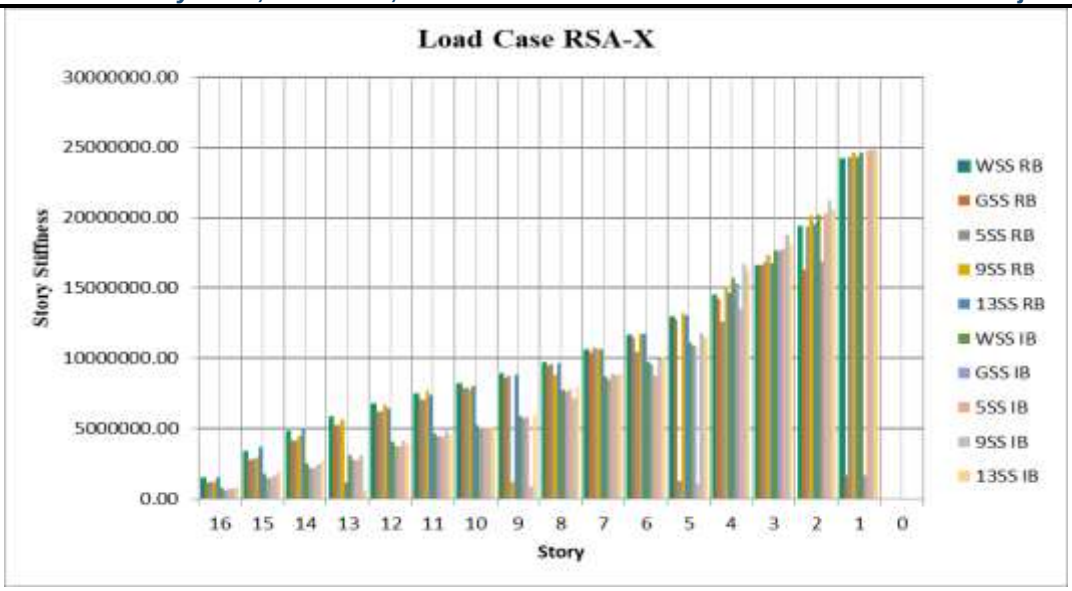
Table 7 represents the value of storey stiffness for regular and irregular building.

Table 7: Stiffness for regular and irregular building in X-direction.

STORY STIFFNESS						
REGULAR						
Sr. No.	*Direction*	*X direction (RSAX)*				
	Story's	*without soft storey*	*groud soft stoery*	*5th soft storey*	*9th soft storey*	*13th soft*
16	Story 16	1442779.39	1156158.46	1170746.36	1232461.28	1523713.86
15	Story 15	3338090.62	2778098.89	2803187.41	2980573.22	3684568.92
14	Story 14	4755380.49	4109351.22	4130499.02	4424869.86	5070861.98
13	Story 13	5835419.63	5222907.27	5234214.59	5638488.02	1145747.55
12	Story 12	6704919.40	6181330.10	6188473.77	6667639.99	6428024.18
11	Story 11	7461181.83	7038922.95	7056685.03	7702258.79	7410024.54
10	Story 10	8173437.36	7843420.05	7889286.82	7778098.39	8046428.02
9	Story 9	8896802.41	8638960.93	8731709.89	1194138.85	8837689.35
8	Story 8	9682440.65	9469341.82	9592732.18	8837993.52	9688677.13
7	Story 7	10578849.00	10381926.00	10748123.00	10625786.00	10643160.00
6	Story 6	11634220.00	11431525.00	10435445.00	11702170.00	11744404.00
5	Story 5	12909497.00	12696483.00	1239370.53	13261437.00	13055814.00
4	Story 4	14498766.00	14227756.00	12578627.00	15096451.00	14675895.00
3	Story 3	16567422.00	16650484.00	16806729.00	17343683.00	16768298.00
2	Story 2	19356323.00	16315375.00	19386658.00	20135593.00	19551406.00
1	Story 1	24181122.00	1667414.54	24320689.00	24632841.00	24295592.00
0	Story 0	0.00	0.00	0.00	0.00	0.00
IRREGULAR						
Sr. No.	*Direction*	*X direction (RSAX)*				
	Story's	*without soft storey*	*groud soft stoery*	*4th soft storey*	*8th soft storey*	*12th soft*
16	Story 16	793353.50	620514.12	648045.04	715468.33	826410.01
15	Story 15	1798069.09	1478888.38	1519962.83	1678655.24	1980147.77
14	Story 14	2526139.44	2177611.88	2203733.63	2433530.33	2692160.58
13	Story 13	3098533.90	2783874.05	2783942.28	3067127.80	641976.58
12	Story 12	4070878.90	3770380.01	3749017.81	4120745.56	3949845.90
11	Story 11	4647745.93	4422316.10	4412385.16	4852260.22	4601981.51
10	Story 10	5232523.64	5062650.29	5089014.02	5017119.17	5175563.02
9	Story 9	5904310.56	5768147.28	5845330.41	845399.97	5927390.32
8	Story 8	7790231.70	7606330.05	7765805.11	7125212.14	7909196.53
7	Story 7	8654433.77	8470684.68	8861357.04	8739801.27	8874295.94
6	Story 6	9714880.68	9510042.08	8761533.92	10010272.00	10022750.00
5	Story 5	11109170.00	10880522.00	1071436.38	11774535.00	11489364.00
4	Story 4	15724722.00	15309381.00	13496791.00	16702554.00	16171551.00
3	Story 3	17636108.00	17677155.00	17801290.00	18775530.00	18108794.00
2	Story 2	20191604.00	16869992.00	20273670.00	21225822.00	20610768.00
1	Story 1	24601736.00	1669742.67	24779033.00	25144881.00	24823579.00
0	Story 0	0.00	0.00	0.00	0.00	0.00

From the table it is observed that,

- Stiffness is more in regular building as compared to irregular building in x direction.
- Stiffness is less where soft story provided for both regular and irregular building.



Graph 4: Stiffness in regular and irregular building in x direction

Graph 4 represents the value of storey drift. In graph x-axis represents the number of storey's and y-axis represents the change in storey stiffness.

VI.CONCLUSION

In this study, the seismic performance of G+15 storey Vertically irregular and regular building with stiffness irregularity at different level by using response spectrum analysis. The results were compared with those of regular shape building and irregular shape building.

According to analysis results it is observed that,

- Base shear is maximum in regular building as compare to irregular building.
- The displacement is observed maximum in regular building as compared to irregular building.
- In both regular and irregular building displacement is maximum at middle floor level where soft story is provided.
- The story drift was observed to be maximum in regular structure than irregular structure.
- Storey stiffness is maximum in regular building than irregular building.
- Drift in the middle soft storey location is maximum in both regular and irregular building.
- With the provision of soft storey there is a large change in stiffness.
- Stiffness is more in regular building as compared to irregular building in both cases.

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