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Optimization of Location of Shear Wall in Irregular Multi Storey Building

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***Abstract:*-- Shear wall is commonly designed to resist the lateral loads such as wind or earthquake load which causes damage to the buildings. Shear wall is a plate like slender structure having large value of stiffness, which resist lateral load in their own plane and also resist the gravity load. Shear wall gives better performance when it is designed properly and placed at optimum location in the building plan. This paper optimizes the location of shear wall based on story drift, story displacement, and torsion of different models on 'H' shape irregular plan building. The results were based on chosencompared parameters with 'H' shape plan of without shear wall and with varying location of shear wall using ETABS software.**

key words: Shear wall, Irregular plan, earthquake load, ETABS etc.

I. INTRODUCTION

Now a days concrete has become an ideal material for building construction because of its ease of work and it is made by locally available material which is generally present in every part of world. Due to its specific properties it is used in construction of tall buildings for long period.As increase in population in urban area of our country, there is a scarcity of the land so there is need to developed high rise building to full fill the housing demand. As building height is increased beyond 12 m, wind forces acting on the building and also the seismic forces which ismost venerable causing loss of properties and life. To ensure safety of building, design building properly and overcome the effect of lateral loads on building, shear wall is one of structural member, where is provided from foundation level to over-all height of building. They resist lateral loads in their own plane and provide large stiffness to the building.

Shear wall give better response if it is provide at optimum location.Main objective of this research work is to study about behaviour of shear wall for different location in 'H' shape irregular building for different models. Out of five models,chosen for study, it was optimized to find the effective location of shear wall, which give better response against seismic excitation. All analysis is performed byTime History Analysis using ETABS 2016 software.

2. BUILDING DISCRIPTION:

Detailing of Office Building with 'H' shape plan of G+20 storey.

2.1.GEOMETRICAL PROPERTIES:

S.No.	Structural Part	Dimension
1.	Length in X-direction	45 m
2.	Length in Y-direction	40 m
3.	Floor to floor height	3 m
4.	Total height of building	60 m
5.	Slab thickness	150 mm
6.	Shear wall thickness	250 mm
7.	Column size	350×350 mm
8.	Beam size	200×400 mm

2.2. MATERIAL PROPERTIES:

S.No	Material	Grade
1.	Concrete(Beam, column)	M30
2.	Concrete(Slab)	M30
3.	Rebar	HYSD-415

2.3. SEISMIC DATA:

1.	Earthquake Zone	IV
2.	Damping Ratio	5%
3.	Importance Factor	1.5
4.	Type of soil	Medium soil
5.	Response Reduction factor	5
6.	Time Period	Program calculated

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2.4. LOADING:

a. Live load 3.5kN/m^2

b. Earthquake load as per IS 1893 part-I

3. PLAN DETAIL:

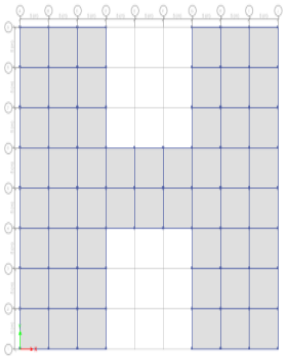
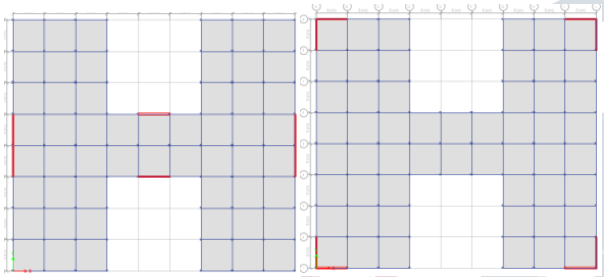
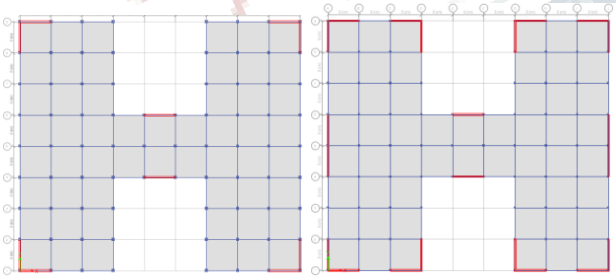


Fig 3.1: Model 1 (Without shear wall)



Model 2 *Model 3*



Model 4 *Model 5*

Fig 3.2: Different Model with varying position of shear wall

4. METHOD OF ANALYSIS:

The plan shape used for analysis is 'H' shape irregular Multi story building. Time history method gives better result in case of irregular and high rise building. In time history analysis actual ground acceleration data in both 'X' and 'Y' direction is used during earthquake analysis which leads to a more better and quick assessment of the structure. Hence this method for analysis was adopted.

5. ANALYSIS RESULT:

The analysis of all the models that includes different location of shearwalls has been done and results are shown below. The parameters which were studied are on the behaviour of building during seismic excitation are story displacement, story drift and torsion.

5.1 Story Drift:

Story drift is the drift of one level of a multistorey building relative to the level below.As per IS 1893:2002, the storey drift in both X and Y direction should not be more than 0.004H, where H is the height of story.

Table 5.1. Story Drift for all model

Story	Story Drift in X Direction(mm)					Story Drift in Y Direction(mm)				
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 1	Model 2	Model 3	Model 4	Model 5
20	2.344	5.038	6.483	6.15	5.43	1.898	5.879	6.281	5.592	5.291
19	3.409	5.333	6.627	6.272	5.517	2.965	6.008	6.432	5.674	5.353
18	4.427	5.682	6.77	6.399	5.607	3.978	6.12	6.584	5.748	5.41
17	5.336	6.083	6.924	6.536	5.699	4.885	6.238	6.748	5.822	5.463
16	6.138	6.498	7.068	6.664	5.781	5.687	6.343	6.904	5.881	5.503
15	6.838	6.9	7.189	6.771	5.843	6.389	6.426	7.039	5.918	5.52
14	7.442	7.268	7.274	6.844	5.874	6.997	6.477	7.139	5.925	5.509
13	7.954	7.584	7.312	6.874	5.869	7.516	6.486	7.193	5.894	5.463
12	8.38	7.835	7.295	6.851	5.819	7.952	6.446	7.192	5.82	5.378
11	8.726	8.009	7.213	6.767	5.718	8.312	6.35	7.126	5.697	5.248
10	8.998	8.093	7.058	6.615	5.561	8.601	6.192	6.987	5.519	5.068
9	9.202	8.075	6.822	6.388	5.342	8.826	5.964	6.768	5.283	4.836
8	9.343	7.941	6.499	6.077	5.057	8.991	5.663	6.46	4.983	4.547
7	9.427	7.675	6.081	5.678	4.7	9.104	5.281	6.056	4.615	4.197
6	9.461	7.256	5.56	5.181	4.266	9.169	4.813	5.548	4.175	3.784
5	9.452	6.655	4.927	4.58	3.75	9.196	4.253	4.926	3.66	3.304
4	9.418	5.839	4.172	3.864	3.145	9.201	3.595	4.18	3.064	2.754
3	9.466	4.764	3.282	3.022	2.444	9.286	2.831	3.297	2.381	2.128
2	10.638	3.357	2.241	2.039	1.637	10.472	1.949	2.258	1.607	1.423
1	21.657	1.656	0.998	0.876	0.697	21.731	0.982	1.013	0.716	0.616

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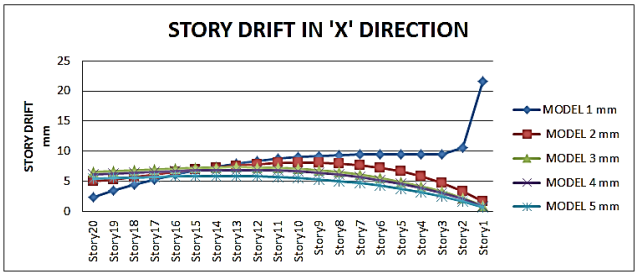

Figure 5.1(a): Comparison of Story Drift in X Direction

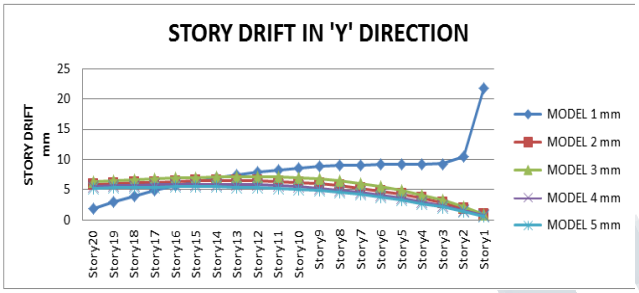

Figure 5.1(b): Comparison of story drift in Y Direction

5.2Story Displacement: According to IS 1893 the value of maximum permissible displacement is H/250,Where H is story height. Here max permissible displacement is 240 mm

Table 5.2: Story Displacement

Story	Story Displacement in X Direction(mm)					Story Displacement in Y Direction(mm)				
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 1	Model 2	Model 3	Model 4	Model 5
20	168.05	127.54	117.79	110.44	93.756	161.15	104.29	116.12	93.975	86.795
19	165.71	122.50	111.31	104.29	88.326	159.25	98.416	109.84	88.382	81.504
18	162.30	117.17	104.68	98.027	82.809	156.29	92.409	103.41	82.709	76.151
17	157.87	111.48	97.916	91.628	77.202	152.31	86.288	96.833	76.96	70.741
16	152.53	105.40	90.992	85.092	71.503	147.42	80.051	90.085	71.139	65.277
15	146.40	98.907	83.924	78.427	65.721	141.74	73.707	83.18	65.258	59.775
14	139.56	92.007	76.735	71.656	59.879	135.35	67.281	76.141	59.34	54.255
13	132.12	84.739	69.462	64.812	54.004	128.35	60.804	69.002	53.415	48.746
12	124.16	77.155	62.149	57.938	48.136	120.84	54.318	61.809	47.52	43.282
11	115.78	69.319	54.854	51.087	42.317	112.88	47.872	54.618	41.7	37.904
10	107.06	61.311	47.642	44.32	36.599	104.57	41.522	47.492	36.003	32.657
9	98.063	53.218	40.584	37.705	31.038	95.975	35.331	40.505	30.484	27.588
8	88.861	45.143	33.762	31.317	25.696	87.149	29.366	33.738	25.201	22.753
7	79.519	37.202	27.262	25.24	20.639	78.158	23.704	27.278	20.218	18.206
6	70.092	29.526	21.181	19.562	15.939	69.055	18.423	21.222	15.603	14.009
5	60.63	22.271	15.621	14.381	11.673	59.885	13.61	15.674	11.428	10.225
4	51.179	15.616	10.694	9.801	7.923	50.69	9.356	10.748	7.768	6.921
3	41.76	9.776	6.522	5.937	4.778	41.489	5.762	6.568	4.704	4.167
2	32.294	5.013	3.239	2.915	2.334	32.203	2.931	3.271	2.323	2.039
1	21.657	1.656	0.998	0.876	0.697	21.731	0.982	1.013	0.716	0.616

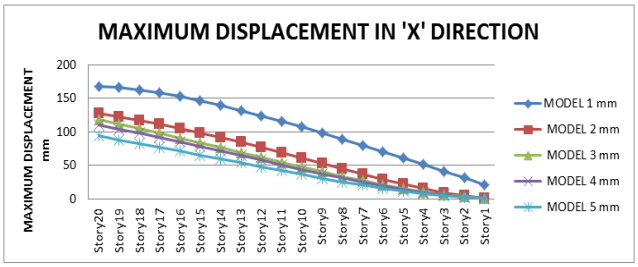

Figure 5.2(a): Comparison of Displacement in X Direction

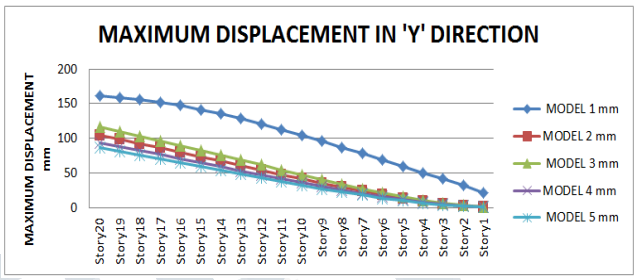

Figure 5.2(b): Comparison of maximum Displacement in Y Direction

Table 5.3: Max/Avg Drift ratio

Storey	Max/Avg Drift ratio in X Direction					Max/Avg Drift Ratio in Y Direction				
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 1	Model 2	Model 3	Model 4	Model 5
20	1.084	1.071	1.058	1.046	1.054	1.137	1.114	1.079	1.082	1.081
19	1.09	1.068	1.057	1.045	1.053	1.136	1.113	1.077	1.081	1.081
18	1.093	1.064	1.056	1.045	1.053	1.136	1.113	1.076	1.081	1.081
17	1.094	1.061	1.055	1.044	1.053	1.135	1.112	1.075	1.08	1.08
16	1.096	1.058	1.054	1.043	1.052	1.135	1.112	1.073	1.079	1.08
15	1.096	1.055	1.053	1.042	1.052	1.135	1.112	1.072	1.079	1.08
14	1.097	1.052	1.052	1.042	1.051	1.135	1.111	1.07	1.078	1.08
13	1.098	1.05	1.051	1.041	1.051	1.135	1.111	1.069	1.078	1.08
12	1.098	1.048	1.05	1.04	1.05	1.135	1.111	1.067	1.077	1.079
11	1.098	1.046	1.05	1.039	1.05	1.135	1.11	1.066	1.076	1.079
10	1.099	1.044	1.049	1.039	1.049	1.135	1.11	1.065	1.076	1.079
9	1.099	1.042	1.048	1.038	1.049	1.135	1.109	1.063	1.075	1.079
8	1.099	1.04	1.047	1.038	1.048	1.135	1.109	1.062	1.074	1.079
7	1.1	1.039	1.046	1.037	1.048	1.135	1.109	1.061	1.074	1.078
6	1.1	1.037	1.045	1.036	1.047	1.135	1.108	1.06	1.073	1.078
5	1.101	1.036	1.045	1.036	1.047	1.135	1.108	1.059	1.073	1.078
4	1.101	1.034	1.044	1.035	1.046	1.135	1.107	1.057	1.072	1.078
3	1.102	1.033	1.043	1.034	1.046	1.135	1.107	1.056	1.071	1.078
2	1.102	1.032	1.042	1.034	1.046	1.135	1.106	1.055	1.07	1.078
1	1.102	1.032	1.042	1.035	1.047	1.133	1.103	1.055	1.07	1.078

As per IS 1893:2002 Code describe that the torsional irregularity will be occur when max storey drift/ average storey drift is more than 1.2

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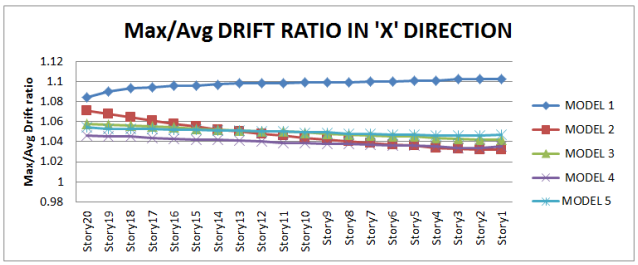

Figure 5.3(a): Comparison of Max/Avg drift ratio in X direction

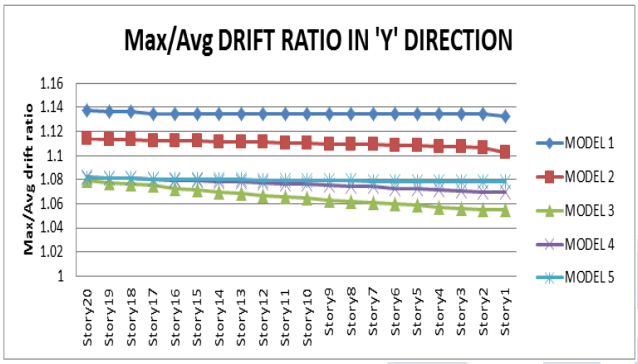

Figure 5.3(b): Comparison of Max/Avg Drift Ratio in Y Direction

CONCLUSIONS:

A linear time history analysis was performed and results were found in terms of story drift, story displacement and max. drift/avg. drift ratio. From the results of analysis of the models following conclusions can be drawn.

• The comparative study of storey drift in X and Y direction for five models are represent in table 5.1, in figure 5.1(a) and figure 5.1(b). The story drift value of non-shear wall model is 21.65 which is higher than that of all four Models in X direction at storey 1. The storey drift value of Model 1 is 21.73 which is higher than the other four model in Y direction at story 1. Thus, the story drift in Model 5 has the smallest value in both direction for all models.

• The comparative study of storey displacement in X and Y direction for five models is given in table 5.2, in figure 5.2(a) and figure 5.2(b). The storey displacement value of non shear wall structure model 1 is 1.31times higher than model 2, 1.42 times greater than those of model 3, 1.52 times greater than those of model 4 and 1.8 times greater than those of model 5. In Y direction the value of non-shear wall structure is 1.54 times greater than those of model 2, 1.38 times greater than those of model 3, 1.72 times greater than those of model 4 and 1.85 times greater than those of model 5. Thus the storey displacement in model 5 is smallest than the other models in Y direction.

• From the table 5.3 and figure 5.3(a) and figure 5.3(b), the value of Torsion in X direction the maximum value of torsion for model 1is 1.084 at storey 20, which is greater than those of all other models. In Y direction maximum value of torsion is 1.137 at storey 20, which is greater than other models. The minimum value of torsion is observed in model 4.

From the above study we can conclude that Model 5 shows better performing among the other models.

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