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Analysis of High Rise Building Subjected to Blast and Earthquake Loads for Effective Position of Shear Walls Using ETABS.

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Abstract – *Over the recent decades, many public buildings located in a region of high-seismic hazard have been subjected to simultaneous effect of abnormal loads against which they are not specifically designed. Designing a building for blast resistance might sound similar to the design against seismic load because neither are static loads. The dominant frequencies of seismic excitation are of lower frequencies of building response. On the other hand, blast load is impulsive and not dynamic. Till date there are many studies performed to study the effect of blast and seismic loading on the building individually. This research paper focusses on analysis of building subjected to both seismic as well as blast load using ETABS. To reduce the damage on the building due to these loads shear walls are provided at different positions and to select the most effective position.*

***Key Words*: Lateral loading, Seismic loading, Blast loading, Shear walls, ETABS.**

1. INTRODUCTION

Blast load is a short, rapid, sudden release of energy which expands radially which affects the building externally as well as internally. This blast load can be in the form of terrorist attacks as well as explosions in the chemical industry. Due to increase in the technology, the buildings in the cities are concentrated on the comfort of living and safety against earthquake loads. Now-a-days the buildings are designed to resist blast loads due to increasing terrorist attacks. But the effect on the building due to combined lateral loads and blast loads are not yet studied. Even though the condition is hypothetical but it is unavoidable. The scope of the paper is the civil engineers has to implement different techniques in planning during the construction and to design the building taking into consideration lateral load and blast load and to resist these forces by providing shear walls.

2. NUMERIC PROBLEM CONSIDERED

For this study, square plan configuration of G+40 Storey Building, with 3.6 m height for each storey is considered. The area of the plan is 1600 sq m. The building is supposed to be situated in Mumbai region. The building is modeled using software ETABS 2018.

ASSUMPTIONS:

- The material is homogeneous, Isotropic and linear elastic.
- All the columns are considered fixed to the foundations.
- The superstructure is analyzed independently from foundation and soil.

2.1 Data Used for the Problem

COLUMNS SIZES AND GRADES	Floor 1 to 10: 1200x1200 mm (M60) Floor 11 to 20: 1000x1000 mm (M60) Floor 21 to 30: 900x900 mm (M50) Floor 31 to 40: 700x700 mm (M40)
BEAM AND ITS GRADE	Throughout: 400x900 mm (M40)
SLAB AND ITS GRADE	Throughout: Thickness 250 mm (M40)
SHEAR WALLS	Thickness is 250 mm

2.2 Load Calculation

- Dead Load (IS 875- Part 1):
  1. For exterior wall=wall thickness*ρ*floor height
     =0.23*20*3.6= 16.56 kN/m²
  2. For interior wall=wall thickness*ρ*floor height
     =0.15*20*3.6= 10.8 kN/m²
  3. For parapet wall=wall thickness*ρ* height
     =0.23*20*1.8= 8.28 kN/m²
- Live load (IS 875-Part 2): 2 kN/m²
- Superimposed Load= 1.5 kN/m²
- Earthquake loads : (IS 1893:2002 (Part 1))
- Wind loads : (IS 875- Part 3)

2.3 Blast Load Calculation

Blast load is applied on a building on which shear walls are applied. Shear wall is a structural member in a reinforced concrete framed structure to resist lateral forces as well as blast loads.

The actual distance of the blast load is obtained from the code book IS4991:1968 table no. 7.

The source of blast load is assumed at a distance (0,2,0)

Actual distance of the building from the blast or explosive is assumed to be 20 m.

2.3.1 Blast Load Calculation for Plan 1

Now, the shear walls are positioned at each corner of the building and the blast loads are calculated.

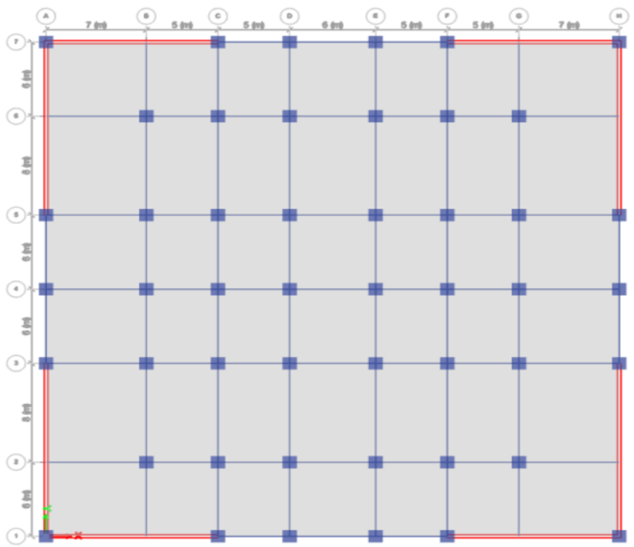


Fig -1: Plan 1

Table -1: Represents distance between source and target

Coordinates of point of interest			Distance b/w source and target	Storey
20	2	6	20.88	1
20	2	8	21.54	
20	2	0	20.00	
20	2	0	20.00	
20	2	8	21.54	
20	2	6	20.88	
20	34.4	6	38.55	10
20	34.4	8	38.91	
20	34.4	0	38.08	
20	34.4	0	38.08	
20	34.4	8	38.91	
20	34.4	6	38.55	
20	70.4	6	71.52	20
20	70.4	8	71.71	
20	70.4	0	71.26	
20	70.4	0	71.26	
20	70.4	8	71.71	
20	70.4	6	71.52	
20	106.4	6	106.47	30
20	106.4	8	106.60	
20	106.4	0	106.30	
20	106.4	0	106.30	
20	106.4	8	106.60	
20	106.4	6	106.47	
20	142.4	6	141.94	40
20	142.4	8	142.04	
20	142.4	0	141.82	
20	142.4	0	141.82	
20	142.4	8	142.04	
20	142.4	6	141.94	

Table -2: Blast load on front face of building

Storey	Scaled distance	Pro (kN/m²)	A (m²)	Force (kN)
1	44.99	162.93	17.28	2815.50
	46.41	153.59	17.28	2653.97
	43.09	182.16	17.28	3147.72
	43.09	182.16	17.28	3147.72
	46.41	153.59	17.28	2653.97
	44.99	162.93	17.28	2815.50
10	83.04	52.60	17.28	908.94
	83.82	52.09	17.28	900.14
	82.03	53.26	17.28	920.37
	82.03	53.26	17.28	920.37
	83.82	52.09	17.28	900.14
	83.04	52.60	17.28	908.94
20	154.08		14.4	0.00
	154.50		14.4	0.00
	153.53		14.4	0.00
	153.53		14.4	0.00
	154.50		14.4	0.00
	154.08		14.4	0.00
30	229.38		12.96	0.00
	229.66		12.96	0.00
	229.01		12.96	0.00
	229.01		12.96	0.00
	229.66		12.96	0.00
	229.38		12.96	0.00
40	305.81		10.08	0.00
	306.02		10.08	0.00
	305.54		10.08	0.00
	305.54		10.08	0.00
	306.02		10.08	0.00
	305.81		10.08	0.00

In the same way blast load is calculated for different position of shear wall for the framed structure. All the positions are given in the figure below.

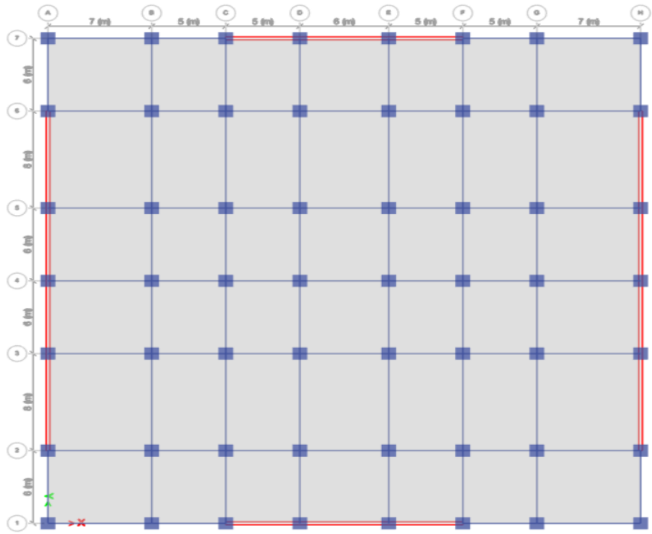


Fig -2: Plan 2

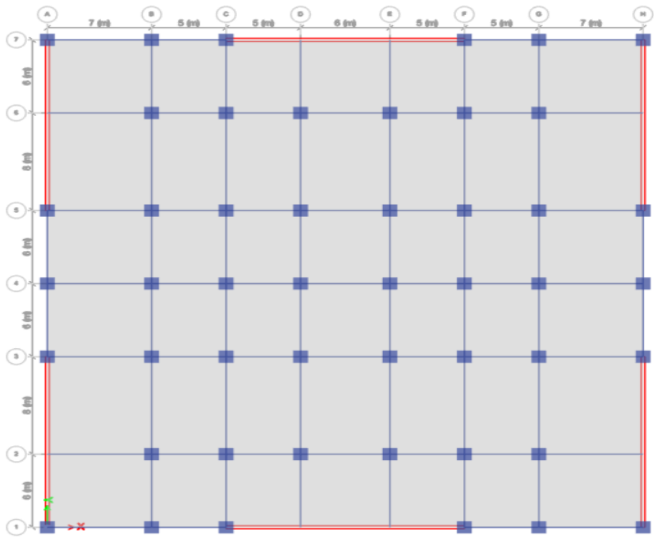


Fig -3: Plan 3

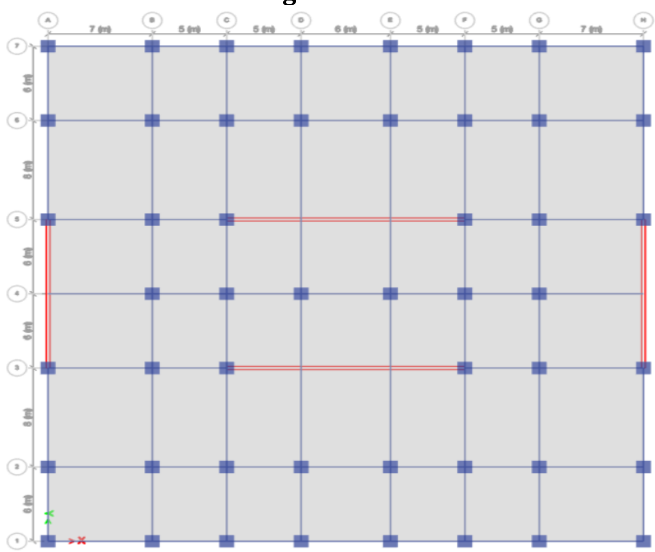


Fig -4: Plan 4

Blast load acting on each column at the face of the building is given in the table below:

Table -3: Blast load for each plan acting on each column

Storey	Plan 1	Plan 2	Plan 3	Plan 4
1	704	704	787	704
	663	787	787	663
	787	787	704	787
	787	787	704	787
	663	787	787	663
	704	704	787	704
10	227	227	230	227
	225	230	230	225
	230	230	227	230
	230	230	227	230
	225	230	230	225
	227	227	230	227
20-40	0.00	0	0	0
	0.00	0	0	0
	0.00	0	0	0
	0.00	0	0	0
	0.00	0	0	0
	0.00	0	0	0

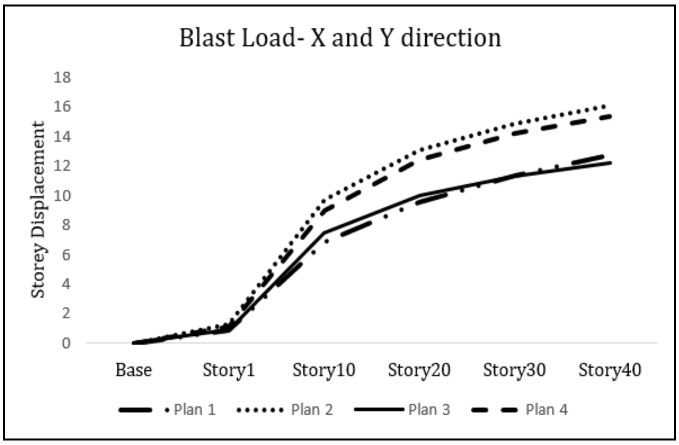
The framed structure is the analyzed for the effects of combined loads like wind loads, earthquake load and above calculated blast loads with ETABS 2018 using non-linear approach with response spectrum analysis for earthquake. The blast load is applied in X and Y direction on one face of the structure on each column. Since the building configuration is square the result for storey displacement and storey drift are same in both directions.

3. RESULT

The response of the structure is given below in terms of Maximum storey displacement and maximum storey drift.

Table -4: Maximum storey displacement for blast loads in X and Y direction

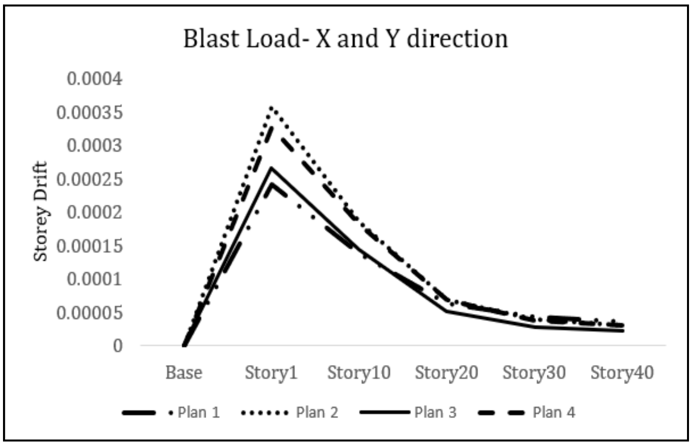
Storey	Load applied in X and Y direction			
	Plan 1	Plan 2	Plan 3	Plan 4
Storey40	12.749	16.077	12.178	15.34
Storey30	11.383	14.886	11.335	14.184
Storey20	9.553	13.103	10.039	12.399
Storey10	6.826	9.726	7.499	8.954
Story1	0.873	1.286	0.959	1.172
Base	0	0	0	0



Graph-1: Maximum storey displacement for blast loads in X and Y direction

Table -5: Maximum storey drift for blast loads in X and Y direction

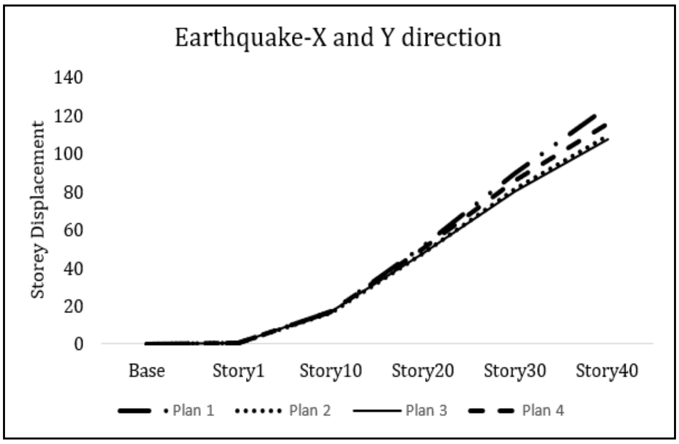
Storey	Load applied in X and Y direction			
	Plan 1	Plan 2	Plan 3	Plan 4
Storey40	0.000036	3.10E-05	2.20E-05	3.00E-05
Storey30	0.000043	3.90E-05	2.80E-05	3.80E-05
Storey20	0.000064	6.90E-05	5.10E-05	6.90E-05
Storey10	0.000138	0.000185	0.000145	0.000182
Storey1	0.000242	0.000357	0.000266	0.000326
Base	0	0	0	0



Graph-2: Maximum storey drift for blast loads in X and Y direction

Table -6: Maximum storey displacement for earthquake loads in X and Y direction

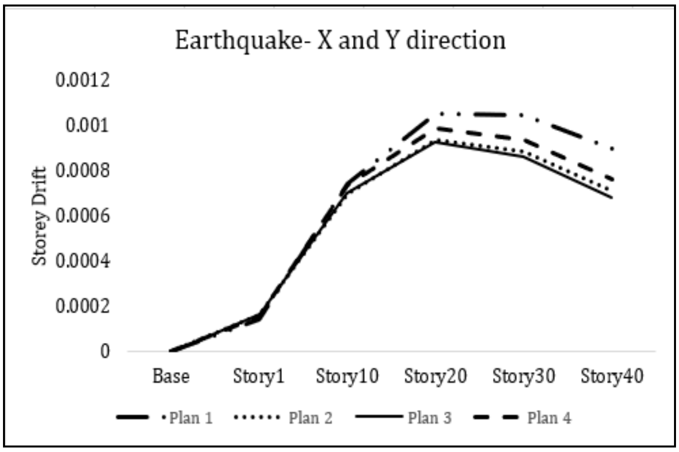
Storey	Load applied in X and Y direction			
	Plan 1	**Plan 2**	**Plan 3**	**Plan 4**
Storey40	124.476	109.429	107.671	115.662
Storey30	89.89	81.1	80.34	85.52
Storey20	51.446	47.783	47.694	50.201
Storey10	17.365	16.78	16.89	17.443
Storey1	0.509	0.573	0.588	0.562
Base	0	0	0	0



Graph-3: Maximum storey displacement for earthquake loads in X and Y direction

Table -7: Maximum storey drift for earthquake loads in X and Y direction

Storey	Load applied in X and Y direction			
	Plan 1	**Plan 2**	**Plan 3**	**Plan 4**
Storey40	0.000899	0.000712	0.000682	0.000759
Storey30	0.001046	0.000887	0.000863	0.000939
Storey20	0.001052	0.000936	0.000924	0.000991
Storey10	0.000745	0.000699	0.000702	0.000737
Storey1	0.000141	0.000159	0.000163	0.000156
Base	0	0	0	0



Graph-4: Maximum storey drift for earthquake loads in X and Y direction

4. CONCLUSION

Constructing a lateral force resistant or blast resistant structure refers to improving structural integrity of structure instead of complete collapse thus preventing loss of life and property. The effect of these loads can also be decreased by providing lateral moment resisting frames like shear walls. These shear walls also reduce the damage and increase the structural integrity. In the present study on G+40 residential building different position of shear walls are provided. From the results we can conclude that the most effective position which gives least variation in terms of maximum storey displacement and maximum storey drift when subjected to combined lateral load and blast load is plan no. 3. This position of shear wall can be adopted to reduce the structural damage by satisfactory range and also increase the capability of structure after damage.

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