International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 11 | Nov 2020 www.irjet.net p-ISSN: 2395-0072

Comparative Study and Analysis of a Building Subjected to Blast Load and Earthquake Load

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Abstract - As seen in the past few years, the structures being subjected to blast load have gained huge importance due to the accidental events or natural events. The magnitude of load by blast is very huge, and also the cost of design and construction is very high. Unlike the earthquake design, blast resistant design is a new concept that has now gained a huge importance in order to make structures safe again blast effect. The present study is concerned with comparative time history analysis of blast load and analysis of earthquake load with the variations in the building floors. In this study we analyzed the buildings with different floor numbers for blast loads and earthquake loads in particular directions to obtain comparative results. The blast parameters are obtained from the Is codes 4991 and same magnitude to earthquake load is applied. The analysis and the results are obtained from the ETABS software. The comparative results are considered in the study for different parameters as storey displacement, storey drift and other parameters.

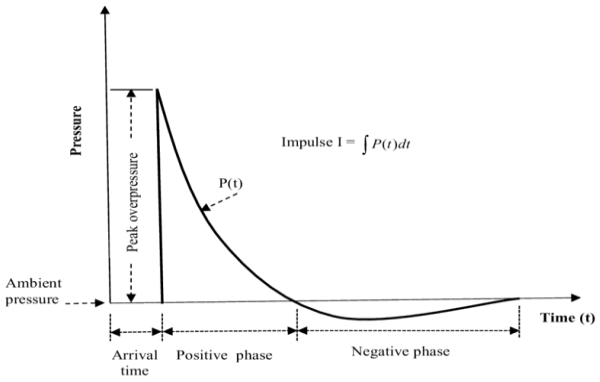
Key Words: **Blast Loads, Earthquake loads, Etabs, storey displacement, storey shear, time history analysis**

1. INTRODUCTION

The increased cases of terrorist attacks in the previous years has shown us that the effect of blast loads on buildings is a very serious matter that should be taken into account for the analysis and design process. The terrorist attacks on buildings has become an emerging issue for every country now. Hence by providing security to the residents of the building against terrorist attacks is gaining importance day by day. It includes prevention, prediction & lessening of such kind of acts. Although these kind of attacks are very rare cases, man-made disasters; blast loads are in fact dynamic loads that is needed to be carefully calculated just like earthquake, wind loads and other load. Damage to the property, social panic and loss of life are the main factors that are affected by the threat of any terrorist action. Designing the structures to be fully blast resistant is not a realistic and economical option, however with the modern civil engineering knowledge and experiences designing a building to be blast resistant within considerable limits will be very much possible. The Earthquake is also a dynamic effect and is a natural disaster, for long times we have been designing for the Earthquake loads and this are also very important for consideration. The earthquake loads are assumed as per the previous occurrence and the zone are being divided on the basis of the effect of the earthquake in that area. The Earthquake can be of dynamic nature of any type and can be even hazardous that other loads. Thus it is very important to understand the effect of building under blast load and also for an earthquake load in so as to protect a structure against its effect.

1.1 Key Parameters of Surface Blast Waves

After the detonation, waves travel toward the structure and hit the structure at tA, with maximum pressure of PSO and this pressure eventually decreases to that of ambient pressure, PO, at time tO, positive phase duration. Then the pressure decreases bellow the value of ambient pressure at tO -, negative phase duration. Simultaneously, waves are reflected by the ground and the structure, and this pressure is higher than PSO. This reflected pressure has a magnitude of Pr.



2. Objective

By understanding the performance of a high-rise building the explosion is of great importance to provide buildings which eliminates or minimizes the damage to building and property in the event of explosion, especially with the recent surgence in extreme activities of targeting at a structures with viable commercial values. As earthquake has been a very important measure that is to be taken into account we would see what the effect would be occurring on to a structure for a similar load.

a) The motto of the study is to get an idea of blast and earthquake phenomenon and to understand their effects on a building.

b) For judging the chances of occurrence of an explosion in the lifetime of a building & the impact factor that is to be considered based on the importance of the structure.

c) To understand the response of a building when subjected to blast loadings and earthquake using ETABS software as per IS Code 4991.

d) To understand the results for the analysis of a building with different construction elements and techniques

3. Methodology

In this study, a ten, fifteen and twenty storey RCC buildings are considered and are then subjected to surface blast of around 150kg charge weight of explosive. The building is having a plan dimension of 14 x 16 m with bottom storey height as 3m and typical storey height of also 3m each. It is then analyzed by using ETABS software for different standoff distances of 35m from the front face of the building. The peak reflected overpressure obtained from IS:4991-1968 is multiplied with its tributary area and this blast load is applied as the joint load on the joints of the front face of the building in the 'x' direction and time history method is carried out. The response of the building with earthquake loads is carried out and also for the blast source of varying building floor numbers is determined by creating different model.

3.1 Building Description

Model: = 4 bays spaced 4m each

Y direction = 4 bays, 2 bays spaced 4m and other 2 spaced 3m

Material Properties: Density of concrete = 30 kN/m3,

Density of steel = 78.5 kN/m3

Grade of concrete = M30,

Grade of rebar (steel) = Fe500

3.2 Sectional Properties:

Beam = 600mm × 400mm, Slab = 150mm

Column

COLUMN	STOREY No.	10 STOREY mm	15 STOREY mm	20 STOREY mm
SIZES	1-5	500X1000	600X1200	600X1200
	5-10	500X1000	500X1000	500X1000
	10-15	-	400X800	400X800
	15-20	-	-	300X600

Loads considered in analysis

The following loads are considered for the analysis of various phases of structure.

Gravity loads: The intensity of dead load and live load considered in the study are given below:

Dead loads: Dead load comprising of self-weight of members i.e. Beam, Column and Slab.

Floor finish load = 1 kN/m2,

Live load: Live load (IS 875, part 2) = 3 kN/m2

3.3 Blast Load and parameters

3.3.1 Stand-off Distance (R) and Weight of the Explosive (W)

One important parameter in determining the intensity of the blast load is the location of the explosive or stand-off distance from the structure and another important parameter is the weight of explosive.

3.3.2 Scaled Factor (Z)

On the basis of the distance of the explosive from the building, effects of the blast waves on the structure can vary.

3.4 Earthquake load: Earthquake design is done in accordance with IS 1893 (part I):2002 and has been taken by specifying the zone in which structure is located. These RC framed building is located in zone IV V. The parameter to be used for analysis and design are given below:-

Zone factor (Z)	IV and V	0.36
Response Reduction factor (RF)	SMRF	5
Importance factor	All general building	1
Rock/Soil type	Medium soil	2
Type of structure	RC frame building	1
Damping Ratio		5%

Different modal conditions with different cases

The building is analyzed for different models with case factors caused on the building

Modal 1 – A 10 (ten) Storey Building

Case 1: Building affected by the blast load of 150kg with the standoff distance of 35meters with normal Frame.

Case 2: Building affected by the blast load of 150kg with the standoff distance of 35meters with shear walls.

Case 3: Building affected by the Earthquake load of same amount of lateral loads as by blast loads.

Case 4: Building affected by the Earthquake load of same amount of lateral loads as by blast loads with shear walls.

Modal 2 – A 15 (fifteen) Storey Building

Case 1: Building affected by the blast load of 150kg with the standoff distance of 35meters with normal Frame

Case 2: Building affected by the blast load of 150kg with the standoff distance of 35meters with shear walls.

Case 3: Building affected by the Earthquake load of same amount of lateral loads as by blast loads.

Case 4: Building affected by the Earthquake load of same amount of lateral loads as by blast loads with shear walls

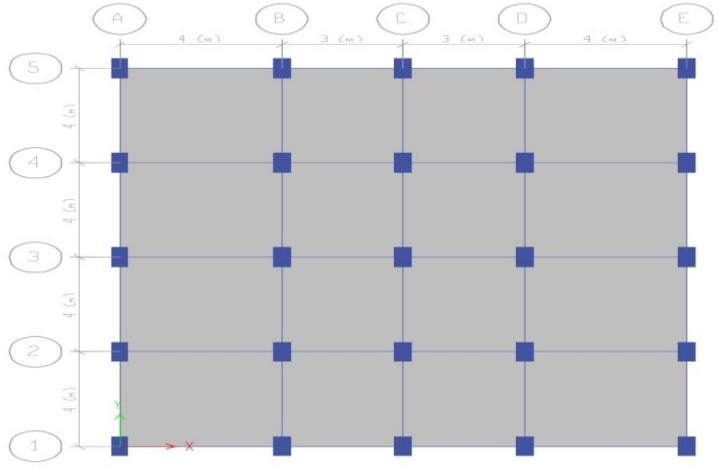
Modal 3 – A twenty (20) Storey Building

Case 1: Building affected by the blast load of 150kg with the standoff distance of 35meters with normal Frame

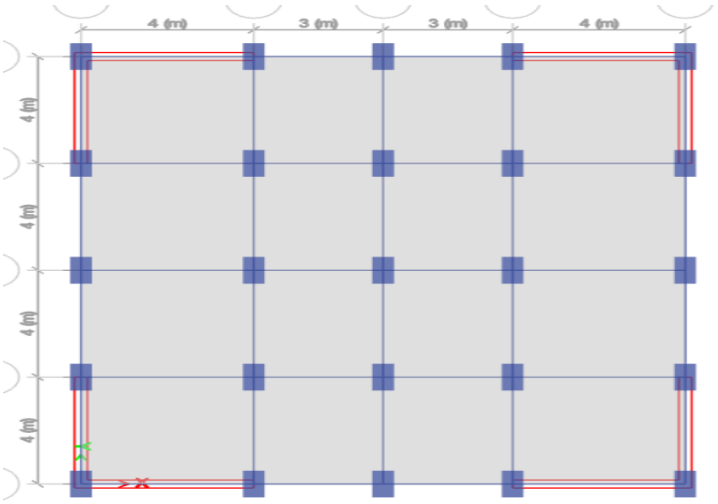
Case 2: Building affected by the blast load of 150kg with the standoff distance of 35meters with shear walls.

Case 3: Building affected by the Earthquake load of same amount of lateral loads as by blast loads.

Case 4: Building affected by the Earthquake load of same amount of lateral loads as by blast loads with shear walls



Plan of the Model



Plan of the Model With shear wall

Blast Load calculations

MODAL 1 – 10 Floor Building

Weight = 150kg Standoff distance = 35m

WEIGHT = 0.15(ton)		FROM TABLE 1 IS CODE				SCALED						
FLOOR	SCALED DIST. (m)	Pso (kg/cm^2)	to1	td2	Pro (kg/cm^2)	to (ms)	td (ms)	Pso (kn/m^2)	Pro (kn/m^2)	Area (m^2)	Pso (kn)	Pro (kn)
1	67.5	0.32	38.4	29.0	0.74	20.4	15.41	32.27	72.59	3	96.8	217.7
	66.2	0.33	38.1	28.8	0.76	20.2	15.30	33.16	74.56	6	198.9	447.3
	65.8	0.34	38.0	28.7	0.77	20.2	15.25	33.45	75.54	6	200.7	453.2

2	67.7	0.32	38.5	29.0	0.74	20.4	15.44	32.18	72.59	6	193.0	435.5
	66.5	0.33	38.1	28.8	0.76	20.2	15.32	32.96	74.65	12	395.5	895.8
	66.1	0.33	38.0	28.7	0.76	20.2	15.29	33.26	75.34	12	399.0	904.0
3	68.5	0.32	38.6	29.1	0.72	20.5	15.49	31.69	71.42	6	190.1	428.5
	67.2	0.33	38.3	28.9	0.74	20.3	15.39	32.47	73.38	12	389.6	880.5
	66.8	0.33	38.2	28.8	0.75	20.3	15.35	32.77	74.16	12	393.1	889.9
4	69.6	0.31	38.9	29.3	0.70	20.7	15.61	30.90	69.55	6	185.4	417.3
	68.4	0.32	38.6	29.1	0.72	20.5	15.49	31.69	71.51	12	380.2	858.1
	68.0	0.32	38.5	29.0	0.73	20.4	15.45	31.98	72.20	12	383.7	866.4
5	71.2	0.30	39.3	29.7	0.68	20.9	15.79	29.93	66.97	6	179.5	401.8
	70.0	0.31	39.0	29.4	0.70	20.7	15.65	30.72	68.95	12	368.6	827.3
	69.6	0.31	38.9	29.3	0.70	20.7	15.61	30.97	69.59	12	371.6	835.0

FLOOR	SCALED DIST. (m)	Pso (kg/cm^2)	to1	td2	Pro (kg/cm^2)	to (ms)	td (ms)	Pso (kn/m^2)	Pro (kn/m^2)	Area (m^2)	Pso (kn)	Pro (kn)
6	73.2	0.29	39.8	30.2	0.65	21.1	16.05	28.63	63.72	6	171.7	382.3
	72.0	0.30	39.5	29.8	0.66	21.0	15.88	29.40	65.65	12	352.7	787.7
	71.6	0.30	39.4	29.7	0.67	20.9	15.83	29.66	66.30	12	355.9	795.5
7	75.5	0.27	40.4	30.9	0.61	21.4	16.43	27.09	60.06	6	162.5	360.3
	74.4	0.28	40.1	30.5	0.62	21.3	16.24	27.83	61.72	12	333.9	740.6
	74.0	0.28	40.0	30.4	0.63	21.3	16.18	28.08	62.36	12	336.9	748.3
8	78.2	0.25	40.8	31.8	0.57	21.7	16.93	25.41	56.61	6	152.4	339.6
	77.1	0.26	40.6	31.5	0.59	21.6	16.75	26.06	58.00	12	312.6	695.9
	76.8	0.26	40.6	31.3	0.59	21.5	16.68	26.28	58.45	12	315.4	701.4
9	81.2	0.24	41.6	31.9	0.54	22.1	16.96	24.44	53.78	6	146.6	322.6
	80.2	0.25	41.3	31.9	0.55	21.9	16.96	24.59	54.14	12	295.0	649.7
	79.8	0.25	41.2	31.8	0.56	21.9	16.95	24.89	55.05	12	298.6	660.6
10	84.5	0.23	42.4	32.0	0.52	22.5	17.03	23.37	51.46	3	70.1	154.3
	83.5	0.24	42.2	31.9	0.53	22.4	17.00	23.70	52.30	6	142.1	313.8
	83.1	0.24	42.1	31.9	0.53	22.3	16.99	23.81	52.52	6	142.8	315.1

Similarly for all the cases we would find out the final loads

Assigning Earth quake Load on Structure by ETABs

1-Define all the live load, dead load and other gravity loads.

2-Define load pattern as earthquake load and select the Is-code

3-Define function as response spectrum for the required conditions.

4-assign the load case with the defined function as per the response spectrum.

5-Now check for the result section table in base shear form after analysis.

6-The obtained base shear should be equal to the sum of the lateral point loads due to the blast loads. If not obtained we can change the acceleration scale factor to obtain the required results.

7-It is done in order to obtain a comparative results cause by same magnitude.

Assigning Blast Load on Structure by ETABs

1- Define a load pattern for blast load. Separate case for each joint.

2- Assign joint load on the external surface and the required direction.

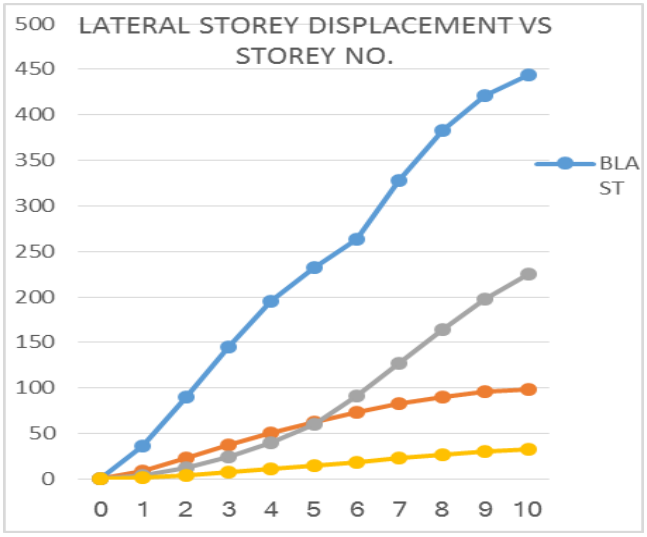
3- Define time history function for each load pattern (Time-Value relation).

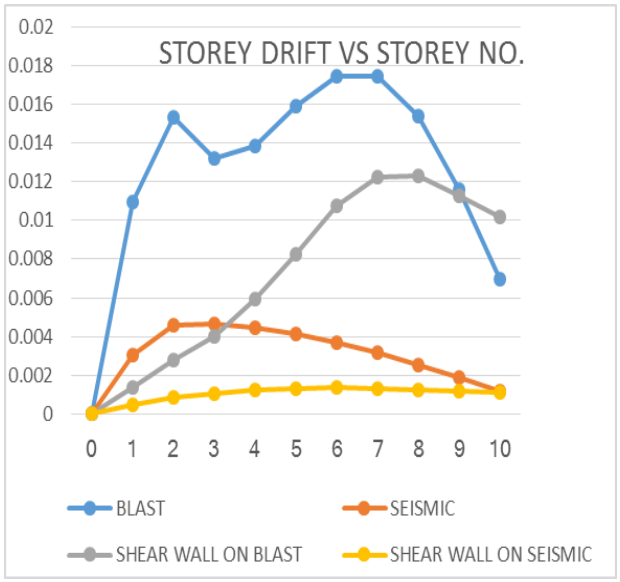
5- Define a time history load case for each load pattern and function, and add the related blast load and function.

6- Run modal analysis

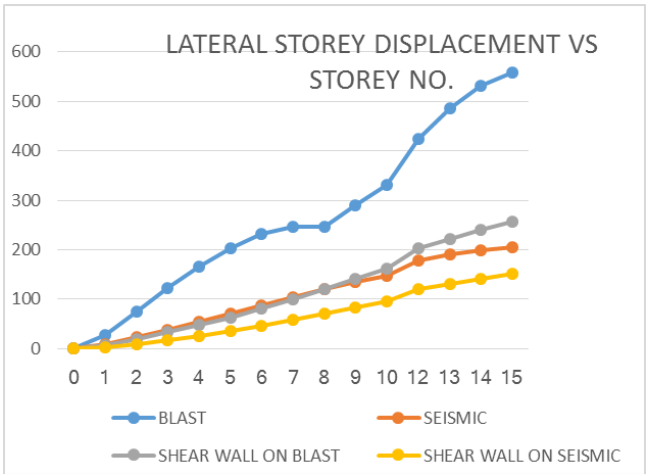
RESULTS

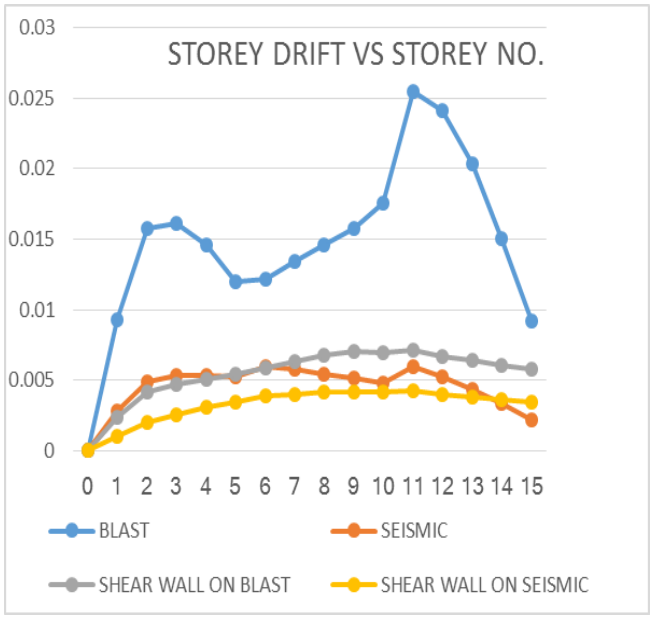
For 10 floors



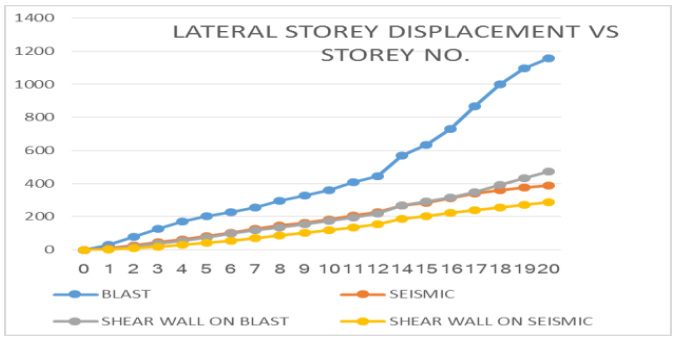


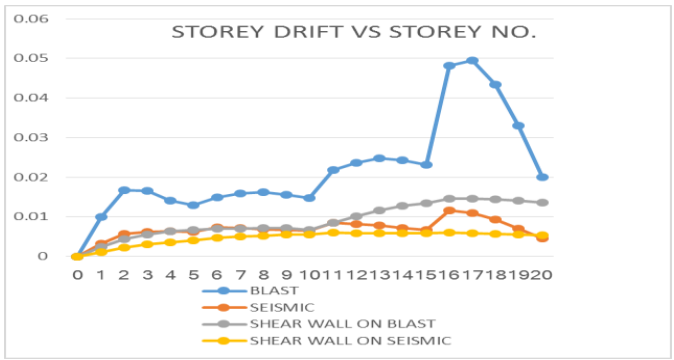
15 floors





20 floors





Conclusions]

After finishing the current work on the analysis of building subjected to blast load and Earthquake load of similar magnitude for a ten, fifteen, and twenty storey building. The study done by the above chapters and all the analysis results and outputs have been obtained and with the obtained results we have come to the following conclusions.

- A building having more no. of Stories is more sensitive for the dynamic loads and proper design and quality should be maintained for the high rise building.

- Since the magnitude for both the types of dynamic loads are same the building is more dangerous in a blast loads case in all the terms as, storey displacement, storey drift, moments and shear.
- As we have added the shear walls to the building at the edges it has given quite good results, there is high reduction in the structural displacement and the different aspects that we have studied in this analysis.

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