Effect of Blast Loads on Multistoried RCC Building

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Abstract - *The large numbers of threat attacks from the past few years have shown the effect on the buildings. These type of attacks are extraordinary cases, artificial disaster etc. The blast loads are required to be calculated like seismic loads and wind loads. The aim of this work is to study the blast effect on the building. The architectural and structural design techniques must consider the blast explosion. The blast loads on the buildings causes more damage. Due to this it should be considered in the design process. The present work is related with the analysis of blast load. In this study a different number of charge weights varying between 100 to 250kgs at an interval of 50kgs and the standoff distances varying between 15 to 24 m at an interval of 3m as per Indian code IS: 4991 specifications are compared.*

***Key Words*: Charge Weight (TNT), Standoff Distance, Joint Displacement, Storey Drift, Number Of Beams And Columns Failed, ETABS-2016.**

1. INTRODUCTION

The numbers of terrorist and threat activities have increased largely in the past few years all over the world. Consequently it has ended up a tremendous problem to think about blast load effects from the stage of designing a building just like the consideration of Earth quake loads, wind loads etc. The terrorist actions have become an alarming issue and guard the residents against terrorist acts. The prediction, prevention and mitigation of such moves have gained importance. If the threat of terrorist attack can't be stopped, at least loss of life, damage to the property and public panic are the key components that are to be reduced. Designing of buildings to be completely resistant to blast is not economical and realistic choice. However present day architectural and engineering experience & intelligence can make way in designing a structure which can resist blast inside significant limits and can be protected in designing of buildings to be built. The conservative steps concerned in the analysis of blast loading effect on a building are:

a) Estimate of the hazard. b) Valuation of the computational load with respect to the predicted hazard. c) Choosing a particular structural system such as tubed, diagrid, space truss etc. d) Study of the structural way of the building exposed to blast load. e) Assessment of the structural actions endangered to blast load.

1.1 OBJECTIVES

The objective of the study is to understand the reprisal of a building when a building is exposed to blast loads using ETABS software in accordance with IS Code 4991 and to study the bearing of two different building models for analysed results.

1.2 Blast Phenomenon and Explosions

An explosion occurs due to the rapid increase in the magnitude and discharge of energy in an epical way. This energy consists of gas, liquid or solid materials these materials produce a high reaction and form a very high temperature and pressure. These high pressure gases spread over the surrounding area and the blast wave is formed. Explosion is occurring in the form of deflagration or denotation depends upon the blazing velocity in the case of explosion. Deflagration is spread by the liberated reaction of thermal conductivity, the other layer or fold of cold material explode by the hot blazing material and burns it and the method is pursuing like that. Detonation is a type of combustion which implies a supersonic exothermic front quickening through an agency that eventually drives a shock front proliferating directly in front of it.

1.3 Design Considerations of Effect of Blast Load on Buildings

The most important aim of designing structures to be blast resistant is to decrease the chances of failure of structure and its house holders to encounter a blast. The main objective is to prevent the catastrophic failure of the whole structure when buildings encounter a blast. It is necessary to reduce the blast waves entering a building through the openings provided in the building as they may cause injuries to the occupants. In few cases it is difficult to design a building to be both blast resistant as well as to be aesthetically good, in such cases importance should be given to priorities.

1. Planning and layout

2. Bomb shelter areas

3. Installation

4. Glazing and cladding

1.4 METHODOLOGY

In the present study the building consists of G+6 storey residential building. It consists of 4 bays in Y-direction with total span of 14.8m and 16m in X-direction. The typical storey height is 3m and overall height of the building is 19.5m from the ground level. Static analysis is performed for the proposed plan by considering dead load, live load taken from IS:875 part -1 and IS 875 part -2. The blast load is calculated by assuming 100,150,200,250kg TNT by a standoff distance of 15, 18, 21,24m by using IS: 4991 using ETABS-2016 software. The respective operation of this study is as follows:

Step-1 Selecting a building Plan. Step-2 Creating grid lines/Importing AutoCAD file to E-TABS. Step-3 Defining material properties and section properties. Step-4 Assigning material properties and section properties. Step-5 Assigning different types of loads like DL, LL& SDL. Step-6 Calculation of blast load based IS: 4991 For 16 cases. Step-7 The loads are calculated for both front face and side face of the building. Step-8 Input of calculated load as UDL on beams and columns. Step-9 Checking of model for any error. Step-10 Static analysis of the structure is performed. Step-11 Note down the number of columns and beams failed due to shear and flexure. Step-12 To Increase the strength of the building shear wall is added at the center of the building. Step-13 Reanalyze the structure for All 16 cases. Step-14 Plotting results and preparation of report.

2. MODELLING

A) Various parameters should be considered in the modeling of structure are:

1) Dimensions of the site - 16m x 14.8m.

2) Horizontal dimension of plan is 16m & it has 4 bays of 4 meters each.

3) Vertical dimension of plan is 14.8m & it has 4 bays of 3.7 meters each.

4) Total height of the building 18 meters with each floor height 3 meters & footing level is 1.5m below ground level.

5) Initial column dimensions provided without blast load - 400mm x 400mm.

6) Initial beam dimensions provided without blast load - 300mm x 400 mm.

7) Slab Thickness - 180 mm thick.

8) Characteristic strength of concrete and steel respectively fck=30N/mm², fy=500 N/mm².

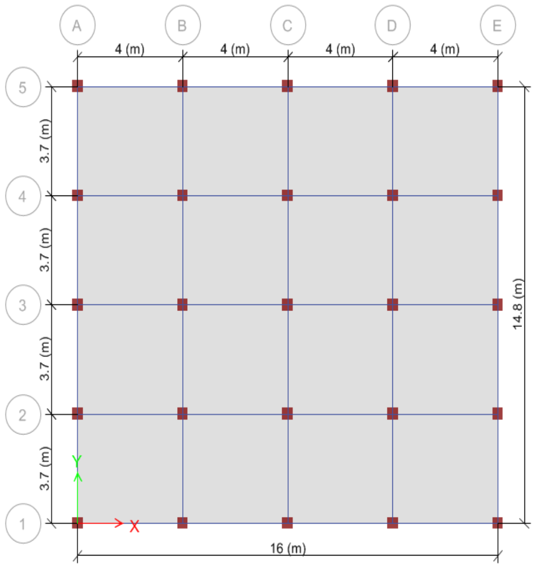


Figure-1 Plan

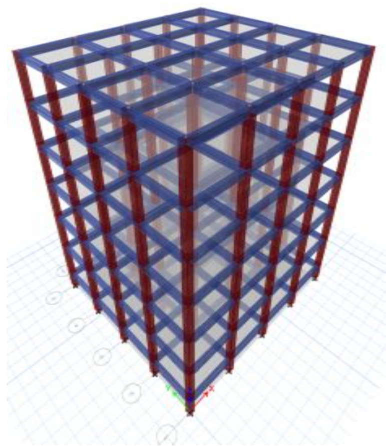


Figure-2 3D model

The figure 1 & 2 represents the plan and 3D model of the regular building of G+6 storeys without shear wall.

B) Load applied- LL of 5 kN/m² and SDL of 1 kN/m² is applied on the slab of 180mm thickness. The wall load of 13.2 kN/m² is applied on the beam. The blast load is calculated as per IS code specification 4991for all 16 cases the calculated blast load is applied as an UDL on exterior beams and columns in both front and side face of the building.

C) Analysis: The analysis of the structure is carried out using ETABS-2016.By using the "Run Analysis" command the model is to be analysed. In this step use as a basis on the loading the structural elements are checked for shear, flexure, torsion etc. Load Combinations: a) 0.9D + 1BL.b) 1.2DL+1.2BL+1BL. c) 1.5DL+1.5LL. d) 1.5D +1BL

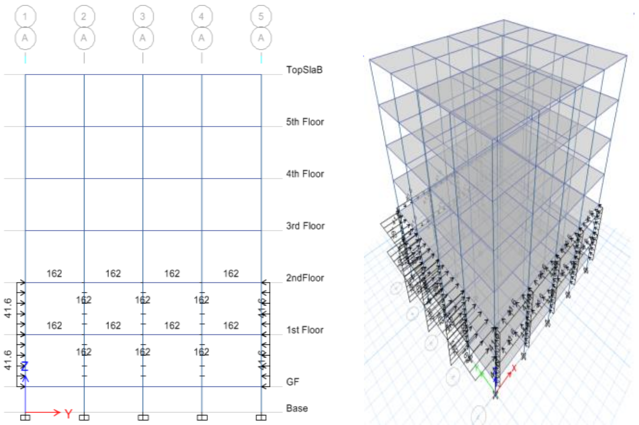


Figure-2 Blast load applied on Front Face & Side Face of the building

2.1 MODIFICATION OF STRUCTURE

The structure is checked for design. Check whether how many numbers of beams and columns are failed due to shear or flexure or torsion. To increase the stability of the structure shear wall is added at the center (like core wall) or at the corners of the building. After the modifications is done the model is again analyzed & verified whether it can with stand the loads imposed on it.

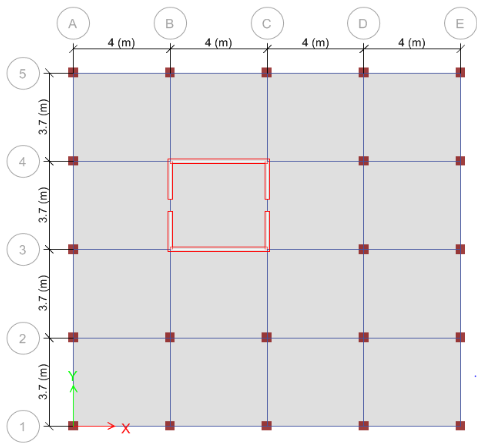


Figure-4 Plan

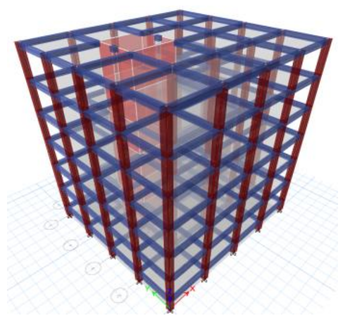


Figure-5 3D model

The figure 1 represents the plan and 3D model of the regular building of G+ 6 storeys with shear. Thickness of shear wall is 200mm.

2.2 Calculation of blast load

Blast parameters obtained due to the check detonation of a 0.1 tonne TNT (125kg's charge weight) explosive & Standoff distance of 15m .

Characteristics of blast:

Scaled distance (x) =15/ $(0.1)^{1/3}$ =32.32m

From Table 1 assuming P_a=1 kg/cm² for the scaled distance of 32.32m, the pressures are directly obtained: P_{so}=1.25kg/cm², P_{ro}=3.62kg/cm², q_o =0.471kg/cm².The scaled times t_o and t_d obtained from Table 1 for scaled distance of 32.32 m are multiplied by $(0.1)^{1/3}$ to get the values of the respective quantities for the actual explosion of 0.1tonnecharge.t_o=24.49x$(0.1)^{1/3}$=11.36milliseconds

t_d=16.0x$(0.1)^{1/3}$=7.47millisecods. M= $\sqrt{1+\frac{6*1.25}{7*1}}$ = 1.43

a=344m/s.U=1.43x344=491.92m/millisecond.

ii) Pressure on the Building;

H=19.5m, B=14.8m, L=16m .S=H or B/2 whichever is less= 19.5 & 14/2=7.4, S=7m.

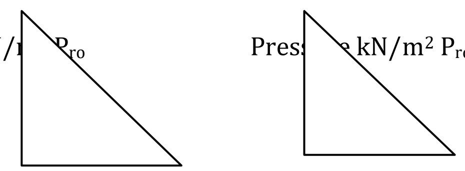
$t_c = \frac{3S}{U} = \frac{3*7.4}{0.492}$ = 42.69 millisec.$t_t = \frac{L}{U} = \frac{16}{0.492}$ = 32.32 millisec

$t_r = \frac{4S}{U} = \frac{4*7}{0.492}$ = 56.92 millisec,t_r > t_d So, no pressure on the Backface are considered.

For Side face C_d= -0.4,

$P_{so}+C_d q_o$ =1.25 + (-0.4) x0.471= 1.061 kg/cm² .Conversion from Kg/cm²to KN/m² = 104 KN/m².For front face pressure = 3.62 Kg/cm² .Conversion from Kg/cm²to KN/m²=355.10 KN/m²

The pressure diagrams are as shown below:



Time (millisec) 7.47 Time (millisec) 7.47

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3. Results and Discussion

Table1-Results&Discussion

Case no	Charge weight in TNT (kgs)	Standoff distance in m	front face pressure in (KN/m²)	Side face pressure in (KN/m²)	Maximum joint displacement (top storey in mm)		Maximum storey drift (at first floor in mm)		No of beams and columns failed	
					For beams & column	With shear wall	For beams & column	With shear wall	For beams & column	With shear wall
1	100	15	355	104	42.54	11.17	0.0075	0.0015	49	3
2	100	18	227	76	75.90	6.25	0.0042	0.0008	25	0
3	100	21	161	59	16.90	4.44	0.0029	0.0006	0	0
4	100	24	122	47	12.84	3.37	0.0022	0.0005	0	0
5	150	15	505	130	53.05	13.93	0.0094	0.0018	92	10
6	150	18	318	96	33.39	8.76	0.0059	0.0012	47	1
7	150	21	218	74	22.88	6.01	0.0040	0.0008	16	0
8	150	24	162	59	16.98	4.46	0.0030	0.0006	0	0
9	200	15	688	156	72.25	20.0	0.0128	0.0027	111	11
10	200	18	393	111	41.22	10.82	0.0073	0.0014	49	4
11	200	21	272	86	28.56	7.50	0.0050	0.0001	39	0
12	200	24	203	70	21.33	5.60	0.0038	0.0007	9	0
13	250	15	860	179	90.34	23.71	0.0160	0.0032	119	12
14	250	18	487	127	51.12	13.42	0.0091	0.0018	79	10
15	250	21	331	99	34.73	9.12	0.0062	0.0012	49	1
16	250	24	238	78	24.95	6.55	0.0044	0.0009	33	0

From the above results plot the following charts should plotted.

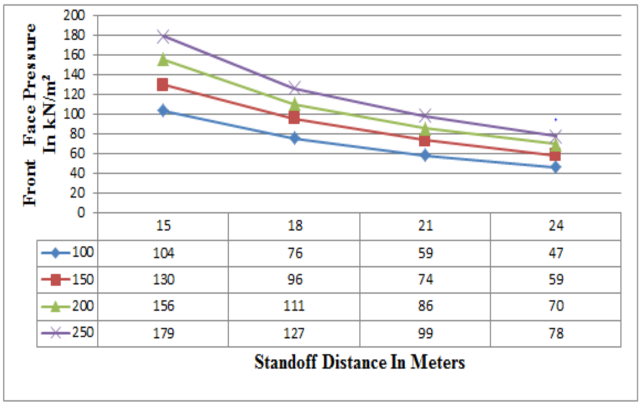

Chart-1 Front face pressure v/s Standoff Distance

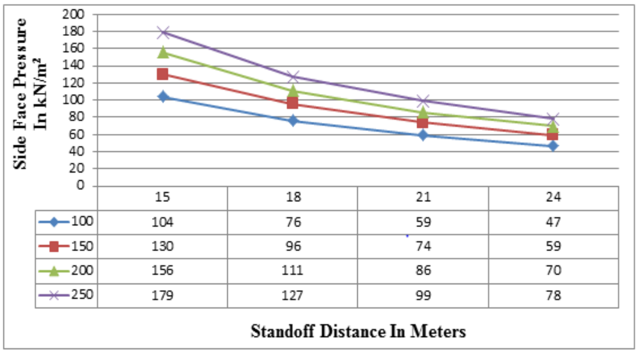

Chart- 2 Side face pressure v/s Standoff Distance

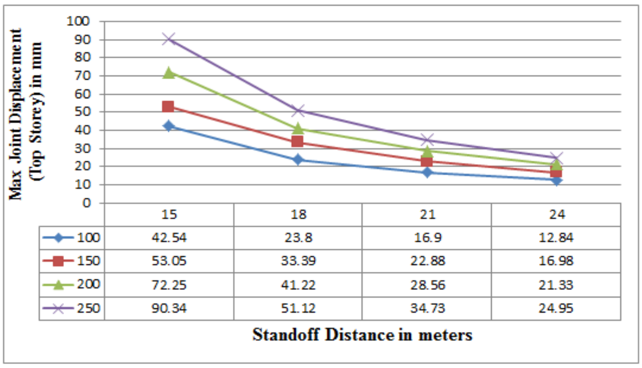

Chart-3 Max joint Displacement v/s Standoff Distance the model consists a beams and columns

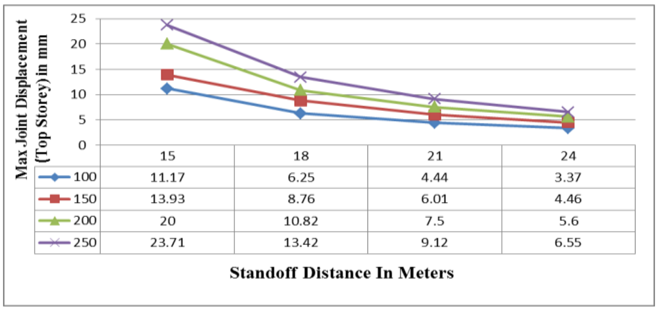

Chart-4 Max Storey Drift v/s Standoff Distance the model consists a beams and columns with Shear wall

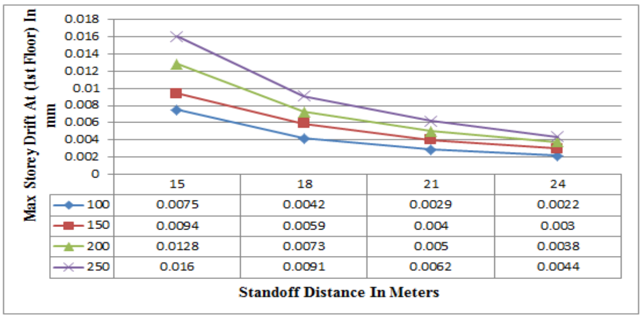

Chart-5 Max Storey Drift v/s Standoff Distance the model consists a beams and columns

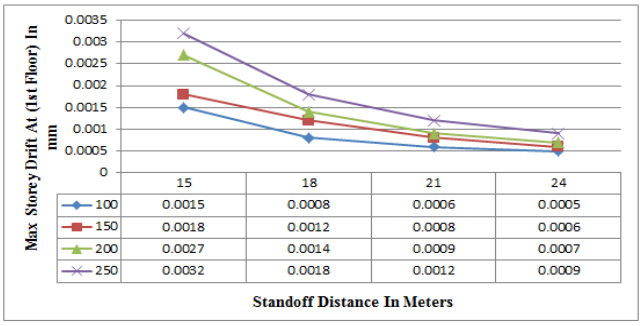

Chart-6 Max Storey Drift v/s Standoff Distance the model consists a beams and columns with Shear wall

All these graphs clearly show response mainly depends on the standoff distance and charge weight. Out of 16 cases the storey drifts and storey displacements are more in case number 13 and less in case no 4.The number of failed structural elements (beams and columns) is less in modified structure compared to structure consisting only beams and columns.

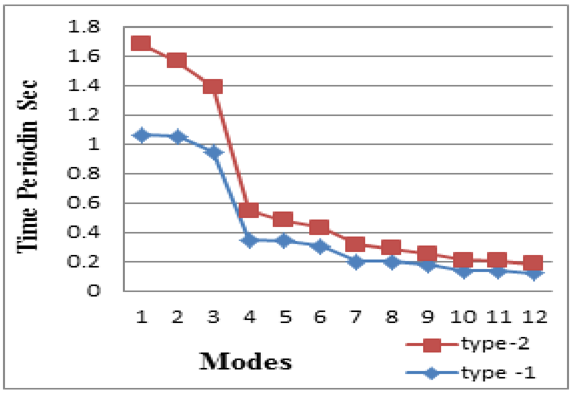

Chart-7 Time Period v/s Modes

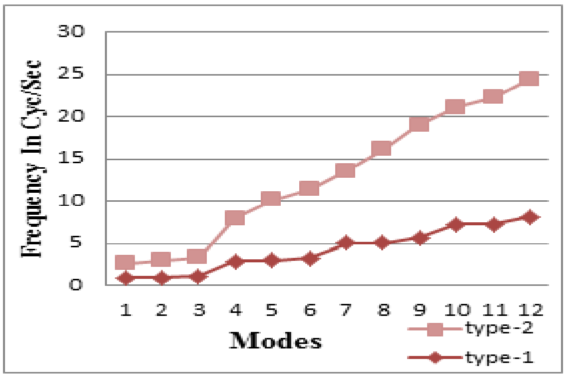

Chart-8 Frequency v/s Modes

The above charts show the time period v/s mode number and frequency v/s mode number. The time period systematically decreases with increase in the number of modes. The time period is less in modified model as compared to the model 1. In case of frequency v/s modes, frequency increases gradually with increase in the number of modes. The frequency is more in model-1 compared to the modified model.

4. CONCLUSION

1. The time period decreases with the increase in the number of modes.
2. The frequency of the structure increases with increase in the number of modes. The modified structure shows large value of frequency because of shear wall.
3. The displacement is less in modified model because of a shear wall.
4. The storey drift is less in modified model because of a shear wall.
5. Based on the graphical representation the number of failed structural elements increased with increase in the blast pressure in front face and side face of the building.
6. In this study out of 16 cases , the displacement and drift is more in case number 13 and less in case number 4.
7. The magnitude and stability of the structure increases with the increase in the standoff distance.

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REFERENCES

1. Jiji Madonna, Vijaya G S, Kirankumar K L (2016) "Analysis of high rise building subjected to blast load" International Research Journal of Engineering and Technology [IRJET] Volume: 03 Issue: pp: 1934 - 1939.
2. Rupert G Williams, William A Wilson, and Reisa Dookeeram (2016)"Analysis of the Response of a One-Storey One-Bay steel frame to blast" Hindawi publishing corporation, Journal of Structures, Volume pp: 35-50
3. Ronald Hamburger, S.E and Andrew Whittaker, S.E(2004) "Design of steel structures for blast-related progressive collapse resistance" Article in Modern steel construction pp 41-53.
4. Ahmed A Bayoumey and Walid A Attia (2016)"Assessment of existing structures under the action of gravity, earthquake and blast loads" International Journal of Engineering Science and Innovative Technology (IJESIT) Volume 5, Issue 3, pp: 37-47.

5. Umesh Jamakhandi and S B Vanakudre (2015) "Design and Analysis of Blast load on structures" International Research Journal of Engineering and Technology (IRJET) Volume 02 Issue 07 pp: 745-748
6. Zeynep Koccaz, Fatih Sutcu and Necdet Torunbalci (2008)"Architectural and Structural design for Blast resistant buildings" The 14th World conference on Earthquake Engineering, Beijing, China, pp:37-50
7. Usman Ilyas, S H Farooq, I Shahid, M Ilyas (2015)" Progressive collapse of reinforced concrete frame structure under column damage considetation" Pak J Engg & Appl Sci Volume 16 pp: 61-66.