Blast Analysis And Blast Resistant Design of R.C.C. Building

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Abstract- *Need of designing certain important structures to resist blast loads is gaining important day by day due to increase in terrorist activities from the recent years. Blast force causes loss of structural integrity due to partial or complete collapse of structural members. Blast loads are dynamic loads that must be calculated carefully as that of other dynamic loads. This project presents effect of blast loads on three storey R.C.C. building. Effect of (100,125,150) kg Tri nitro toluene (TNT) blast source which is at (15,30,45) m away from the building is considered for analysis and designed. Blast loads are calculated manually as per IS: 4991-1968 and force time history analysis or blast load analysis is performed in STAAD Pro. The influence of blast loads on structure is compared to that of same structure in static condition. The parameters like peak displacements, velocity and acceleration are studied.*

Keywords- Blast Loading, Explosives, Charges, Standoff Distance.

I. INTRODUCTION

The term blast refers to release of enormous amount of energy from the blast source that lasts for few milli-seconds. General buildings are not designed for blast loads due to which design loads because of explosion are quite high. Blast loads primarily depend on weight of charge taken and distance between source and the target. Throughout the force-time profile the force above ambient level is positive phase that lasts for very small duration and below the ambient level is Negative phase of duration that lasts for longer duration of time.

II. OBJECTIVE OF THE BLAST DESIGN

The primary objectives for providing blast resistant design for building are:

1. Personnel safety
2. Controlled shutdown
3. Financial consideration

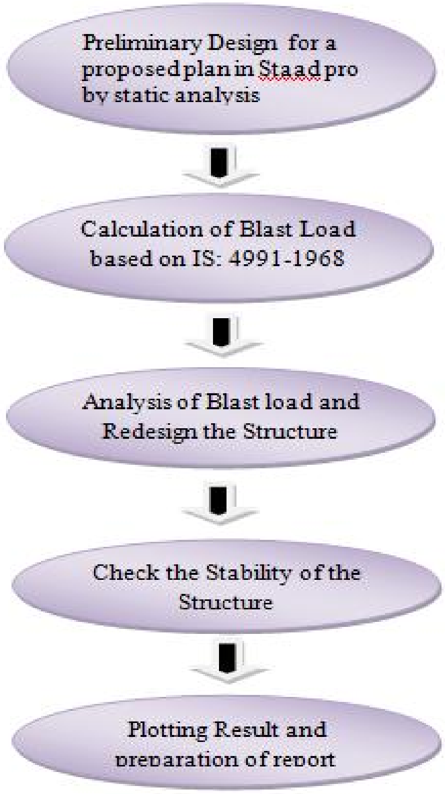
Blast resistant design should provide a level of safety for persons in the building that is no less than that for persons outside the building in the event of an explosion. Evidence from past incidents has shown that many of the fatalities and serious injuries were due to collapse of buildings onto the persons inside the building. This objective is to reduce the probability that the building itself becomes a hazard in an explosion.

Preventing cascading events due to loss of control of process units not involved in the event in another objectives of blast resistant design. An incident in one unit should not affect the continued safe operation or orderly shutdown of other units.

III. METHODOLOGY

3.1 Methodology Flow chart

The following flow chart drawn below represents analysis and design of RCC building in step wise procedure. The method used for blast analysis is Time-history analysis by which we can apply blast force as an impulse load because blast force does not prevail for longer period of and it last's for a few milli-seconds, so time-history method is most suitable for designing a building for blast loads and the method used for preliminary design is static analysis by imposing dead, live loads and combination loads.

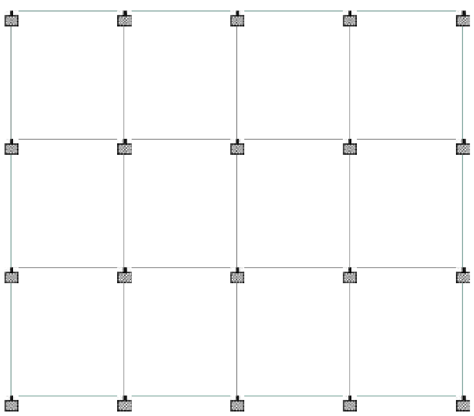


IV. RESULT AND ANALYSIS

4.1 Member and load specifications

Column : 0.23mX0.5m
Beam : 0.23mX0.4m
Slab : 100mm
Fe-500 & M35
Dead load (IS 875 part I) : $4KN/m^2$
Live load (IS 875 part II) : $2KN/m^2$
Blast load: calculated manually as per IS: 4991-1968 and given in table 2

4.2 Load calculation



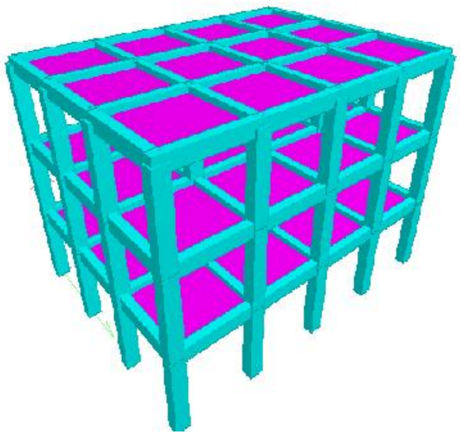


Fig. no 1 2D & 3D Plan of Building

Blast parameters due to the detonation of a 0.1 tonne explosive are evaluated on an above ground rectangular structure, 9m high, 12m wide and 9m length, situated at 30m from ground zero.

a) Characteristics of the Blast

$$\text{Scaled distance } x = \frac{30}{(0.1)^{\frac{1}{3}}} = 64.65\text{m}$$

From Table assuming p_a = 1.00 kg/cm^2 and linearly interpolating between 63m and 66m for the scaled distance 64.55m, the pressure are directly obtained:

$P_{so} = 0.35\ kg/cm^2$

$P_{ro} = 0.81\ kg/cm^2 = 81\ KN/m^2$

$q_o = 0.042\ kg/cm^2$

The scaled times t_o and t_d obtained from table 1 for scaled distance 64.65m are multiplied by $(0.1)^{\frac{1}{3}}$ to get the values of the respective quantities for the actual explosion of 0.1 tonne charge.

$t_o = 37.71X(0.1)^{\frac{1}{3}}$ = 17.5millisec

$t_d = 28.32X(0.1)^{\frac{1}{3}}$ = 13.15millisec

$M = \sqrt{1 + \frac{6}{7}\frac{p_{so}}{p_a}}$ = 1.14

a = 344m/s

U=392 m/s = 0.392m/millisecond

b) Pressures on the building

Here H=9m, B=12m, and L=9m
Then S=6m

$$t_c = \frac{3S}{U} = \frac{3x6}{0.392} = 45.91\ millisec > t_d$$
$$t_t = \frac{L}{U} = \frac{9}{0.392} = 22.95\ millisec > t_d$$
$$t_r = \frac{4S}{U} = \frac{4x3}{0.392} = 61.22\ millisec > t_d$$

As $t_r > t_d$ no pressure on the back face are considered. For roof and sides C_d = -0.4
$P_{so} + C_d q_o = 0.35 - 0.4X0.042 = 0.33\ kg/cm^2$

The pressure diagrams are shown below:

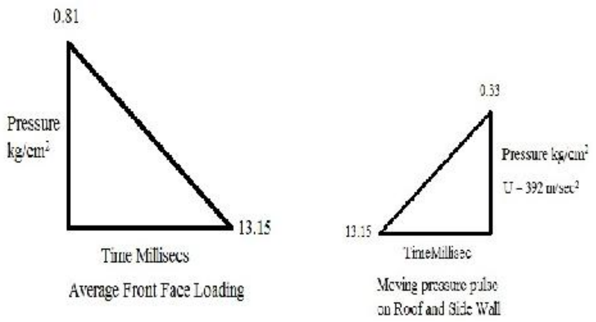


Fig. no 2 Pressure Diagrams

Table No. 1 Detail of calculation of parameters of the different blast loads

S. No.	Parameters	For 100 kg of explosion	For 125 kg of explosion	For 150 kg of explosion
Blast Distance 15m				
1	(x)	32.32 m	30.00 m	28.24 m
2	(p_a)	1 kg/cm²	1 kg/cm²	1 kg/cm²
3	(p_{so})	1.24 kg/cm²	1.4kg/cm²	1.64 kg/cm²
4	(p_{ro})	3.62 kg/cm²	4.2 kg/cm²	5.14 kg/cm²
5	(q_o)	0.471 kg/cm²	0.583 kg/cm²	0.78 kg/cm²
6	(t_o)	24.49 millisec	22.93 kg/cm²	21.75 kg/cm²
7	(t_d)	16.1 millisec	15.39 kg/cm²	14.16 kg/cm²
8	(M)	1.44	1.48	1.55
9	(a)	344 m/sec	344 m/sec	344 m/sec
10	(U)	0.49536 millisec	0.50912 millisec	0.5332 millisec
11	(S)	6	6	6
12	$(t_c = 3S/U)$	36.34 millisec	35.36 millisec	33.76 Millisec
13	$(t_t = L/U)$	18.17 millisec	17.68 millisec	16.88 millisec
14	$t_r = 4S/U$	48.45 millisec	47.15 millisec	45.02 millisec
15	(C_d)	-0.4	-0.4	-0.4
16	$(p_{so} + C_d q_o)$	1.0516 kg/cm²	1.1668 kg/cm²	1.328 kg/cm²
Blast Distance 30m				
1	(x)	64.64 m	60.00 m	56.47 m
2	(p_a)	1 kg/cm²	1 kg/cm²	1 kg/cm²
3	(p_{so})	0.35 kg/cm²	0.40kg/cm²	0.44 kg/cm²
4	(p_{ro})	0.81 kg/cm²	0.93 kg/cm²	1.03 kg/cm²
5	(q_o)	0.042 kg/cm²	0.054 kg/cm²	0.065 kg/cm²
6	(t_o)	17.5 millisec	18.145 millisec	18.78 millisec
7	(t_d)	13.15 millisec	13.33 millisec	13.87 millisec
8	(M)	1.14	1.16	1.17
9	(a)	344 m/sec	344 m/sec	344 m/sec
10	(U)	0.39216 millisec	0.39904 millisec	0.40248 millisec
11	(S)	6	6	6
12	$(t_c = 3S/U)$	45.99 millisec	45.11 millisec	44.73 millisec
13	$(t_t = L/U)$	22.95 millisec	22.56 millisec	22.37 millisec
14	$t_r = 4S/U$	61.22 millisec	60.15 millisec	59.64 millisec
15	(C_d)	-0.4	-0.4	-0.4
16	$(p_{so} + C_d q_o)$	0.3332 kg/cm²	0.3784 kg/cm²	0.414 kg/cm²
Blast Distance 45m				
1	(x)	96.95 m	90.00 m	84.70 m
2	(p_a)	1 kg/cm²	1 kg/cm²	1 kg/cm²
3	(p_{so})	0.186 kg/cm²	0.222 kg/cm²	0.237 kg/cm²
4	(p_{ro})	0.406 kg/cm²	0.470 kg/cm²	0.523 kg/cm²
5	(q_o)	0.0126kg/cm²	0.016 kg/cm²	0.019 kg/cm²
6	(t_o)	45.54 millisec	43.60 millisec	42.46 millisec
7	(t_d)	35.64 millisec	33.39 millisec	32.06 millisec
8	(M)	1.08	1.09	1.1
9	(a)	344 m/sec	344 m/sec	344 m/sec
10	(U)	0.37152 millisec	0.37496 millisec	0.3784 millisec
11	(S)	6	6	6
12	$(t_c = 3S/U)$	48.45 millisec	48.01 millisec	47.57 millisec
13	$(t_t = L/U)$	24.23 millisec	24.01 millisec	23.79 millisec
14	$t_r = 4S/U$	64.60 millisec	64.01 millisec	63.43 millisec
15	(C_d)	-0.4	-0.4	-0.4
16	$(p_{so} + C_d q_o)$	0.18096 kg/cm²	0.2136 kg/cm²	0.2294 kg/cm²

4.3 RESULT

Table No. 2 Detail of the result obtain

Case No.	Denotation charge weight (in kgs)	Stand off distance (m)	Front face pressure (KN/ m^2)	Side-face pressure (KN/ m^2)	Maximum joint displacement (Top Storey) in mm
1	100	15	355	103	576
2	100	30	79	32	179
3	100	45	39	17	88
4	125	15	412	114	935
5	125	30	91	37	206
6	125	45	46	20	104
7	150	15	504	130	1143
8	150	30	101	40	229
9	150	45	51	22	115

The above obtained results are analyzed by plotting the following graphs:-

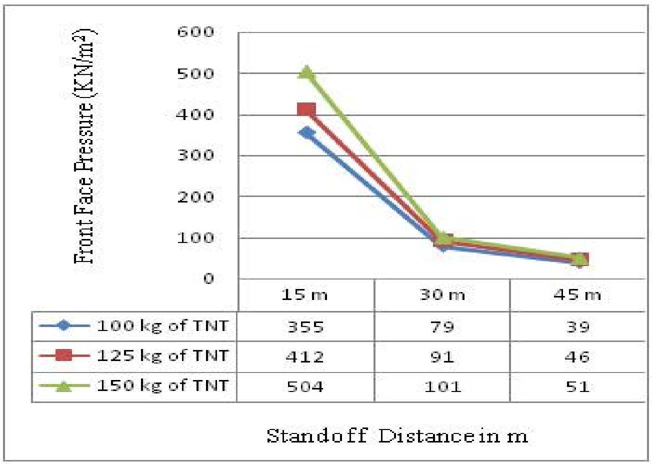


Chart -2: Front face pressure vs Standoff distance

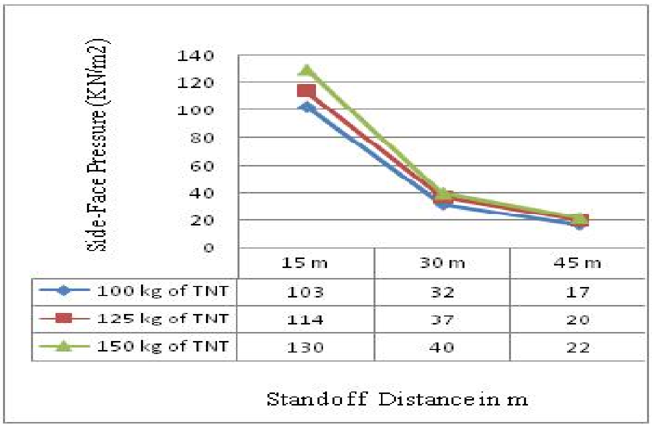


Chart-3:Side-face pressure vs Standoff distance

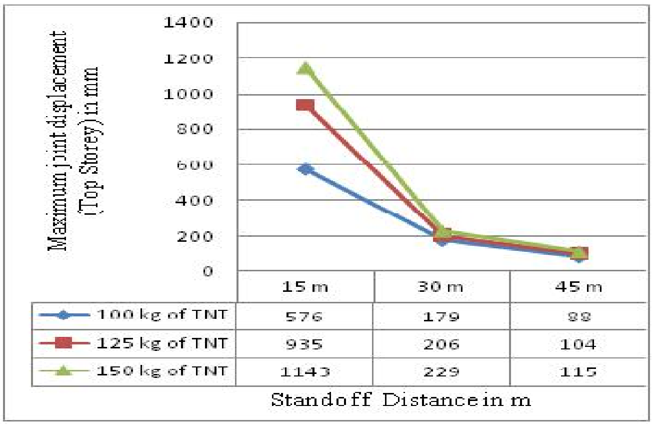


Chart 4: Maximum joint displacement vs Standoff distance

In this analysis, in every case some beam and column are fail. So dimension of the beam and column are increase in respective cases. Because of this dead weight is increase so resistivity against the blast load also increase. The result become no failure of structure.

Table No. 3 Required Dimension for the blast resistant beams & columns

Case No.	No. of beam/ column failed	Column dimensions required for blast resistant building (mm^2)	Beam dimensions required for blast resistant building (mm^2)
1	19	850x850	500x500
2	15	600x600	350x500
3	2	400x600	230x400
4	38	850x850	600x600
5	22	500x600	300x400
6	6	450x500	230x400
7	45	900x900	750x750
8	18	550x600	400x500
9	10	500x500	300x500

This analysis shows that the stand-off distance increases from the building, the magnitude of blast pressure reduces. In case no. 1,4,7 are critical with respect to their blast load so required dimension of structure are comparatively more which is undesirable. In this type of cases if we provide the shear wall, it increases the structural integrity of the building and also decreases the dimension of the structure. But providing the shear wall in the building increase the cost of construction and make the structure uneconomical.

V. CONCLUSIONS

Blast resistant design refers to improving structural integrity of structure instead of complete collapse of building, the present study on three storey building proves that increase in stiffness of structural members by increasing in size proving better which also resist the uplift force on footings by increasing in dead weights.

Effects of blast loads can also be decreased by providing lateral moment resisting frames like shear wall thereby decreasing the effect of lateral loads which also reduces damage and increase structural integrity of the building. But it increase the cost of construction and make uneconomical project.

Though there are guidelines available for the design of buildings to be blast resistant, those guidelines are very rarely used in designing the general structures. Hence by considering such guidelines the buildings are designed more robust in nature.

It was found that the most ideal model to resist the blast effect is a regular symmetrical frame because they are least prone to damage & exhibit great strength when compared to that of irregular buildings.

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