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RESEARCH ARTICLE

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DETERMINATION OF BLAST LOAD PARAMETERS FOR 2D FRAMED OVER THE FACADE OF THE STRUCTURE

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ABSTRACT

Blast resistant analysis explores non linear Two Dimensional dynamic responses of tall building (G+13) storey. Tall reinforced concrete structural buildings have been designed for normal loads like dead, live, and wind. In the present scenario challenges for civilian structures are the loads due to blasting i.e. terrorism. These blast loads are of high intensity and these loads acts on the structure for short durations. Hence blast loading is nothing but impulsive loading. These loads are analyzed by TM-5 1300. As the structures are designed for normal loads the structures get destroyed when subjected to blast loading. Here comes the major challenge for civil engineers to design the structure for blast loads. Impact from the blast loads damages the target structure as well as the surrounding structures. Hence the structure should be designed for blast loads along with normal loads, so that they can resist shock waves due to blast (impact) loading. The blasting energy releases high intensity pressure waves which are called as incident pressure waves. These incident waves affect the surrounding structures along with target structure. These waves touches the structure and rebounds to the source after which they gets combined with the incident waves forming high intensity waves called reflected pressure waves. With this reflected pressure waves a mach front is formed with the summation of both incident pressure as well as reflected pressure. The dynamic blast loads are needed to be carefully calculated just like wind and earthquake loads. In this article the blast load parameters are calculated for 2-D tall structural frame which is done manually. Columns are key load bearing elements in frame structure. The blast loads was analytically determined as a pressure time-history analysis.

Key Words: Blasting, Dplot, TM-5 1300, tall structure, terrorist activities.

1. INTRODUCTION

Blast resistant designs were familiar since 55 years. As blast loads are not of much importance in the earlier days there was no much significance for blast resistant designs. But as the technology improves and the world is much concerned about safety these blast resistant designs came into light. One example for this is Khobar tower bombing in Saudi Arabia which was being used for foreign military purpose, in this incident surrounding structures are severely damaged compared to the target structure due to blast resistant design of the structure. In this paper surface burst is considered which destroys the structure very easily. Due to this the structure is designed for abnormal loads (bomb loads or charge weights). In air burst blast wave propagation is in spherical shape, but as we have considered the surface burst where the wave propagation is in hemispherical shape, explosion materials will propagate waves in different directions. In the present work TM-5 1300 code and the analysing tool Dplot graphs are used. Figure 1 shows the reflected pressure, incident pressure, arrival time which is obtained from incident wave. Pressure intensities depend upon the bomb size or charge weight and also with standoff distance between blast source and impacted (2D frame) structure (target). The main aim of this paper is to understand how the pressure varies from floor to floor with the help of Dplot application for the 2D tall structural building with positive front face of the structure (nothing but target)

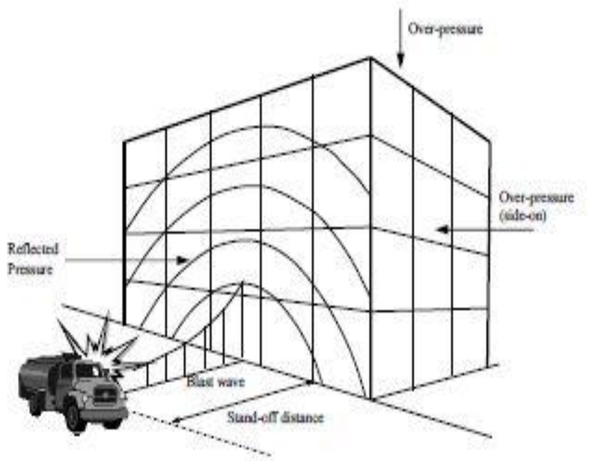


Figure 1: Blast loading on structure

1.1 Paper methodology

Determination of blast wave parameters

By determining blast wave parameters we can learn about the surface burst. The loads due to Explosion are huge applied in different directions for short durations. Maximum damage is occurred when charge weight (bomb weight) is more. Explosive materials (bomb) release shockwaves in different directions. These waves are reflected pressure waves, which travels through surface, touches the building then the waves are distributed to the entire building. All the pressure waves are merged with the incident wave at the point of detonation to form a single wave; these waves are in hemispherical shape.

B. Procedure for field wave blast parameters of a surface burst

- Select point of interest on the ground relative to the charge. Determine the charge weight and ground distance $R_{G.}$
- Apply 20% safety factor to the charge weight.
- Calculate scaled ground distance $Z_{G:}$

$$Z_G = R_{G/W}{}^{1/3}$$

- Determine free field blast wave parameters from figure for corresponding scaled distance Z_G.

Here: Peak positive incident pressure P_{so}

Reflected Pressure P_r

Shock front velocity U

Scaled unit Positive incident impulse $i_s/w^{1/3}$

Scaled positive phrase duration $t_{o/}w^{1/3}$

Scaled arrival time $t_A/w^{1/3}$

Multiply scaled values by $W^{1/3}$ to obtain absolute values.

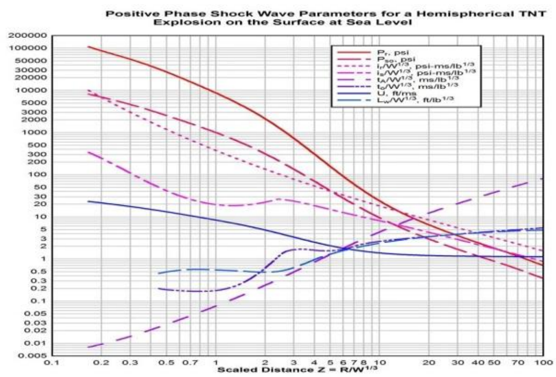


Figure 2: positive phase shock wave parameters for hemispherical TNT i.e. surface burst

C. Brief over view of structure

A G+13 storied building consisting of each story height 4m and the total height of the building frame is 52m. The present project is proposed to study the blast wave pressures of the multi-story 2-D building frame using TM-5 1300 plots in UFC (Unified Facilities Criteria). The following structure is considered, for determining the pressures which are induced due to TNT charge weights.

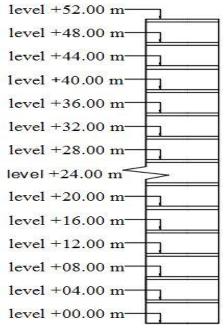


Figure 3: facade of 2D tall structure

D. Analysis results of blast loads

Table 1: BLAST LOAD PARAMETERS FOR 10m DISTANCE CHARGE WT:- 500Kg TNT

Floor	Scaled Distance ($m/Kg^{1/3}$)	P_r (Kg/m^2)	P_{so} (Kg/m^2)	t_A (ms)	ta+to(ms)
G Floor	2.99	512920.41	94930.38	5.38	23.59
1st Floor	3.22	413580.41	80431.51	6.18	24.82
2nd Floor	3.83	244495.95	54209.81	8.54	26.66
3rd Floor	4.67	134916.48	34273.53	12.39	29.59
4th Floor	5.64	76556.17	22256.62	17.60	35.52
5th Floor	6.68	46934.41	15260.85	23.99	44.82
6th Floor	7.77	31155.27	11059.26	31.35	55.77
7th Floor	8.89	22151.59	8407.79	39.50	66.37
8th Floor	10.02	16657.73	6649.29	48.27	77.06
9th Floor	11.17	13095.43	5428.55	57.53	87.87
10th Floor	12.32	10663.09	4547.44	67.16	98.81
11th Floor	13.49	8929.22	3889.86	77.08	109.85
12th Floor	14.65	7644.00	3384.55	87.22	120.99
13th Floor	15.83	6610.64	2986.78	97.53	132.21

Table 2: BLAST LOAD PARAMETERS FOR 10m DISTANCE CHARGE WT:- 1000Kg TNT

Floor	Scaled Distance ($m/Kg^{1/3}$)	P_r (Kg/m^2)	P_{so} (Kg/m^2)	t_A (ms)	ta+to(ms)
G Floor	2.37	1718028.83	155944.47	3.73	12.56
1st Floor	2.55	1439905.74	133462.24	4.25	15.35
2nd Floor	3.04	928289.60	91561.32	5.78	25.72
3rd Floor	3.71	537129.11	58398.70	8.30	36.96
4th Floor	4.48	308814.58	37776.37	11.79	41.26
5th Floor	5.30	184772.77	25573.13	16.21	44.00
6th Floor	6.17	116868.71	18209.95	21.49	48.83
7th Floor	7.05	78233.58	13581.27	27.57	55.91
8th Floor	7.95	55160.06	10538.17	34.35	65.27

9th Floor	8.86	40712.34	8451.54	41.75	76.98
10th Floor	9.78	31238.45	6964.99	49.68	88.40
11th Floor	10.70	24769.56	5870.77	58.08	99.48
12th Floor	11.63	20191.83	5040.96	66.87	110.53
13th Floor	12.56	16850.26	4397.20	76.00	121.58

E. Velocity of blast wave.

Table 3: Blast wave velocity for 500Kg TNT charge weight

Floor	Arrival time (t_A) ms	Time of decay (t_o) ms	Velocity (U) m/ms
Ground level at 0.0m	5.3847	18.2081	1.0110
Roof level at 52.00m	97.5299	34.6800	0.3801

The above table indicates the blast wave velocity in surface burst for 500Kg TNT Charge weight at 10m distance. Velocity of the wave is 1.0110 at arrival time 5.3847, time of decay is started and blast wave velocity is reduced to 0.3801 which was at roof level. From the observation of results, blast wave velocity is reduced for different charge weights when increasing the arrival time. Similarly same type of cases occurred for the remaining charge weights to facade of two dimensional tall structural frames 2000, 3000, 4000Kg TNT Charge weights.

F. Graphs for incident pressure

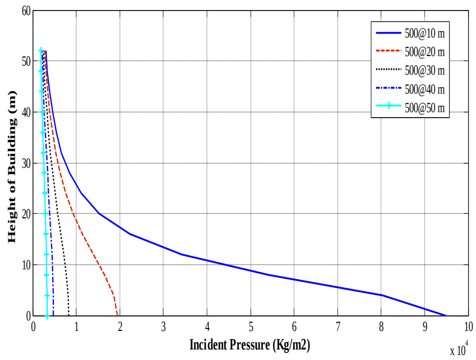


Figure 4: Incident pressure for 500Kg TNT @10, 20, 30, 40 and 50m distances

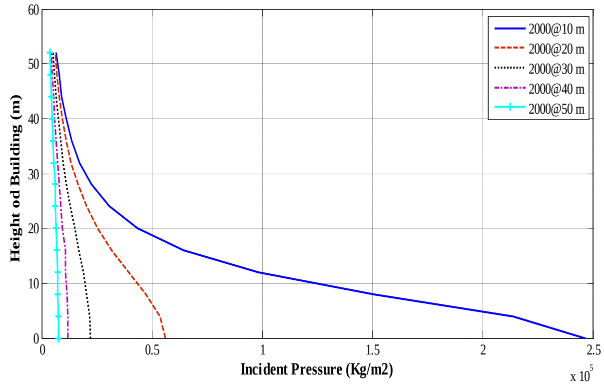


Figure 5: Incident pressure for 2000Kg TNT @10, 20, 30, 40 and 50m distances

G. Graphs for reflected pressure

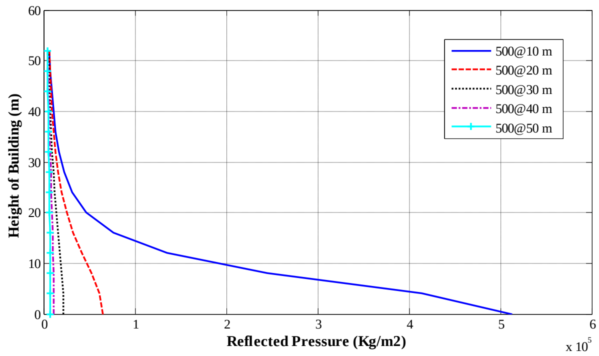


Figure 6: Reflected pressure for 500Kg TNT @10, 20, 30, 40 and 50m distances

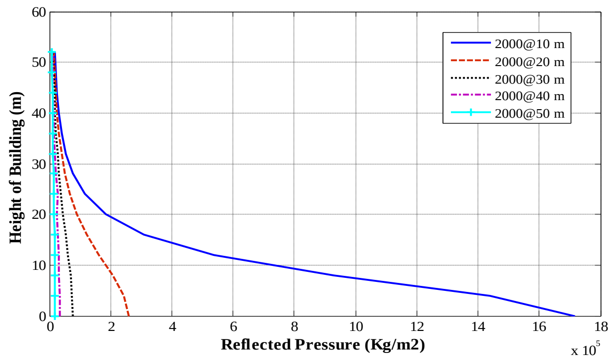


Figure 7: Reflected pressure for 2000Kg TNT @10, 20, 30, 40 and 50m distances

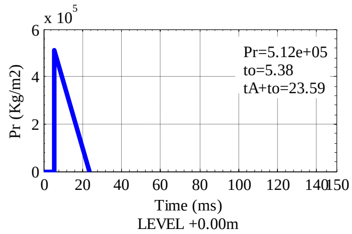
For analysis approach 500, 1000, 2000, 3000 and 4000 Kg's TNT charge weights are considered with respect to different distances 10m, 20m, 30m, 40m and 50m. The graphs are shown above for 500Kg, 2000Kg TNT @10, 20, 30, 40 and 50 m. As the bomb size increases, then the intensity of pressure (incident and reflected) increases. Maximum incident and reflected pressures occurred at ground floor is 94.930×10^3, 5.12×10^5 for 500Kg TNT Charge weight at 10m distance and for 2000Kg TNT charge weights pressures are represented in table from graphs. For further height of building i.e. 52m (roof level) pressures are decreased. Similarly reflected pressures are more intensity pressures when compared with the incident pressure waves, because as mentioned earlier when the shock waves touches the structure and rebounds to detonation position they combine with the incident pressures.

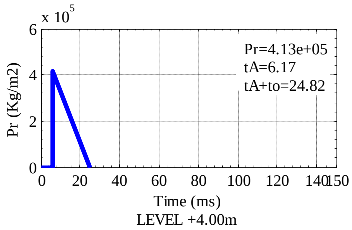
H. Graphs for impulsive peak pressure

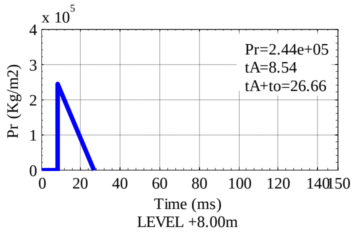
In order to analyze the blast loadings it is necessary to determine the initial reduction and the dynamic pressure of the time as the effects on the structure depend on the pressure-time history as well as on the peak value. The explosion shock wave is characterized by a sudden increase in pressure to peak, decrease to an atmospheric pressure (positive phase) and for the period in which the pressure falls below the atmospheric pressure (negative phase). Pressure time history analysis is the reduction of speed for the initial and dynamic pressures, after passing of the wave front; it is a function of the peak pressure and the magnitude of detonation. For the analysis purposes, the actual reduction of the initial pressure can be assumed as a triangular pressure impulse. The actual duration of the positive phase is replaced by a fictitious duration and is expressed as a function of the total positive impulse and the peak pressure.

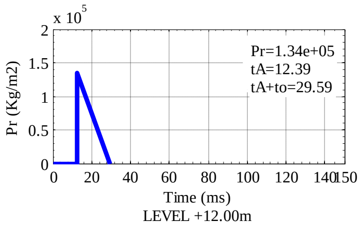
These impulse graphs are plotted using MAT LAB Software where the graphs are much accurate with the values obtained in the design. MATLAB is a high performance interactive software tool for scientific and engineering computation. MATLAB which integrates numerical analysis, matrix computation, signal processing and graphics in an easy way. Where problems and solutions are expressed as just they are written mathematically.

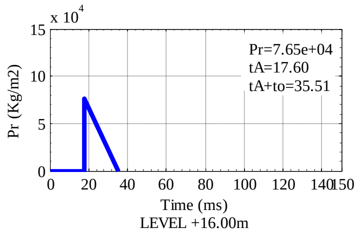
I. Graphs for impulse

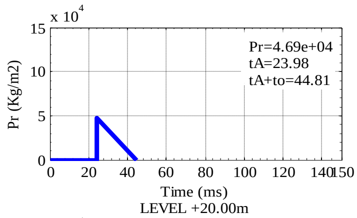


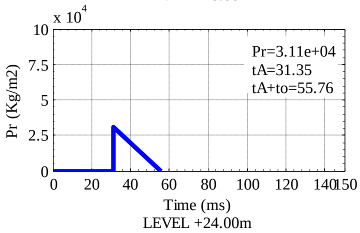












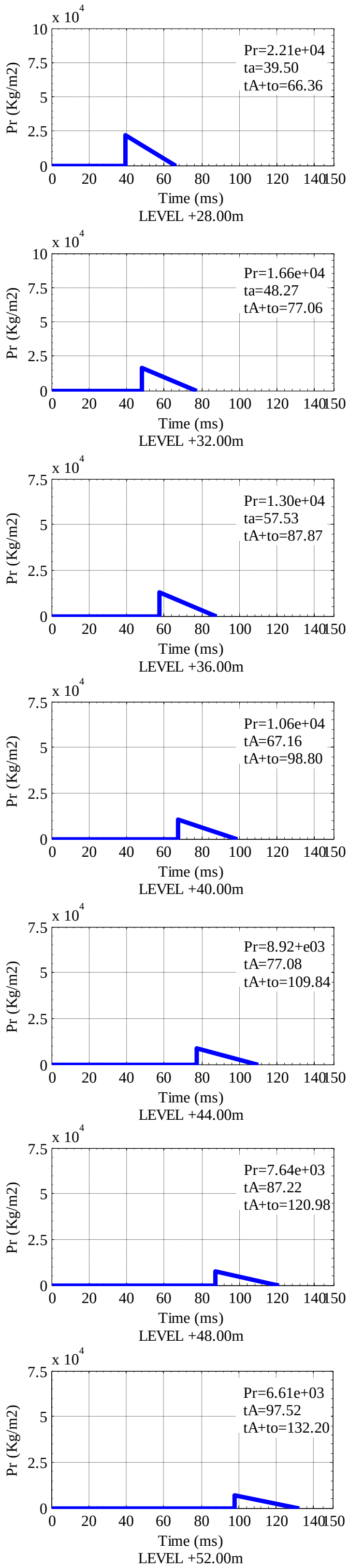
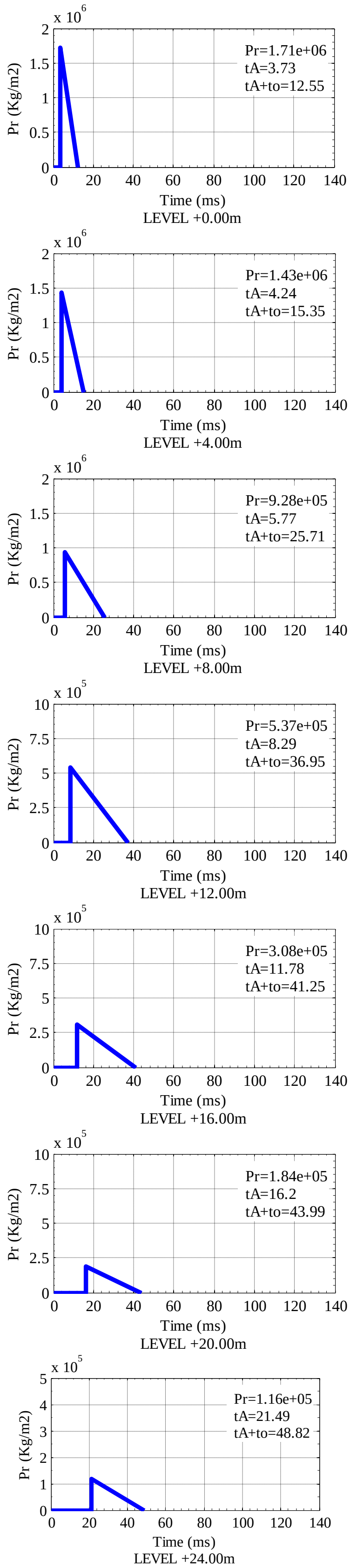


Figure 8: Impulse grphs for variations of 500Kg TNT charge weight @ 10m distance.

Note: 2000Kg TNT charge weight at 10m distance



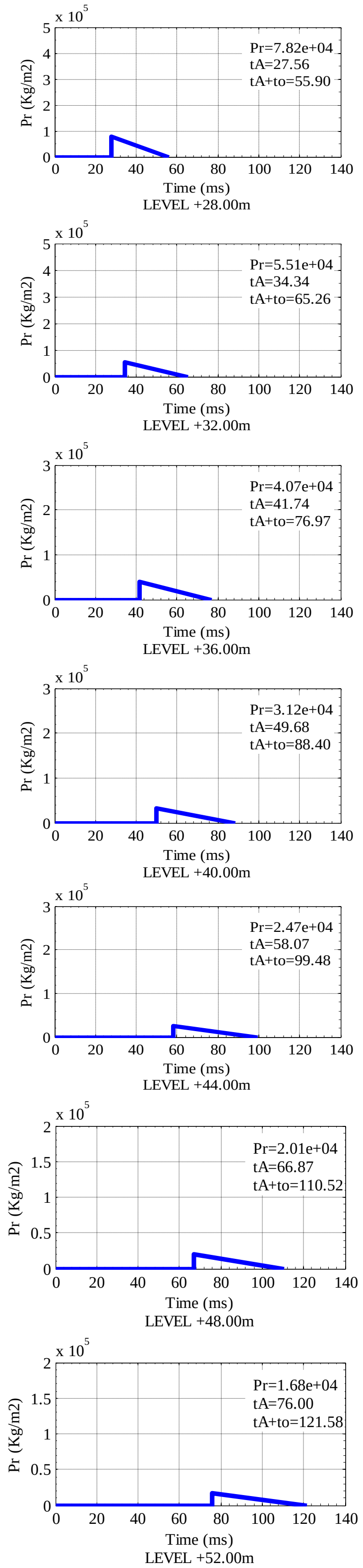


Figure 9: Impulse grphs for variations of 2000Kg TNT charge weight @ 10m distance.

From results i.e. impulse graphs of 500Kg, 2000Kg TNT Charge weights at 10m distance shown in above at the ground floor peak reflected impulse for 500Kg, 2000Kg @10m distance are 5.12×10^5, 1.71×10^6 respectively. When the time of decay is started peak reflected pressure values are reduced at roof level to 6.61×10^3, 1.68×10^4, hence from these graphs peak impulse is reduced when time decay is started and reaching the total time duration peak impulsive value may be negligible

II. Results and discussion

I. The 2-D tall structural frame (G+13) subjected to five charge weights 500, 1000, 2000, 3000 and 4000 Kg TNT.
II. The study aimed on external short time blast loads on facade of the structure by using TM-5 1300 over the front face of structure(positive phase 2D frame is considered).
III. Reflected pressure Pr, reflective impulse Ir, time of arrival t_a and also finding the positive phase time duration for reflected pressure t_r.
IV. In this analysis twenty five combinations of ground distances and charge weights are considered for the determination of blast Pressures.
V. The TNT charge is in the shape of hemispherical for all frames of the structure.
VI. Above mentioned frame is simulation for five blast load combinations 10m range 500, 1000, 2000, 3000and 4000Kg TNT Charge weights.
VII. Similarly 20m, 30m, 40m, 50m, to the above charge weights are considered.

III. CONCLUSION

[1]. The explosions near to the structure can cause damage to the surrounding buildings.
[2]. Blasting over the facade of tall structural two dimensional frame analysis gives distribution of reflected pressure is in decreasing order with the height of structure.
[3]. Distribution is approximately uniform for shorter ranges, and this assumption is not valid.
[4]. Because as the structure first collapse locally then distributed to entire structure, the response in the structure is more, in the case of lower ranges.

[5]. The reflected pressure at the top of the structure is observed in the case of 10m range and more in 20, 30, 40 and 50m range for all charge weights 500 to 4000Kg TNT.

[6]. This is due to angle of incidence which is varying at high range as in the case of 10m and 50m respectively.

[7]. For 10 m range, the factor of the reflected pressures and for charge weights 4000 kg TNT to 2000 kg TNT and 2000 kg TNT to 500 kg TNT increased in between third and fifth floors i.e. in between 40^0 to 60^0 angle of incident.

[8]. This is due to the peak incident over pressure and angle of incidence.

[9]. If the shock front approaches the structure at an incident angle then the peak reflected pressure will be a function of the peak incident over pressure and the incident angle between the front and the facade of the structure.

[10]. Starting at an angle of incidence of approximately 40^0, TM 5 – 1300, depending on the static condition.

[11]. From the above observation reflected impulsive pressure is more in the case of ground (bottom) floors, low in roof level (top) floors for different charge weights.

[12]. From figure 4, 5, 6 and 7 reflected peak impulse is uniform for different charge weights 500 to 4000Kg TNT.

[13]. The time of arrival (t_A) and the sum of time of arrival and time of positive phase time duration of reflected pressure (t_A+t_O) are in increasing order with increase in range and decrease in charge weight.

[14]. The variation in the above times and ($t_{A,}$ t_A+t_O) with height is nonlinear at the lower levels and approximately linear in the upper levels, this is due to the expansion of the shock front from the point of explosion and the incident pressure decreases up to ambient pressure with the distance from the point of explosion.

[15]. Because of the decay in the incident pressure, the positive phase time duration of reflected pressure will increase.

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