EFFECT OF SURFACE BLAST LOAD ON THE RC STRUCTURES

Priyanka [1], Dr. Vijaya G S[2]

[1]*Postgraduate Student, Department of Civil Engineering, GSKSJTI, Karnataka, India*
[2]*Assistant Professor, Department of Civil Engineering, GSKSJTI, Karnataka, India*

---***---

Abstract - *Terrorist activities and threats is a growing problem nowadays around the world. Hence, the concept blast protection is found to assume an imperative part with the structural engineers. Terrorist attacks target where human causalities and economic consequences are likely to be substantial. Structural buildings are considered to be attracting targets because of its potential impacts and accessibility on economic activities and human lives. Multi storey buildings are designed primarily to satisfy the needs of an intended occupancy whether commercial, residential or both hence it makes a major part of targeted structures. Hence, the structure should have designed in such way that it should resist the impact loads.*

Key Words: Explosion, Charge Weight, Standoff Distance, Blast Load, Storey Displacement, Storey Drift.

1. INTRODUCTION

In recent years the activities of terrorist is the major growing problem. The impact effect of blast load leads to the failure of structure. Usually structure is not ready to take the blast load, because the blast loads are irregular, immediate and dangerous.so the structure should be designed in a way that it should resist the blast load up to certain extent. The term blast is defined release of enormous amount of thermal energy. Explosion is mainly depending upon the capacity of explosive material, explosive material is categorised mainly based on their physical state i.e. solid, liquid and gases. Usually solid type of explosive materials is used in the explosion process, the solid type explosive has high detonation capacity.

The main aim of this work is to know the response of RC structure subjected to surface blast and to give protection against the explosion. The guidance describes method for mitigating the effect of blast, thus provides the protection for human life and important equipment inside structure.

1.1 CHARACTERISTICS OF BLAST WAVE AND ITS PROCESS

The quick release of large amount of energy is characterised based on air pressure and its audible blast. An explosive is mainly used for destruction purposes such as military uses, construction or progress works, demolitions, etc. Detonation is a kind of combustion, which involves a supersonic exothermic front quickening through a medium that eventually drives a shock front proliferating directly in front of it. It happens in both conventional solid and fluid explosives, and in emitted gases. An explosive reaction that produces a high intensity shock wave travelling at about 1500 to 9000 meters per second faster than the velocity of deflagration process is Detonation. The actual speed of detonation process mainly depends on the constituents of the explosive material.

Smith and Hetherington explained in 1994 about explosive process. The explosive process that includes the sequence of events when the high explosive material is initiated. Typical pressure wave is illustrated in figure 1. Whenever the blast occurs, there is rise in the peak pressure Pso, and the pressure is below the microsecond. This pressure is also known as ambient pressure (Po). The ambient pressure is zero at arrival duration there is a sudden increase in the peak positive pressure at positive duration this is known peak positive over pressure. As the time increases, there is occurrence of negative pressure, which is less than the ambient pressure with negative duration (t_{neg}). The expansion of detonation creates the vaccum source from the centre of explosion this leads the turnaround motion. Generally, the negative phase pressure has less in magnitude than the positive phase pressure but it is longer in duration than the positive phase duration.

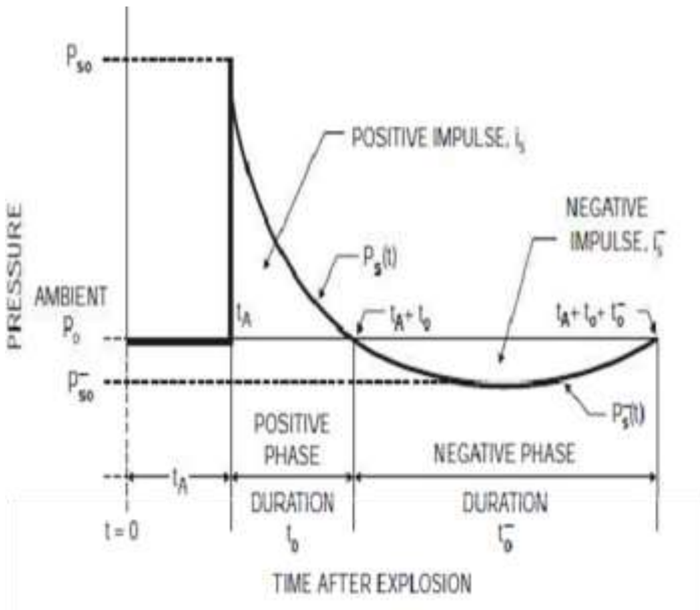

Fig 1: pressure variation with time after explosion

2. CALCULATION OF BLAST LOAD

CASE 1: CALCULATION OF BLAST LOAD FOR 100KG TNT AT 25M STANDOFF DISTANCE ARE SHOWN BELOW.

(For calculation purpose, charge weight of TNT is expressed in terms of lbs and standoff distance in ft.)

Surface blast load calculation.

1. Charge Weight 'W'= 220lbs at Stand of distance 'R' = 82.02ft
2. Apply safety factor of 20% for charge weight = 264lbs
3. Scaled distance 'Z"= R / $W^{1/3}$ = 82.02/$264^{1/3)}$ = 12.78 ft/$lb^{1/3}$
4. Determine the blast wave parameters Pso, U, i_s, i_r, t_A, to, U, L_w
   a) P_{so} - Peak positive incident pressure
   b) U - Shock front velocity
   c) i_s/ $W^{1/3}$ -Scaled unit positive incident impulse
   d) t_o/ W1/3-Scaled positive phrase duration
   e) ta/ W1/3 - Scaled arrival time

   Psi = 6 psi

   $t_A = 5(264)^{1/3} = 32.075$ ms/$lb^{1/3}$

   $t_o = 2.9(264)^{1/3} = 18.60$ ms/$lb^{1/3}$

   $i_s = 8(264)^{1/3} = 51.32$ psi-ms/$lb^{1/3}$
5. from the graph figure 2-193 determine the reflected pressure and impulse

   $C_{r\alpha}$ for Pso = 6 Psi and angle $\alpha = 0^0$, from the

   graph the value of $C_{r\alpha} = 2.2$

   $P_{r\alpha} = C_{r\alpha}$ X Pso =2.2 X 6 = 13.2 Psi

   Figure 2-194, obtain the value of irα / w $^{1/3}$ =

   $14(264)^{1/3}$ = 89.81 psi-ms
6. Front wall loading, positive phase.

   Calculation of sound velocity in reflected over

   pressure region obtain C_r

   From the figure 2-192 for Pso = 6 Psi

   C_r = 1.23 ft/ms
7. Calculate the clearing time t_c = 4S/ (1+R) Cr = 64.96 ms
8. Calculate fictitious positive phase duration, t_{of} = 2($i_{s)}$ / Pso = 17.10 ms
9. Calculate fictitious duration t_{rf} of the reflected pressure = t_{rf} = 2 I_{ra} / P_{ra}

   t_{rf} = (2 x 14)/ 13.2 = 2.12 ms
10. Determine the q_0 for Pso = 6 psi from the figure 2-3 q_0 = 0.8
11. Pso + C_D q_o = (6 + 1 x 0.8) = 6.8 Psi

    6.8 x 6.89 = 46.852 KN/ m^2 (pressure)

The load on each node = (46.852 x 3.5 x 4.5) / 4 = 184.5 KN (at corner)

At middle, joint load is about 368 KN similarly for 200kg TNT at 25m and 30 standoff distance is calculated.

Table 1: Summary of blast on structure

Weight of Explosive (TNT)	Pressure on the front face in KN/m²	Stand-off distance in m	Corner joint load in KN	Middle joint load in KN
100 Kg	46.85 KN/m²	25 m	184 KN	368KN
	38.54 KN/m²	30m	152 KN	304 KN
200 kg	75.10 KN/m²	25m	296 KN	592 KN
	61.32 KN/m²	30m	242 KN	484 KN

3. METHODOLOGY

In this work, two models were generated in SAP2000 software and analysed as non-linear static (the loads are applied as static joint load) in two different models. The model description is four bay of 4.5m along x direction and three bay of 5m along y direction. Each storey height is 3.5m. The material used are M30 grade concrete and Fe415 grade steel. The models generated as follows.

Model 1: Regular structure of column size 600x600mm and beam size 350x500mm

Model 2: Addition of bracing on model 1(bracing used is section ISMB 200)

Blast loads cases used are

Case 1: Blast load of 100kg TNT at 25m standoff distance

Case 2: blast load of 100kg TNT at 30m standoff distance

Case 3: Blast load of 200kg TNT at 25m standoff distance

Case 4: blast load of 200kg TNT at 30m standoff distance

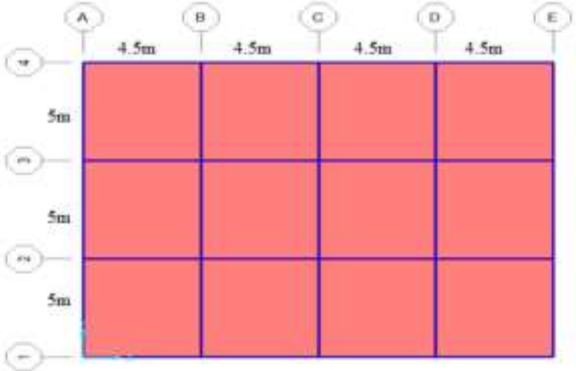

Fig 2: Plan of a model 1

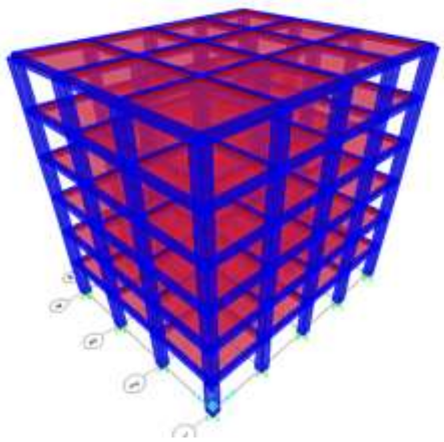

Fig 3: Rendered View of G+5 Story Building

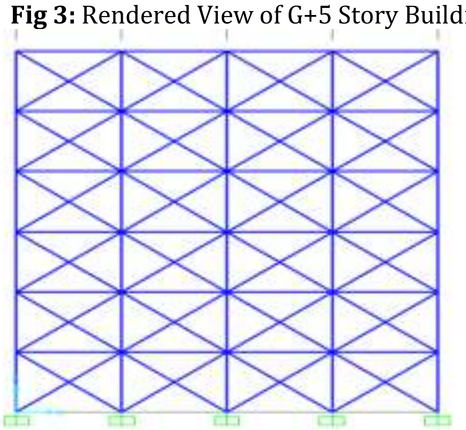

Fig 4: Building with bracings provided at outer periphery Section ISMB 200

4. RESULTS AND DISCUSSIONS

Based on the results obtained from the lateral displacement gives the stability of building. The 100kg TNT placed at 25m standoff distance gives the maximum storey displacement about 101.45mm and at 30m distance it is about 83.81mm. The 200kg TNT placed at 25m standoff distance gives the maximum storey displacement about 163.21mm and at 30m distance it is about 133.43mm.

Model -1: As per the Indian code IS 1893, the allowable maximum lateral displacement is 42mm (i.e. H/500). So that the lateral displacement of building with charge weight of 100kg and 200kg TNT at 25m and 30m standoff distances are not satisfying the code provision.

Model -1: As per the IS 1893 code provision, the allowable maximum inter storey drift is 14mm (i.e. 0.004x h). So that the inter storey drift of building with charge weight of 100kg, 200kg TNT at 25m and 30m stand of distances are satisfying the codal provision.

When the bracing is provided for the structure with 100kg TNT explosive at 25m standoff distance gives the maximum storey displacement about 28.41mm and for 30m stand off distance its about 23.46mm. For 200kg, the bracings provided the lateral displacement for 25m standoff distance give the 45.49mm.and for 30m standoff distance it is about 37.36mm.

Model-2: here the building provided with bracings at the periphery to control the lateral displacement and inter storey drift. As per the IS 1893 code provision, the allowable maximum lateral displacement is 42mm and inter storey drift is 14mm.

Model 2: The inter storey drift of building with charge weight of 100kg, 200kg TNT at 25m and 30m stand-off distances satisfies the codal provision IS 1893.

STOREY DISPLACEMENT

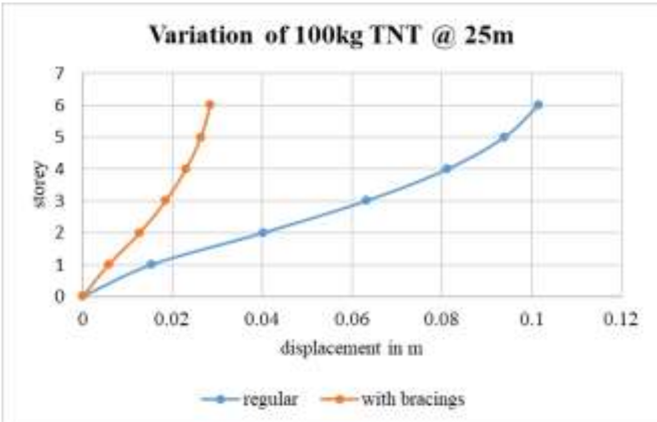

Fig 5: Storey displacement for 100 kg TNT at 25m

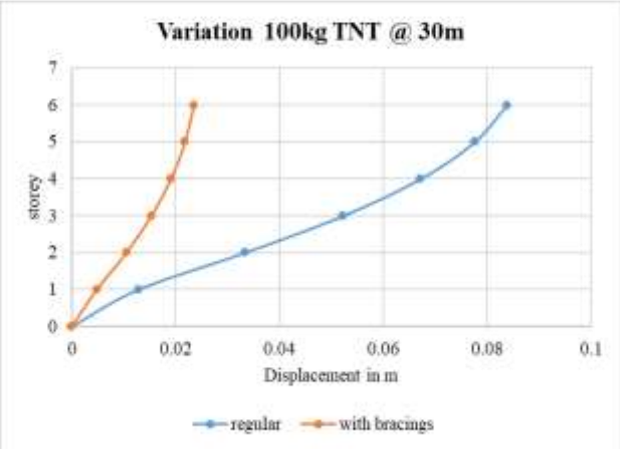

Fig 6: Storey displacement for 100 kg TNT at 30m

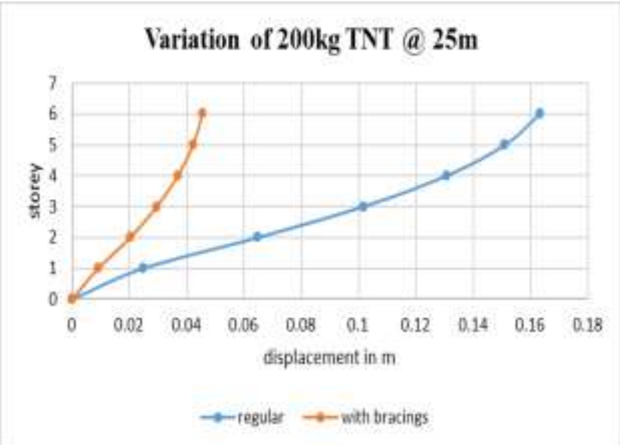

Fig 7: Storey displacement for 200 kg TNT at 25m

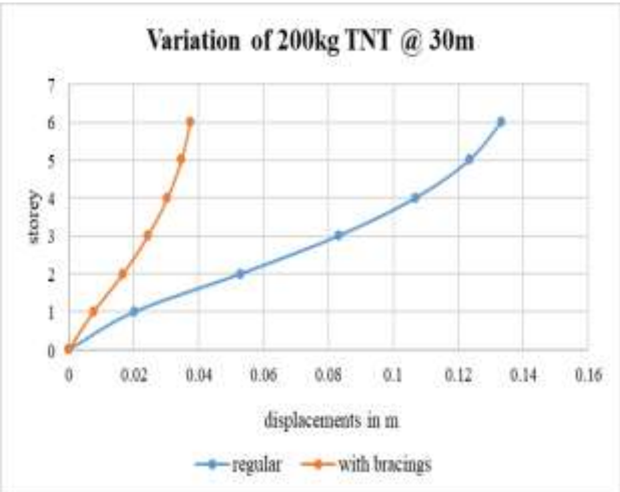

Fig 8: Storey displacement for 200kg TNT at 30m

Figure 5, 6, 7, and 8 shows the storey displacement for 100kg and 200kg TNT is placed at 25m and 30m stand with and without bracing.

STOREY DRIFT

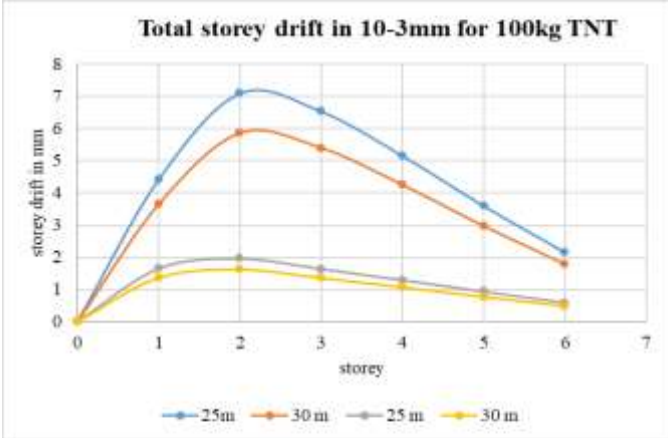

Fig 9: Storey drift for 100 kg TNT at 25m

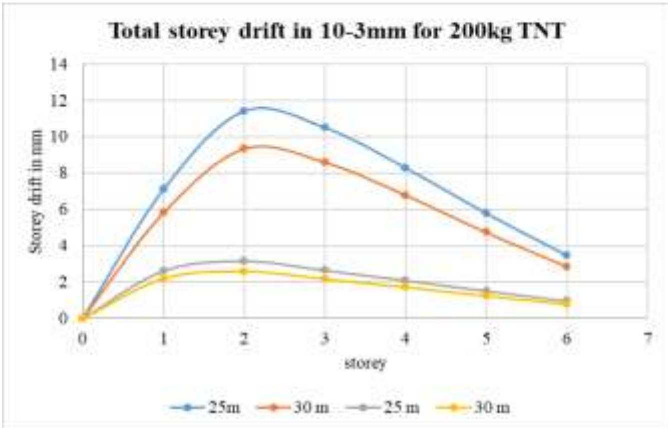

Fig10: Storey drift for 200kg TNT at 30m

Figure 9 and 10 shows the storey drift for 100kg and 200kg TNT is placed at 25m and 30m stand with and without bracing.

5. CONCLUSIONS

1. As the blast load increases with decrease in standoff distance. Blast load also increases based on capacity of explosive material.

2. The increase in blast load leads to increases displacement and inter storey drift Therefore, blast parameters mainly depends upon the charge weight and standoff distances. Providing the huge cross section of column and beam will resist the blast load up to certain limit, but practically it is not possible, Because of serviceability problems.

3. The steel bracing addition give the best result almost the maximum storey displacement and inter storey drift is reduced up to 80% but steel bracing is cost effective therefore it is un economical compared to other resisting methods.

REFERENCES

[1] Jiji Madonna Mrs. Vijay G S, Er. Kirankumar K L "Analysis of High Rise RCC Building Subjected To Blast Load". International research journal of engineering and Technology.ISSN:2395-0072, Volume 3(8), August 2016.

[2] Neeti Mishra, Ashish Mishra, and Rajesh kr. Pandey (2018). "Effect of Blast Loading on Framed Structure: A Review". International Research Journal of Engineering and Technology (IRJET). ISSN: 2395-0072.

[3] Alex M Remennikov and Timothy A.Rose. "Modelling blast loads on buildings in complexity geometries" Engineering system department Cranfield University, Royal military college of science, shrivenham, Swindon UK 2005.

[4] Zeynep Koccaz, Fatih Sutcu, Necdet Torunbalci. "Architectural and structural design for blast resistant buildings". The 14th World Conference on Earthquake Engineering October 2008. Beijing, china.

[5] Nelson lam, Priyan Mendis, Tuan Ngo. "Response spectrum solution for blast loading". Electronic Journal of Structural Engineering, 4 (2004). The University of Melbourne.