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Prediction of Blast Loading and Remedial Measures on Buildings

Mr. Vedprakash C. Marlapalle
Department of Civil Engineering, MGM's College of Engineering & Technology, Kamothe
Email: civilved@gmail.com , Phone no.- 8097531745
Prof. N. g. Gore
Department of Civil Engineering, MGM's College of Engineering & Technology, Kamothe
Email: nggore@yahoo.com , Phone no.- 9820977905

--ABSTRACT---

Events of the last ten years have greatly heightened the awareness of building owners and designers of the threat of terrorist attacks using explosives. Blast loads become important service loads for certain categories of structures. An important task in blast-resistant design is to make a realistic prediction of the blast pressures. The distance of explosion from the structure is an important datum, governing the magnitude and duration of the blast loads. The current practice is to choose some arbitrary distance for design purposes. This paper presents some results of analytical studies to show that such a notion is likely to be erroneous, particularly for tall and slender structures. The elements of the blast phenomenon are reviewed, before going into the formulations leading to the 'critical blast distance' at which the transient dynamic response rises to a maximum. It also contains Treatment provided to various part of a structure to improve blast resisting mechanism and Architectural aspect of blast resistant buildings design.

Keywords –:Anti-ram Bollards, Blast load, Explosion, stand-off distance,

1. INTRODUCTION

In the past few decades considerable emphasis has been given to problems of blast and earthquake. The earthquake problem is rather old, but most of the knowledge on this subject has been accumulated during the past fifty years. The blast problem is rather new; information about the development in this field is made available mostly through publication of the Army Corps of Engineers, Department of Defense, U.S. Air Force and other governmental office and public institutes. Much of the work is done by the Massachusetts Institute of Technology, The University of Illinois, and other leading educational institutions and engineering firms.

Due to different accidental or intentional events, the behavior of structural components subjected to blast loading has been the subject of considerable research effort in recent years. Conventional structures, particularly that above grade, normally are not designed to resist blast loads and because the magnitudes of design loads are significantly lower than those produced by most explosions, conventional structures are susceptible to damage from explosions. With this in mind, developers, architects and engineers increasingly are seeking solutions for potential blast situations, to protect building occupants and the structures.

Disasters such as the terrorist bombings of the U.S. embassies in Nairobi, Kenya and Dar es Salaam, Tanzania in 1998, the Khobar Towers military barracks in Dhahran, Saudi Arabia in 1996, the Murrah Federal Building in Oklahoma City in 1995, and the World Trade Center in New York in 1993 have demonstrated the need for a thorough examination of the behavior of columns subjected to blast loads. To provide adequate protection against explosions, the design and construction of public buildings are receiving renewed attention of structural engineers

As we all know, the greeter the stand- off distance, the more the blast forces will dissipate resulting in reduced pressure on the building. Several recommendations can be made to maintain and improve the stand- off distance for the building under consideration. Use of anti-ram bollards or large planters placed around the entire perimeter.

2. EXPLOSION AND BLAST PHENOMENON

In general, an explosion is the result of a very rapid release of large amounts of energy within a limited space. Explosions can be categorized on the basis of their nature as physical, nuclear and chemical events.

The discussion in this section is limited to air burst or surface burst. This information is then used to determine the dynamic loads on surface structures that are subjected to such blast pressures and to design them accordingly. It should be pointed out that surface structure cannot be protected from a direct hit by a nuclear bomb; it can

however, be designed to resist the blast pressures when it is located at some distance from the point of burst.
The destructive action of nuclear weapon is much more severe than that of a conventional weapon and is due to blast or shock. In a typical air burst at an altitude below 100,000 ft. an approximate distribution of energy would consist of 50% blast and shock, 35% thermal radiation,
10% residual nuclear radiation and 5% initial nuclear radiation.

3. EXPLOSIVE AIR BLAST LOADING

The threat for a conventional bomb is defined by two equally important elements, the bomb size, or charge weight *W*, and the standoff distance (*R)* between the blast source and the target For example, the blast occurred at the basement of World Trade Centre in 1993 has the charge weight of 816.5 kg TNT. The Oklahoma bomb in 1995 has a charge weight of 1814 kg at a stand- off of 5m. As terrorist attacks may range from the small letter bomb to the gigantic truck bomb as experienced in Oklahoma City, the mechanics of a conventional explosion and their effects on a target must be addressed.

Stand-off distance
Stand-off distance refers to the direct, unobstructed distance between a weapon and its target.

Height of burst (HOB)
Height of burst refers to aerial attacks. It is the direct distance between the exploding weapon in the air and the target.

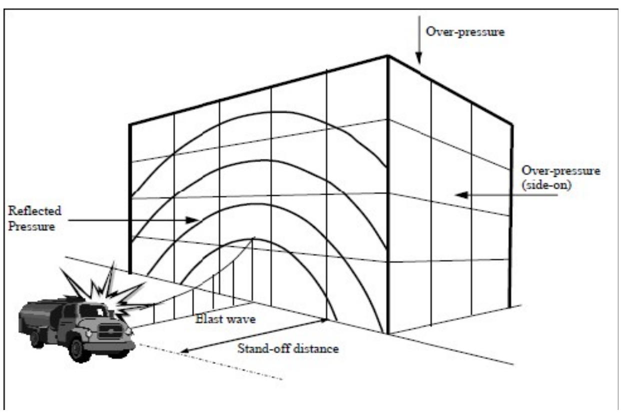

Figure 1: Blast Loads on a Building.

4. PREDICTION OF BLAST PRESSURE

Blast wave parameter for conventional high explosive materials have been the focus of a number of studies during the 1950's and 1960's.
The estimations of peak overpressure due to spherical blast based on scaled distance
$Z = (R/W)^{1/2}$
In 1961, Newmark and Hansen introduced a relationship to calculate the maximum blast pressure (Pso), in bars, for a high explosive charge detonates at the ground surface as:

$$Pso = 6784 \frac{W}{R^3} + 93 \left(\frac{W}{R^3}\right)^{1/2}$$

As the blast wave propagates through the atmosphere, the air behind the shock front is moving outward at lower velocity. The velocity of the air particles, and hence the wind pressure, depends on the peak overpressure of the blast wave.
Peak reflected overpressures *Pr* (in MPa) with different W-R combinations

R \ W	100 Kg TNT	500 Kg TNT	1000 Kg TNT	2000 Kg TNT
1m	165.8	354.5	464.5	602.9
2.5m	34.2	89.4	130.8	188.4
5 m	6.65	24.8	39.5	60.19
10 m	0.85	4.25	8.15	14.7
15 m	0.27	1.25	2.53	5.01
20 m	0.14	0.54	1.06	2.13
25 m	0.09	0.29	0.55	1.08

Duration *td* is related directly to the time taken for the overpressure to be dissipated.
Overpressure arising from wave reflection dissipates as the perturbation propagates to the edges of the obstacle at a velocity related to the speed of sound (*Us*) in the compressed and heated air behind the wave front. Denoting the maximum distance from an edge as *S* (for example, the lesser of the height or half the width of a conventional building), the additional pressure due to reflection is considered to reduce from *Pr – Pso* to zero in time 3*S*/*Us*. Conservatively, *Us* can be taken as the normal speed of sound, which is about 340 m/s, and the additional impulse to the structure evaluated on the assumption of a linear decay.

5. DYNAMIC PROPERTIES OF CONCRETE UNDER HIGH-STRAIN RATES

The mechanical properties of concrete under dynamic loading conditions can be quite different from that under static loading. While the dynamic stiffness does not vary a great deal from the static stiffness, the stresses that are sustained for a certain period of time under dynamic conditions may gain values that are remarkably higher than the static compressive strength (Figure 3.9). Strength magnification factors as high as 4 in compression and up to 6 in tension for strain rates in the range: 10^2–10^3 /sec have been reported

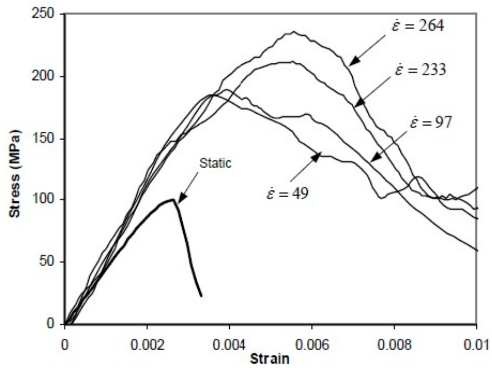

Figure 2: Stress-strain curves of concrete at different strain rates.

6. ACCEPTABLE DAMAGE LEVELS

Levels of damage computed by means of analysis may be described by the terms: minor, moderate or major depending on the peak ductility, support rotation and collateral effects. A brief description of each damage level is given below.

Minor: Non-structural failure of building elements as windows, doors, and cladding. Injuries may be expected, and fatalities are possible but unlikely.

Moderate*:* Structural damage is confined to a localized area and is usually repairable. Structural failure is limited to secondary structural members, such as beams, slabs and non-load bearing walls. However, if the building has been designed for loss of primary members, localized loss of columns may be accommodated without initiating progressive collapse. Injuries and possible fatalities are expected.

Major*:* Loss of primary structural components such as columns or transfer girders precipitates loss of additional adjacent members that are adjacent or above the lost member. In this case, extensive fatalities are expected. Building is usually not repairable.

Generally, moderate damage at the "Design Threat" level is a reasonable design goal for new construction. For buildings that need to remain operational post-event or are designated as high risk, minor damage may be the more appropriate damage level.

7. ARCHITECTURAL ASPECT OF BLAST RESISTANT BUILDING DESIGN

The primary way of safeguarding the structure from blast is it architectural planning. The layout of the structure should be such that all possible blasting effect can be minimized.

The entire entry route to the structure should be well barricaded and all entry vehicles should be thoroughly cheeked before allowing it in to the building compound. No vehicle should be allowed beyond exclusion zone. all roads leading to the building should have functional fire hydrants so that in the event of blast spread of fire can be controlled . Well ventilated emergency exit should be provided preferably at the near of the building for safe evacuation of the survivors. Active surveillance system and smoke detectors should be installed for monitoring the movement of the users.

8. CONCLUSION

1. The surfaces of the structure subjected to the direct blast pressures cannot be protected; it can, however, be designed to resist the blast pressures by increasing the stand-off distance from the point of burst.
2. For high-risks facilities such as public and commercial tall buildings, design considerations against extreme events (bomb blast, high velocity impact) are very important. It is recommended that guidelines on abnormal load cases and provisions on progressive collapse prevention should be included in the current Building Regulations and Design Standards. Requirements on ductility levels also help to improve the building performance under severe load conditions.
3. During the architectural design, the behavior under extreme compression loading of the structural form, structural elements e.g. walls, flooring and secondary structural elements like cladding and glazing should be considered carefully. In conventional design, all structural elements are designed to resist the structural loads. But it should be remembered that, blast loads are unpredictable, instantaneous and extreme. Therefore, it is obvious that a building will receive less damage with a selected safety level and a blast resistant architectural design. On the other hand, these kinds of buildings will less attract the terrorist attacks.

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