Effect of blast loading on Reinforced Concrete structures

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Abstract : The increase in numbers of terrorist attacks has shown that the effect of blast loads on building is serious matter and its effect on structure should be taken into consideration in design of that structure.

The objective of this study is to analyze the blasting effect on Reinforced Concrete structure and to shed light on blast resistant building design theories. This paper introduces different kinds of blast loading, their effects on reinforced concrete structures and the essential techniques for increasing the capacity of a building to provide protection against explosive effects.

Key words : Blast load classification, Design of blast resistant building, Effect of blast load, Structural response.

INTRODUCTION

The blast loading is a very rapid release of stored energy, imposes extreme loading on window glazing which produces high velocity airborne sharp glass fragments that causes large percent of all nonfatal injuries. The pressure due to blast entering the building can cause bodily harm to occupants and source of extensive property damage.

The blast design of structure has become important not only for federal and military buildings but also for other high risk buildings such as hospitals, banks, and international business buildings. The high explosion causes extensive damage to the structure and nearby buildings. If the structure is properly designed for this loading, the damaging effect can be controlled.

The structures designed to resist blast loads are subjected to completely different types of load than that considered in conventional design. The analysis and design of structures subjected to blast loads require a detailed understanding of the blasting effect and the dynamic response of various structural elements. Blast design has to take into consideration both impact loads from the initial wave front of the blast and additional time-dependant pressure, which can occur due to thermal effects behind the wave front. The reflected pressure must be taken into account as well as ventilation to relive built up pressure.

For analysis of blast loading first we must have good understanding of a structural characteristic of beams and its behavior under common loading conditions. The principal effect of blast due to conventional explosive on structures are the imposition of transient pressure pulse of high amplitude and relatively small duration compared to the fundamental period of the structure.

CLASSIFICATION OF BLAST LOADING

The blast loading is generally divided into two categories Air burst and surface blast. When an explosion occurs near and above the building structure such that no amplification of the initial shock wave occurs between the explosive charge and the structure, then the blast is called free air burst. The characteristics of air burst wave are affected by the physical properties of the explosion source. An explosion of high energy material such as trinitrotoluene (TNT), or mixtures of ammonium nitrate and fuel oil (ANFO) causes a very rapid release of energy that compresses and pushes surrounding air out and away from the detonation source to form a blast wave. At a certain distance from explosion centre, regardless of the source, all blast waves have almost the same shape.

The blast pressure variation with time has generally two phases, the phase with pressure above ambient called positive phase and the one with pressure below ambient is called as negative phase. In structural evaluation, blast wave parameters associated with positive phase, such as shock front velocity, peak overpressure and its duration, blast impulse; it means that the area under the pressure-time curve and dynamic pressure are of primarily importance. The dynamic pressure or blast wind is a function of the velocity of the air particles behind the shock front and is similar to conventional wind pressure.

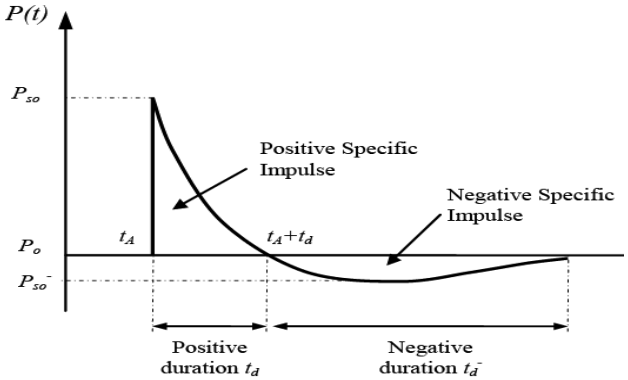

Figure1: Blast wave propagation with time

When a surface blast occurs very near to the ground surface the blast is considered as the surface blast. In surface blast unlike the air blast the wave combines to create the total effect which is the combination of reflected wave produced after the reflection from the ground and the initial wave which is hemispherical in shape.

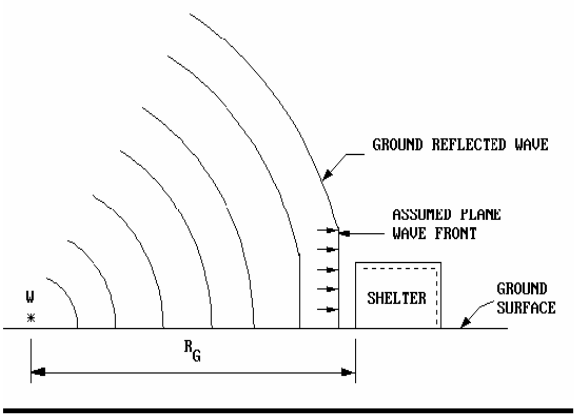

FIGURE 2: WAVE SHOWING SURFACE BLAST CONFIGURATION

STRUCTURAL RESPONSE TO BLAST LOADING

The structural response to blast loading is governed by many factors, including charge mass, standoff distance, structure size and orientation, proximity of the target to other structures or to significant land features. Due to the pulse nature of the blast pressure and its short duration the dynamic response of structure is mainly governed by the ratio of positive phase duration and natural period of vibration of the target.

It has been observed that when a blast wave impinges on a small size target, reflected pressure is created on its front face. The reflected pressure does not persist because the finite boundaries of the target allow a part of the blast wave to propagate around the edges. This phenomenon is referred to as blast wave clearing, which is typically associated with pressure drop. Due to the time it takes the reflected pressure to drop and a lack of adequate knowledge about the precise value of the reduced pressure, there is often uncertainty about the blast wave parameters in such cases. In assessment of the blast load on small size targets, the clearing effect need be considered.

GENERAL OVERVIEW OF BLAST LOADING

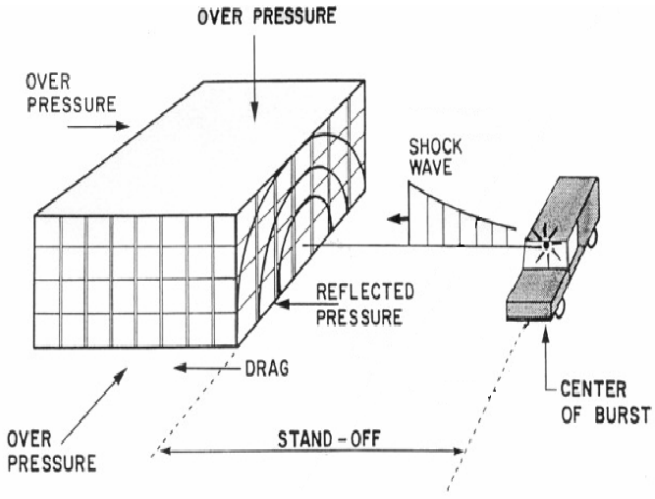

Figure 3: Overview of blast loading

For large scale distances, structural components can be designed to resist different kinds of blasting effects. If the exterior building walls are capable of resisting the blast load, the shock front penetrates through window and door openings, subjecting the floors, ceiling, walls, contents and people to sudden pressures and fragments from shattered windows, doors, etc.

Close to the source of explosion the blast wave is formed and violently hot and expanding gases will exerts intense loads which are difficult to calculate accurately. Once the blast wave has formed and propagating away from the source, it is convenient to separate out different types of loading experienced by the surrounding objects. Three effects has been identified in three categories. The effect of rapidly compressing the surrounding air is called 'air shock wave'. The air pressure and air movement effect due accumulation of gases from the explosive chemical reaction is called 'dynamic pressure' and the effect rapidly compressing the ground is called ground shock wave.

When the initial blast wave has passed the reflected surface of the building the peak overpressure decays to zero. As the sides and top faces of the buildings are exposed to overpressures a relieving effect of blast overpressure is experienced on the front face. The rear of the structures experiences no pressure until the blast wave.

DESIGN OF BLAST RESISTANT CONCRETE STRUCTURE

Blast design is the design of structures to withstand loading due to explosions. This includes the protection of the structural integrity of the building as well as the protection of people and equipments inside the building. To design the structure capable of resisting blast loads, members and joints are permitted to deflect and strain much greater than is allowed for usual static loads. This permitted deflection is ordinarily, well into the plastic range of materials. Large energy is absorbed during this action, thus reducing the required designed strength considerably below that required by conventional design within elastic range. Moreover under the higher rates of loading the strength developed by the material, increases with the rates of loading, may often be adequately described as a function of time within a certain range.

Whereas if location of the ground zero, and the size of bomb are known, the corresponding blast loading for existing structure may be found by methods explained in IS:4991-1968. However it will never be possible to have extra data for specifying the expected ground zero and bomb size.

Due to the impulsive nature of most blast events, the design of structural components must account for the structural dynamics of the response. The standard design approach of having the capacity of the member is greater than the demand becomes much more complex dynamic evaluation. Under dynamic loading the strength of the system can be considered a combination of components resistance and the inertial force generated as mass of the component is accelerated. This analysis can be conducted using complex finite-element analysis; however, simplified methods provide adequate accuracy at modeling the response.

The predominant method used in blast design is a single degree of freedom (SDOF) approach. Using SDOF methods, the structural components response is simplified to that of an

equivalent mass-spring system, in which the equivalent mass is related to the distribution of mass of component and the spring characteristics are related to the resistance of the component.

CONCLUSION

The aim of blast resistant building design is to prevent the overall collapse of the building and fatal damages. In design process it is vital to determine the potential danger and the extent of this danger. Most importantly human safety should be provided. This study is motivated from making buildings in a blast resistant way and to put the necessary regulations into practice for preventing human and structural loss due to blast loads. 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 the building will receive less damage with selected safety level. On other hand these kinds of buildings will less attract the terrorist attacks.

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