Performance and assessment of shear wall under blast load

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***Abstract* - This paper describes the process of determining the blast load on structures and provides a numerical example of a fictive structure exposed to this load. The aim was to become familiar with the issue of blast load because of ever growing terrorist threat and the lack of guidelines from national and European regulations on the verification of structures exposed to explosions.**

***keywords* - Shear wall, Blast load, Boundary element, Displacement**

I. INTRODUCTION

It is impractical to design a civilian structure to remain undamaged from a large explosion. To save lives, the primary goals of the design professional are to reduce building damage and to prevent progressive collapse of the building, at least until it can be fully evacuated. A secondary goal is to maintain emergency functions until evacuation is complete. Preventing the building from collapsing is the most important objective. Historically, the majority of fatalities that occur in terrorist attacks directed against buildings are due to building collapse. Collapse prevention begins with awareness by architects and engineers that structural integrity against collapse is important enough to be routinely considered in design.

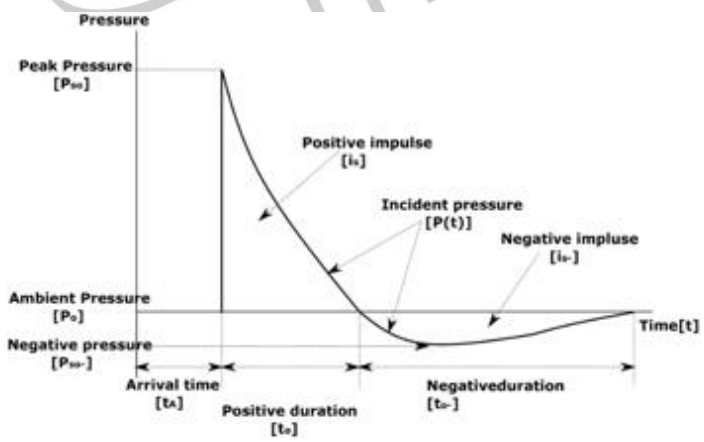
II. EXPLOSION AND BLAST PHENOMENON

An Explosion is defined as a large-scale rapid and sudden release of energy. The explosion is a phenomenon of rapid and abrupt release of energy. An explosion in air generates a pressure bulb, which grows in size at supersonic velocity. The resulting blast wave releases energy over a small duration and in a small volume, thus generating a pressure wave of finite amplitude, travelling radially in all directions. Explosive is widely used for demolition purposes in construction or development works.

III. BLAST WAVE PRESSURE TIME HISTORY

The pressure-time profile, two main phases can be observed portion above ambient is called positive phase of duration while that below ambient is called negative phase of duration. The negative phase is of a longer duration and a lower intensity than the positive duration. During the negative phase, the weakened structure may be subjected to impact by debris that may cause additional damage.

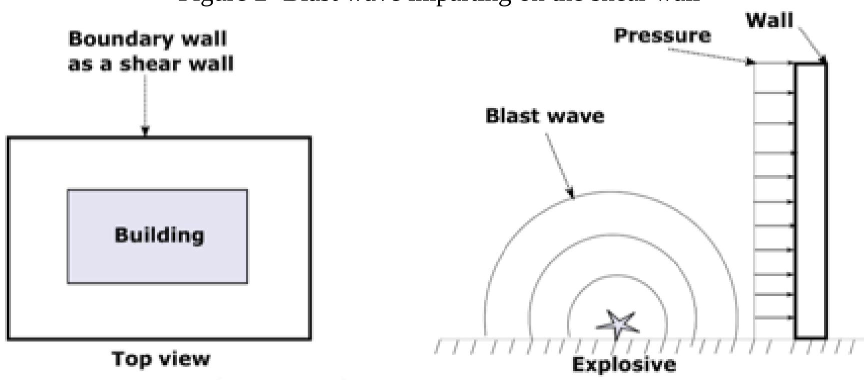
Figure 1- Reflected and Incident pressure time histories



IV. SAP 2000 SOFTWARE

SAP 2000 implements the plastic hinge properties described in FEMA-356. The shear wall is modelled in SAP 2000 considering column as a frame element and wall as a shell element which is shown in Figure Nonlinear material property is included in the model by using Mander model for concrete and simple model of steel (kinematic hysteresis type). Assuming that the blast will occur at a distance of 15 m from the boundary wall and the blast will happen due to small truck carrying a charge weight of 550 kg TNT.

Figure 2- Blast wave imparting on the shear wall



V. LITERATURE REVIEW

(TM, 5-1300) This manual is titled "Structures to resist the effects of accidental explosions" which provide guidance to designers, the step to step analysis and design procedure, including the information on such items (i) Blast, fragment and shock loading. (ii) Explosions, type of explosive. (iii) Principle of dynamic analysis. (iv) Reinforced Concrete design. (v) Structural steel design. (vi) Number of special design consideration.

Dharaneepathy, Rao, and Santhakumar (1995) This paper contains effects of the stand off distance on tall buildings of different heights. His overall study is to know the effect of distance of detonation point on the blast response. Some assumption is followed for predicting the blast pressure for the design of blast resistant building. The explosion distance from the structure is the main issue, for calculating the magnitude and duration of the blast loads. His research has resulted in the detection of a critical ground-zero distance at which the cumulative blast effect reaches the maximum. He said that there is a distance known as 'critical ground-zero distance' at which the blast response is maximum. The critical distance is used as design distance, instead of any other arbitrary distance.

Pandey, Kumar, Paul, and Trikha (2006) This paper shows the research on nuclear containment structure. Their main aim of the research is to study the effect of external blast on the outer reinforced concrete shell of nuclear containment structure. The analysis was carried out by using the nonlinear material property. According to them, the percentage crack is sufficiently high for heavy weight TNT as compare to low weight TNT for the same distance of explosions. Under the blast loading, most of the cracks are distributed throughout the structure. The location of the peak tensile stress in reinforcement is at the base of the front face of the shell and the peak compressive stress is at the rear face of the shell. The location of peak deflection is at the top of the shell.

Ngo et al. (2007) This paper gives an overview of the explosives and its effects on the structure. Mechanism of the blast wave and nature of explosions is given. He also introduces different methods for finding out blast loads and its calculation and the response of the structure. A comprehensive overview on the analysis and design of the structures subjected to blast loads require a detailed understanding of blast phenomena. He gives the idea that for highly populated buildings, design consideration against extreme events like bomb blast is very important and the design of the building under blast load should be included in the building regulations and design standards.

Moon (2009) has studied the methods for calculating the blast loads on the structures with or without openings and frame structures. Also to know the dynamic response of column, beam, slab in RCC and steel structures. He finds out that the column subjected to non-uniform blast load is affected by higher vibration modes. The surface directly subjected to blast load is design as a blast resistant with certain assumptions. The comparison between higher strength column and normal strength column under blast load is carried out.

Karlos and Solomos presented their report in which calculation of the external explosion loads to be considered in the blast protection design of the structure. Empirical formula for the prediction of the blast loads have been chosen as this is the easiest way for the engineers to calculate blast load. Thus, several formulas and graphs is included in this report for the understanding point of view. Case studies is there to understand more efficiently the problem and calculation of blast load.

Mirgal, Tikate, Suryawanshi, and Tande have studied the effect of blast loading on a structure from architectural point of view. Structural form is a parameter that affects the blast loads on the building. Arches and domes are the types of structural forms that reduce the blast effects on the buildings. Single story buildings are more blast resistant compared with multi-story buildings. Internal layout of the building is another parameter from architectural point of view for blast resistant building. Lobby area should be protected with reinforced concrete walls; double doors should be used and the doors should be arranged eccentrically within a corridor to prevent the blast pressure entering the internals of the building.

Hamra proposed an easy way to examine the type of damage introduced into the building when one compartment is subjected to blast. Firstly whole frame is not studied and individual component of structure like beam, column is studied separately. The materials are assumed elastic - perfectly plastic. For the blast loading, the blast pressure is uniformly distributed along each structural member. For the analysis of simple frame blast loading, two scenarios were involved in the studies. The first corresponds to quasi-static blast loading while the others refers to a dynamic blast loading. The effects of strain rate on the yield strength and the ductility capacity of the structural elements were neglected.

Marchand and Alfawakhiri (2004) reviews facts for steel buildings and it gives a comprehensive overview of the blast effects with certain case studies of the buildings, which were damaged due to blast loading. He has done case study in Murrah Building, Oklahoma City; in Dhahran, Saudi Arabia and others. Also shows the behavior of ductile steel column and dynamic response of a steel structure subjected to the blast loading. His research includes certain recommendations for steel splice configurations under blast load, recommendations for connections subjected to blast load, recommendations for baseplate configuration and design to resist direct shear failure at column bases.

Luccioni, Ambrosini, and Danesi for their study on "Analysis of building collapse under blast loads" presented the analysis of the structural failure of a reinforced concrete building caused by blast load. All the process from the detonation of the explosive charge to the complete demolition, including the propagation of the blast wave and its interaction with the structure is reproduced. The comparison of numerical results with photographs shows that the numerical analysis accurately reproduces the collapse of the building under blast load confirming the location and the magnitude of the explosion previously established based on the analysis. The collapse was due to gravitational mechanism originated by the destruction of the lower column.

VI. Summary

Considerable research is going on blast, type of explosion, how to calculate blast load on various structure, design of blast resistant building. To make blast resistant building or elements of structure few researchers have given different approach.

VII. Conclusion

Design of shear wall is completed by using IS:13920-2016 and IS:456-2000. With the same description shear wall is designed according to UFC (3-340-02). The aim of the analysis of the shear wall is to check demand ductility and compare it with available ones. The result of stress distribution of shear wall confirms that as the distance of detonation point from the structure increases, pressure decreases. Also added that during the blast if the weight of explosive increases, displacement of shear wall also increases.

VIII. Aknowldgement

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