Analysis of Structural Beam under Blast Load

by

Brian Cabello

Project Proposal

MASTER OF MECHANICAL ENGINEERING
ABSTRACT

A bomb explosion within or immediately nearby a building can cause catastrophic damage on the building’s external and internal structural frames, collapsing of walls and blowing out of large expanses of windows. Loss of life and injuries to occupants can result from many causes, including direct blast-effects, structural collapse, debris impact, fire and smoke. Due to the threat from such extreme loading conditions, efforts have been made during the past three decades to develop methods of structural analysis and design to resist blast loads. The analysis and design of structures subjected to blast loads require a detailed understanding of blast phenomena and the dynamic response of various structure elements.

INTRODUCTION/BACKGROUND

An explosion is a rapid release of stored energy characterized by a bright flash and an audible blast. Part of the energy is released as thermal radiation (flash); and part is coupled into the air as airblast and into the soil (ground) as ground shock, both as radially expanding shock waves. The rapid expansion of hot gases resulting from the detonation of an explosive charge gives rise to a compression wave called a shock wave, which propagates through the air. The blast wave instantaneously increases to a value of pressure above the ambient atmospheric pressure. This is referred to as the positive phase that decays as the shock wave expands outward from the explosion source. After a short time, the pressure behind the front may drop below the ambient pressure (Figure 1.0). During such a negative phase, a partial vacuum is created and air is sucked in. This is also accompanied by high suction winds that carry the debris for long distances away from the explosion source.

![Figure 1.0 Blast wave propagation](image.png)
As the shock wave travels outward from the charge, the pressure in the front of the wave, called the peak pressure, steadily decreases. At great distances from the charge, the peak pressure is infinitesimal, and the wave can be treated as a sound wave.

**PROBLEM DESCRIPTION**

This project will focus on the analysis of how a blast loading (shock wave) affects a structure beam of two types of strengths. The project will evaluate the performance of high strength concrete (HSC) columns with concrete strength of 10 Ksi and compared with similar specimens made of normal strength concrete, (NSC) column with a concrete strength of 4.5 Ksi. Each specimen will consist of a 12 x 12 x 56 inch column and 20 x 30 x 32 inch stub which represent a footing.

**METHODOLOGY/APPROACH**

Computational methods in the area of blast-effects mitigation are generally divided into those used for prediction of blast loads on the structure and those for calculation of structural response to the loads. Computational programs for blast prediction and structural response use both first-principle and semi-empirical methods. Programs using the first principle method can be categorized into uncouple and couple analyses. The uncouple analysis calculates blast loads as if the structure were rigid and then applying these loads to a responding model of the structure. The shortcoming of this procedure is that when the blast field is obtained with a rigid model of the structure, the loads on the structure are often over-predicted, particularly if significant motion or failure of the structure occurs during the loading period. For a coupled analysis, the blast module is linked with the structural response module. In this type of analysis the computational fluid mechanics (CFD) model for blast-load prediction is solved simultaneously with the computational solid mechanics (CSM) model for structural response. To account for the motion of the structure while the blast calculation proceeds, the pressures that arise due to motion and failure of the structure can be predicted more accurately by using AUTODYN, DYNA3D AND LS-DYNA.

**RESOURCE REQUIRED**

The resource I need to complete this project is LS-DYNA. This software provides a large material library of various metals, concrete and explosives. Almost all of these predefined materials contain the shock equation of state, which is needed for the analyses. Single degree of freedom (SDOF) models have been widely used for predicting dynamic response of concrete
structures to blast loading. The popularity of the SODF method in blast-resistant design lies in its simplicity and cost-effective approach that requires limited input data and less computational effort. SDOF model gives reasonable good results if the response mode shape is representative of the real behavior.

**EXPECTED OUTCOME**

By simulating a blast loading on a structural beam having different concrete strengths I would generate two possible outcomes. The model will generate the lateral resistance and the lateral deflection of the beams. With these findings I will identified which beam has a better energy absorption capacity.

**MILESTONES/DEADLINE**

02/01/11: Submit Project Proposal Draft  
02/08/11: Complete Research (Beam Specification and Blast Loading)  
02/18/11: Learn/Start creating model using ANSYS AUTODYN  
02/22/11: Submit First Progress Report  
03/09/11: Complete Model Results  
03/15/11: Submit Second Progress Report  
03/22/11: Verification of results and Start Final Draft  
03/29/11: Submit Final Draft  
04/12/11: Submit Final Report

**REFERENCES**

In Progress