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Behaviour of Reinforced Concrete Beams under Different Kinds of Blast Loading

Aditya Kumar Singh[1], Md. Asif Akbari[1] and P. Saha[2]

[1]Students, School of Civil Engineering, KIIT University, Bhubaneswar, Odisha, India.
[2]School of Civil Engineering. KIIT University, Bhubaneswar, Odisha, India.

Abstract

As we know that in today's world terrorists' attacks are common and not a single country is completely safe. High-explosive detonations propagate blast energy in all directions, causing extensive damage to both the target structure and nearby buildings. Structural damage and the glass exposure have been major contributors to death and injury for the targeted buildings. If the structures are properly designed for these abnormal loads damage can be controlled. Within the Indian Standard Codes these types of situations are not dealt with and they need further explanation as the engineers have no guidelines on how to design or evaluate structures for the blast phenomenon for which a detailed understanding of structural behavior as well as effects of different kinds of blast load is required. In this paper, an attempt has been made to review various loading which can occur during a blasti.e, the dynamic impact loading, varying rate concentrated loading &transverse blast loading and the methods applied to analyze those loading phenomenai.e Single Degree of Freedom (SDOF) model, Finite Element Model (FEM) & non-linear dynamic analysis. Based on the results obtained by different methodsa comparison has been made and the suitability is discussed.

Keywords: Blast loading, reinforced concrete, blast wave, SDOF

1. Introduction

A blast loading is a very rapid release of stored energy characterized by an audible blast. It imposes extreme loading on window glazing which produces high velocity airborne sharp glass fragments that causes large percent of all nonfatal injuries from the bomb and major part of the energy is transmitted as a shock wave through the surrounding air at a supersonic velocity **[1]**. Thepressure due to blast entering the building can cause bodily harm to occupants and source of extensive property damage. The propagation of blast energy in all directionscause extensive damage to both the objectstructure and nearby buildings. The design and construction of buildings which resist these kinds of explosions started during World War II in response to air attacks, continued through the cold war and more recently this concern has grown with the increase of terrorism worldwide **[2]**. Today the modern explosive devices are being used in majority of terrorist attacks because of the ease of access of information on the constructionof bomb devices, relative ease of manufacturing, mobilityand portability, coupled with significant property damage andinjuries. No one can deny the strength ofthese attacks after 09/11 World Trade Centre bombing. The terrorist activity has increased and the present tendency suggests that it will be even larger in the future. The fact is that many of the government buildings, civilian buildings, embassy buildings and bridgesare at risk to terrorist attacks.That’s why the issue of protecting infrastructure against multiple extreme events is gaining importance in civil engineering. Research into methods for protecting buildings against such bomb attacks is required.

1.1 Analysis of structure

For the understanding of blast loading first we must have good understanding of the structural characteristics of beams and its behavior under common loading condition.

The beam consists of reinforcement and concrete which has their specific characteristics under loading. In general reinforcement shows the behavior which is shown in figure 1 under stress, but the solution using such curve involves complex equation, answer to those are cumbersome in nature. Hence for simplicity we use an ideal curve which is shown in figure 2 and it is quite easier to solve. And the tensile strength of concrete is neglected.

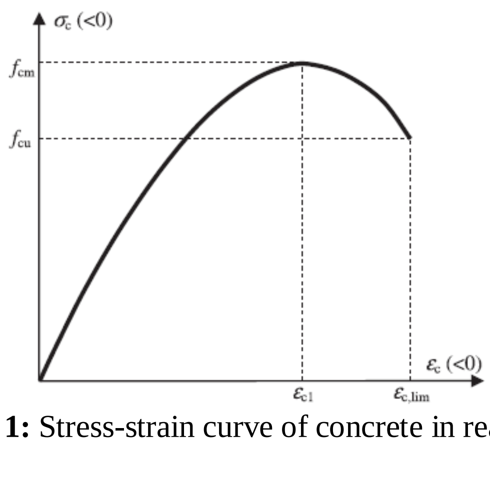

Figure 1: Stress-strain curve of concrete in reality.

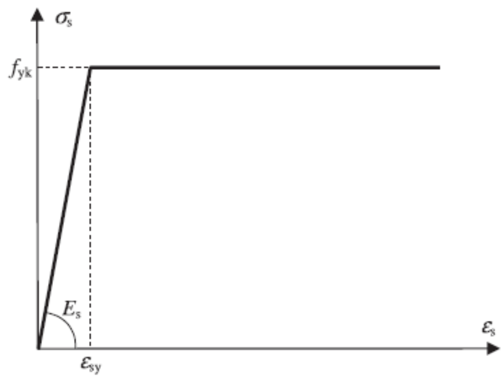

Figure 2: Stress-strain curve of mild steel adopted for simplicity.

At the same time the reinforcement bar shows the different type of curve when stress is applied and the uniaxial behavior of reinforcing steel – both in tension and in compression – is approximated by an elastic – perfectly plastic diagram as shown in figure 3.Let's take a doubly reinforced beam as shown in figure 3,

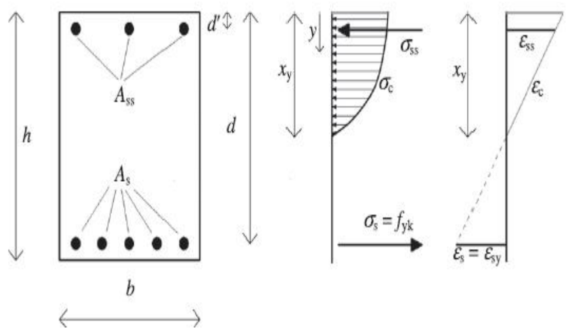

Figure 3: Sketch of cross section of doubly reinforced beam with its stress and strain diagram.

The analysis of concrete beam is based of the Euler–Bernoulli's theory, according to which the plane section normal to the axis of bending remain plane after bending. The maximum strain in concrete at the outermost edge is taken as .0035 in bending and the relationship between the compressive stress distribution and the strain in concrete is assumed as per the sets of result e.g. rectangular, parabola **[3]**.Andit is assumed that as soon as the stress in the tensile reinforcement σs equals the yield strength fyk, the yield state of the beam is reached.

2. Analysis of Blast Loading

The following steps are commonly followed in this practice: the determination of the threat, development of the design loadings for the determined threat, analysis of the behavior and selection of structural systems, the design of structural components, and the retrofitting of existing structures **[4]**. The blast loading is commonly divided into two categories namely air burst and surface burst.

2. 1 Air Brust

When an explosion occurs nearby to and above a 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 blast.

Figure 4: Air brust near a building.

The observed characteristics of air blast waves are found to be affected by the physical properties of the explosion source.

At the arrival time *tA*, following the explosion, pressure at that position suddenly increases to a peak value of overpressure, *Pso*, over the ambient pressure, *Po*. The pressure then decays to ambient level at time *td*, then decays further to an under pressure *Pso-* (creating a partial vacumn) before eventually returning to ambient conditions at time *td* + *td-*. The quantity *Pso*is usually referred to as the peak side-on overpressure, incident peak overpressure or merely peak overpressure **[5].**

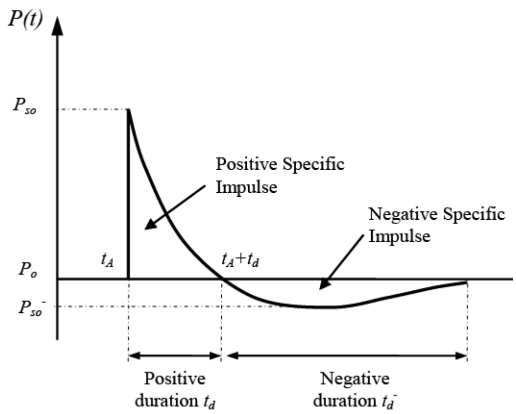

Figure 5: Blast wave propagation with time..

2 2 Surface blast

The the blast occurs very near to the ground surface the blast is considered the surface blast. In surface blast unlike the air blast the wave combines to create the total effect of the which is the combination of reflected wave produced after the reflection from the ground and the initial wave which is hemispherical in shape[6].

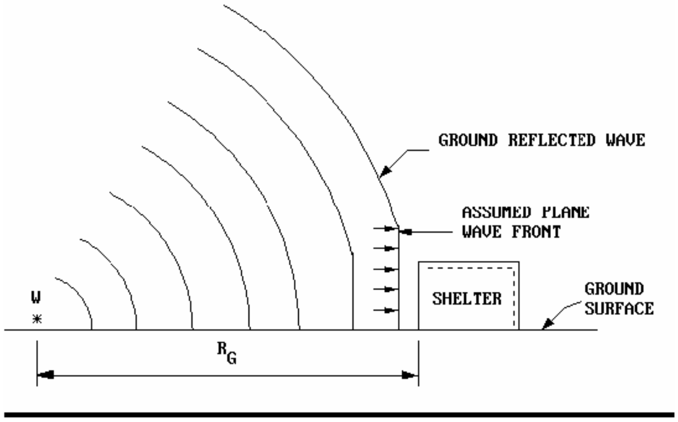

Figure 6: Showing surface blast configuaration.

After categorizing the different blast system the following methods are adopted for the analysis of blast loading.

The category of blast (eg. surface, air); (b) the period of response of the structure (c) The positive phase duration of the blast.

3. Different Models

3.1 Single digree of freedom model

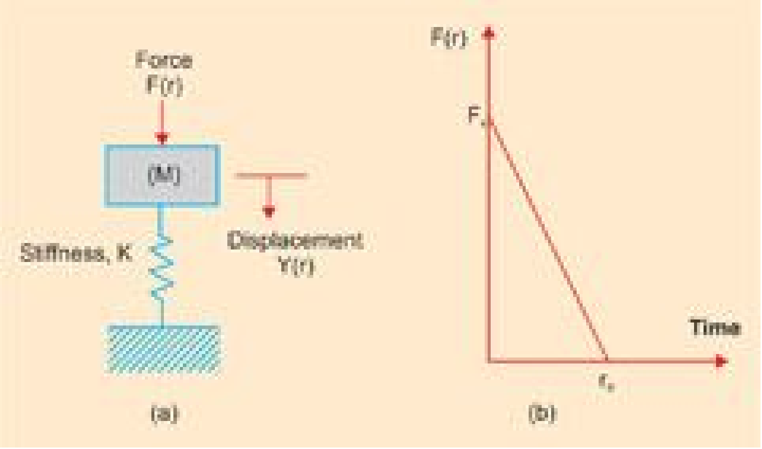

Figure 5: (a) SDOF system (b) Blast loading.

The above mentioned system is called the SDOF (Single Degree of Freedom) system It is the simplest vibratory system that can be described by a single mass connected to a spring (and possibly a dashpot). The mass is allowed to travel only along the spring elongation direction. The schematic diagram of SDOFis shown in the following figure,

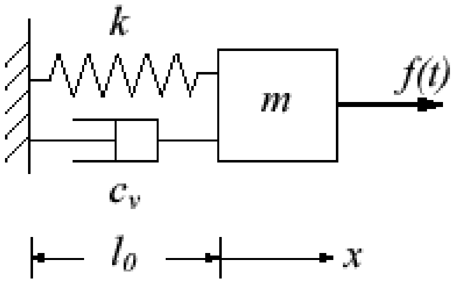

Figure 7: SDOF model.

This model is generally used of analysing blast loading.

3.2 Finite element model

This model is based on multi degree of freedom (MDOF) , in this model beam is devided into finite number of elements and those elements are further subdivided into fibre, this helps to take account into the variation along the depth of specimen. This modeling is generally done by ABAQUS.

3.3 Non-linear dynamic analysis model:

In this method the ends of the sample are restrained against translation and rotation which is assumed as a semi rigid joint in a frame. The rapid dynamic loading is applied to the sample and the displacements and the ratedependent effect of effect of steel material is observed.

4. Conclusion

As we have seen above the brief review of various blast loading phenomenon we can analyse that the lack of relevant code is the major concern behind the ignorance of this phenomena while designing the structure. In our review work we have found that the various kind of loading phenomena the non- linear analysis of beam column agrees satisfactorily with the finite element model as analyzed on ABAQUS. The above discussed methods has the competence and can be used in structural analysis and design where the progressive collapse is important.

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