

# Consequence of Reinforced Concrete Beam Subjected To Blast Load

Prasanna Prabhugouda Biradar<sup>1</sup>, Kiran K K<sup>2</sup>

PG student (M.Tech - CADs), Department of Civil Engineering, SJBIT, Karnataka, India<sup>1</sup>

Assistant Professor, Department of Civil Engineering, SJBIT, Karnataka, India<sup>2</sup>

**ABSTRACT:** With a rising threat of terrorism, protecting important structures like educational institute like (school, college, research centres), hospitals, defence buildings etc, against explosive blast has become a major concern. An attempt study is made on a beam subjected to blast load by using LS-DYNA software. LS-DYNA is 3D finite element software used for the analysis of structural member subjected to dynamic load in a very short period of time. This study is done on the behaviour of reinforced bars and concrete for particular explosive mass and time period by changing the location of explosive mass.

**KEYWORDS:** Terrorism, Structures, Explosive, Beam, Blast load, LS-DYNA, Analysis, reinforced bars, location.

## I. INTRODUCTION

In the serviceability of some structures there are potential threats from unexpected dynamic loads those generated from accidental gas explosion, vehicle accidents and terrorist bomb attacks. For these reasons more attentions have been made to the structure protection against blast loadings. Experimental and theoretical methods were the primary approaches for structural response of blast Load.

An explosion or blast may be defined as a large scale rapid release of energy in short period of time. This energy is in the form of high pressure shock waves and heat energy; these two can cause a severe damage to the structure and also to people's life.

Recent studies have been done on the analysis of structure or structural member subjected to blast load using various finite element software's like LS-DYNA, ABAQUS, AUTODYN, DYNA 3D numerical analysis also carried out in recent studies in order to predict the accuracy of analysis results, it is difficult to do experimental investigations on the structural member subjected to blast load because of high risk, cost and time requirement.

This paper focus on the behaviour of reinforced concrete beam subjected to blast load. The position of explosive mass is kept perpendicular to the rebars and parallel to rebars. Analysis is carried out for these two conditions and maximum responses are calculated.

## II. LITERATURE SURVEY

1. This paper presents a comprehensive overview of the effects of explosion on structures. An explanation of the nature of explosions and the mechanism of blast waves in free air is given. This paper also introduces different methods to estimate blast loads and structural response.( T. Ngo, P. Mendis, A. Gupta & J. Ramsay)
2. The finite element (FE) model is discussed in detail and verified through correlated experimental studies. An extensive parametric study was carried out on a series of 12 columns to investigate the effects of transverse reinforcement ratio, axial load ratio, longitudinal reinforcement ratio, and column aspect ratio. These various parameters were incorporated into a proposed formula, capable of estimating the residual axial capacity ratio based on the mid-height displacement to height ratios.( Xiaoli Bao, Bing Li)

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Vol. 6, Issue 6, June 2017

3. In this work they used LS-Dyna FEA software for calculation, with Lagrangian finite elements and explicit time integration. Reinforced concrete may be represented in a fairly accurate fashion with recent models such as CSCM model and segregated rebars constrained within the continuum mesh. The main objective of this work is to provide a strategy for modelling such scenarios based on structural elements, using available material models for structural elements and techniques to include the reinforcement in a realistic way. These models are calibrated against fully three dimensional models and shown to be accurate enough. At the same time they provide the basis for realistic simulation of impact and explosion on full-scale buildings.(Mario Bermejo and Anastasio Santos)
4. A two-step numerical approach, which substantially reduces the modeling and computational effort in analyzing structural responses to blast loads, was recently proposed. The method solves the responses of the equivalent SDOF system of a structural component during the blast loading phase to obtain the structural displacement and velocity at the end of the blast loading duration. Using these displacements and velocities as initial conditions, a detailed FE model is developed to solve the free-vibration response of the structure.( Jun Li, Hong Hao)
5. This paper presents the blast response, damage mechanism and evaluation of residual load capacity of a concrete–steel composite (CSC) column using dynamic computer simulation techniques. . The procedure and results presented herein can be used in the design and safety evaluation of key elements of multi-storey buildings for mitigating the impact of blast loads.( M. Bermejo, A. Santos, J.M. Goicolea)

### III. RESPONSE ANALYSIS

#### NUMERICAL MODEL

The modelling of beam and assigning of properties is done in LS- Prepost. In this work a fixed ended reinforced concrete beam is used the RC beam used for the modelling is of rectangular cross section having dimensions 320mm X 400mm with four numbers of 20mm diameter longitudinal bars and 10mm diameter stirrups are placed along the beam with 150mm spacing. A 50mm cover is provided for the bars, model details are shown in fig 1.

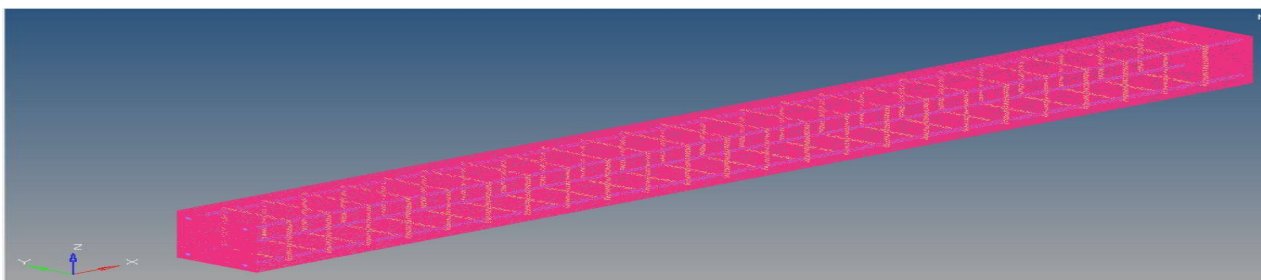


Fig 1. Beam Modelling

#### MATERIAL MODEL

In this study material model MAT CONCRETE DAMAGE REL3 is chosen to model the concrete material. The input parameters used for the concrete material are mass density, poisson's ratio, compressive strength are given in the table 1.

Table 1. Concrete material properties

LS-DYNA model	Input parameters	magnitude
MAT CONCRETE DAMAGE REL3	Mass density	2.5E-6kg/mm <sup>3</sup>
	Poisson's ratio	0.2

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Vol. 6, Issue 6, June 2017

Material model MAT PLASTIC KINEMATIC is chosen to model both longitudinal bars and stirrup steel. The material properties used for the modelling of steel, mass density, poisson's ratio, young's modulus is given in table 2.

Table 2. Steel material properties

LS-DYNA model	Input parameters	magnitude
MAT PLASTIC KINEMATIC	Mass density	7.85E-6kg/mm <sup>3</sup>
	Poison's ratio	0.3
	Young's modulus	210Gpa
	Yield stress	0.4Gpa

Material model MAT HIGH EXPLOSIVE BURN is chosen to model the explosive material. The material properties used for the explosive is given in table 3.

Table 3. Explosive material properties

LS-DYNA model	Input parameters	magnitude
MAT HIGH EXPLOSIVE BURN	Mass density	1630kg/mm <sup>3</sup>
	Detonation velocity	6930m/s

## IV. ANALYSIS RESULTS

### CASE-1 EXPLOSIVE MASS PERPENDICULAR TO REBARS

Analysis is done in LS-DYNA manager, the results are as follows:

In the below tables element number 1, 2 represents the steel material and 3,4 represents the concrete material, below tables showing the values of displacement, velocity and stress values.

Table 4. Displacement values

Sl. No	Element no	Displacement (mm)		
		X	Y	Z
1	209561	0	0	0
2	208170	0	0	0
3	185126	58.8	-2.95	0.87
4	179472	56.7	0.33	1.31

Table 5. Velocity values

Sl. no	Element no	Velocity (m/s)		
		X	Y	Z
1	209561	0	0	0
2	208170	0	0	0
3	185126	60.1E+03	-3.28E+03	1.52E+03
4	179472	58.3E+03	0.71E+03	-1.24E+03

Table 6. Stress values

Sl. no	Element no	Stress (N/mm <sup>2</sup> )		
		X	Y	Z
1	209561	0.001E+06	0.001E+06	0.001E+06
2	208170	0.001E+06	0.001E+06	0.001E+06
3	185126	-3.86E+06	-3.86E+06	-3.86E+06
4	179472	-3.88E+06	-3.88E+06	-3.88E+06

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Vol. 6, Issue 6, June 2017

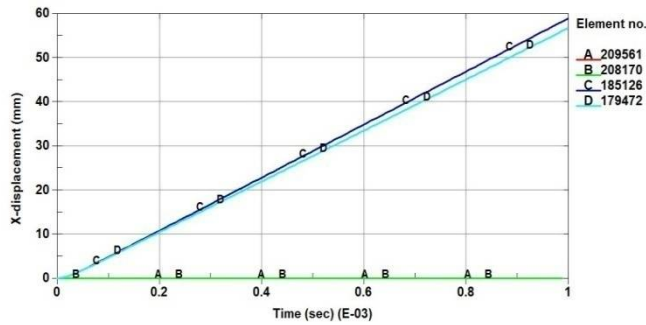


Fig 2.X displacement

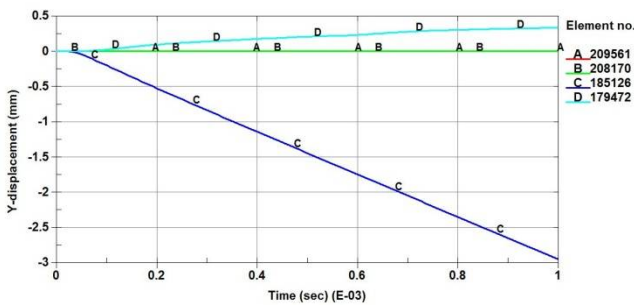


Fig 3.Y displacement

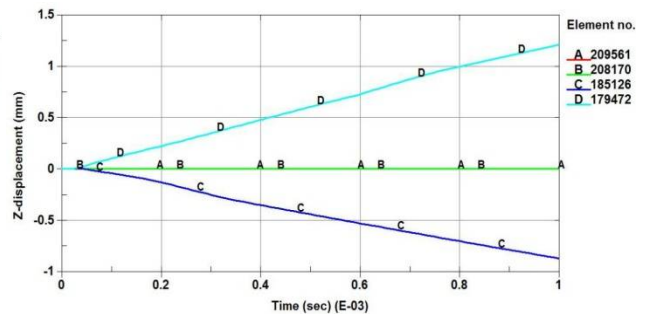


Fig 4. Z displacement

The above figures 2,3,4, showing displacement of steel and concrete in global X,Y,Z directions, element number A,B, represents the steel material and C,D, represents the concrete material, by seeing figures concrete will displace more and is maximum in global X direction.

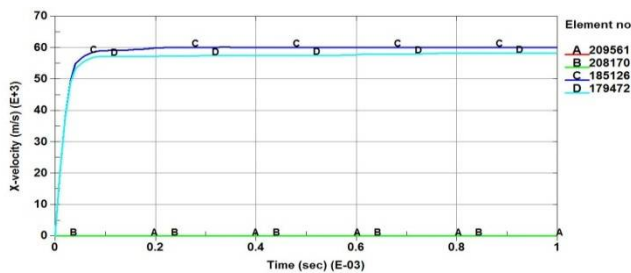


Fig 5. X velocity

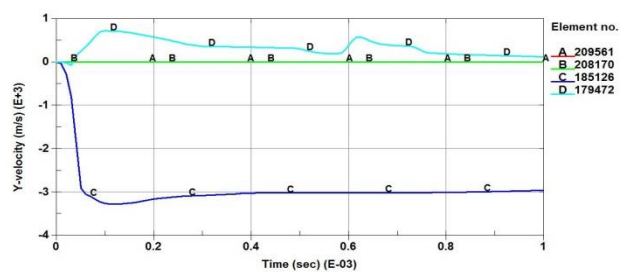


Fig 6. Y velocity

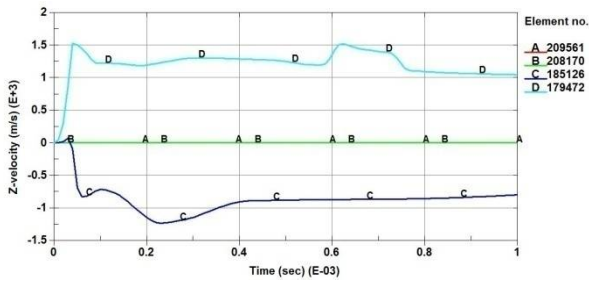


Fig 7. Z velocity

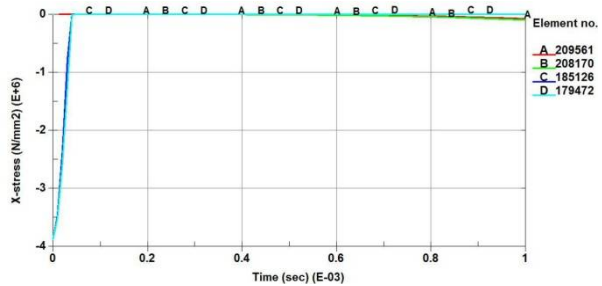


Fig 8. X stress

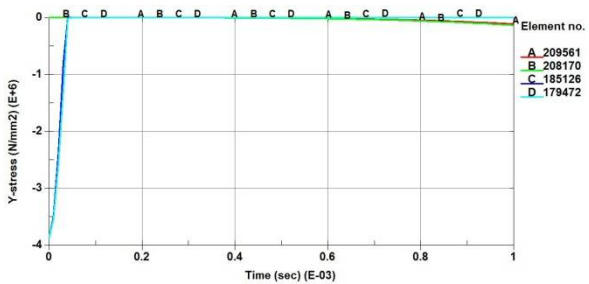


Fig 9. Y stress

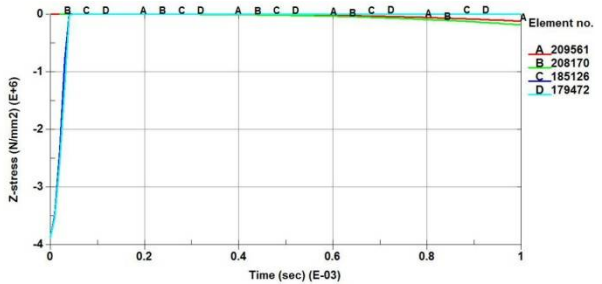


Fig 10. Z stress

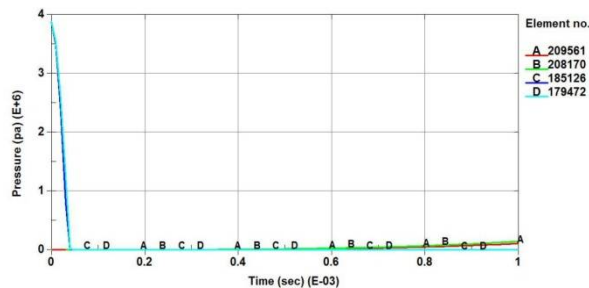


Fig 11. Pressure

The analysis results are shown in table 5,6,and 7, for the results we considered four elements, the serial number 1,2 represents the steel material element and 3,4 represents the concrete material element. From the above results we can see that for the applied explosive mass concrete will destructed more and a very less destruction in steel happens, from the above graphs we can see that concrete will displaced up to 58.8 mm, maximum velocity of 60m/s, and maximum stress of 3.88E+6N/mm<sup>2</sup> in the global X direction, And concrete took a pressure up to 4.0E+6 pa in a given detonation time period.

## CASE-2 EXPLOSIVE MASS PARALLEL TO REBARS:

Table 7. Displacement values

Sl. No	Element no	Displacement (mm)		
		X	Y	Z
1	206755	0	0	0
2	207184	0	0	0
3	181647	53.4	0.99	-0.59
4	179563	61.0	2.51	-2.18

Table 8. Velocity values

Sl. no	Element no	Velocity (m/s)		
		X	Y	Z
1	206755	0	0	0
2	207184	0	0	0
3	181647	55E+03	1.30E+03	-0.714E+03
4	179563	63.3E+03	2.33E+03	-3.5E+03

Table 9. Stress values

Sl. no	Element no	Stress (N/mm <sup>2</sup> )		
		X	Y	Z
1	209561	0.001E+06	0.001E+06	0.001E+06
2	208170	0.001E+06	0.001E+06	0.001E+06
3	185126	-3.86E+06	-3.86E+06	-3.86E+06
4	179472	-3.88E+06	-3.88E+06	-3.88E+06

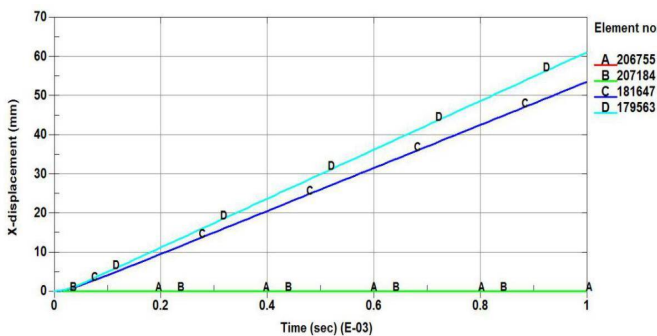


Fig 12. X displacement

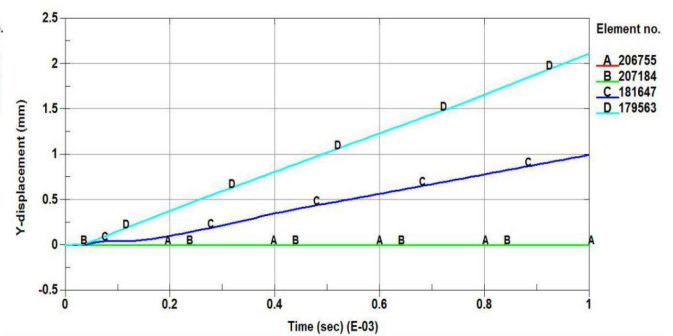


Fig 13. Y displacement

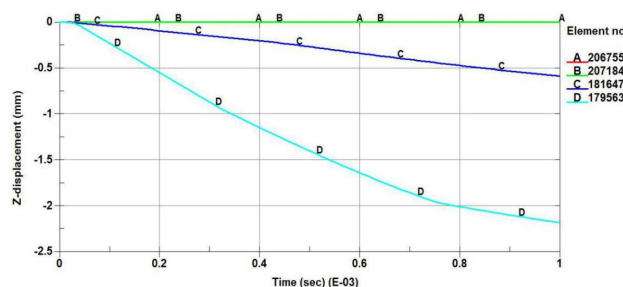


Fig 14. Z displacement

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Vol. 6, Issue 6, June 2017

The above figures 12,13,14, showing displacement values for case-2 in this case also concrete displaces more and is maximum in global X direction, figures 15-20 showing values of velocity and stress. Negative sign indicates the global oppositedirection.

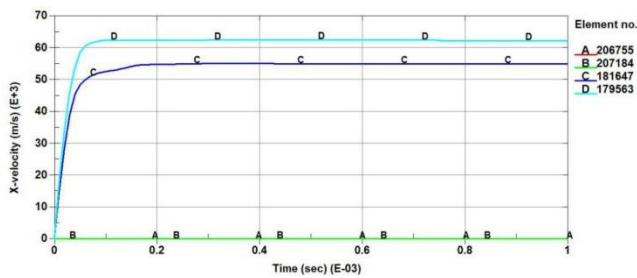


Fig 15. X velocity

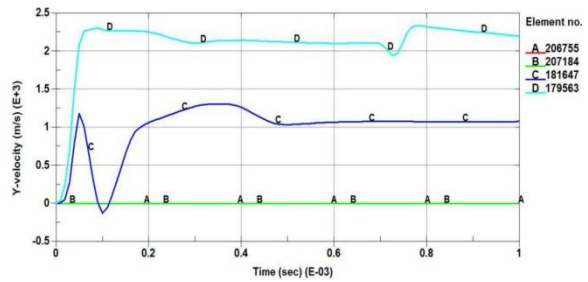


Fig 16. Y velocity

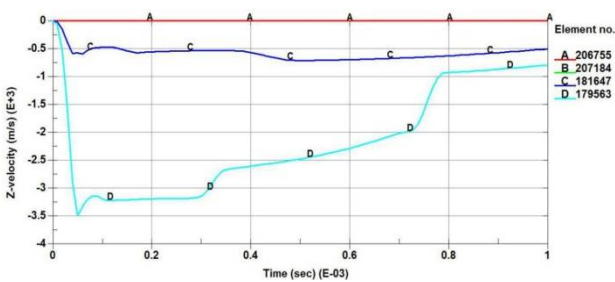


Fig 17. Z velocity

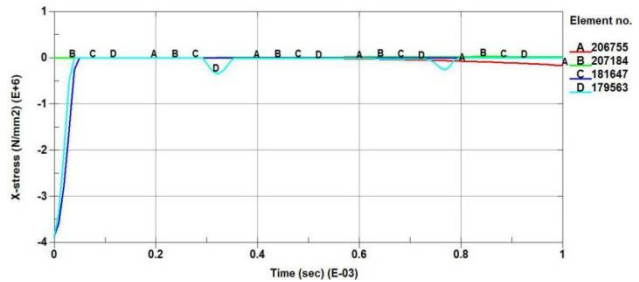


Fig 18. X stress

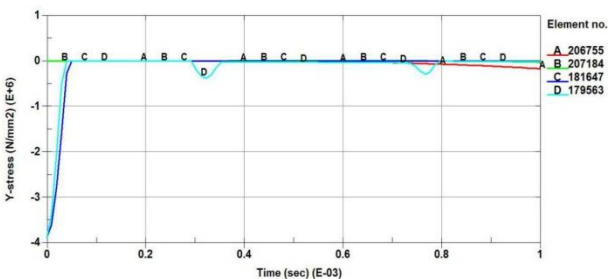


Fig 19. Y stress

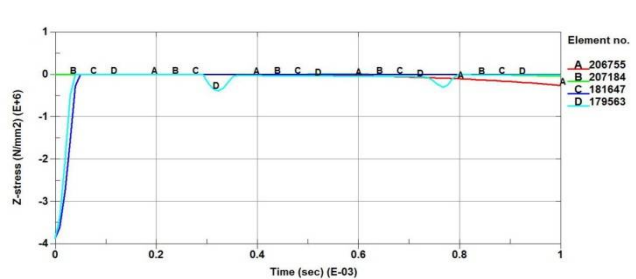


Fig 20. Z stress

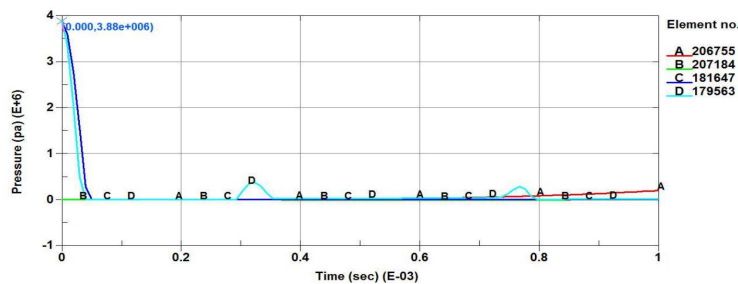


Fig 21. pressure

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Vol. 6, Issue 6, June 2017

In case 2 the blast load is applied parallel to the rebars of the beam, the results are shown in table 7, 8 and 9, and from figures 12 to 21. in this case also concrete will be destroyed more, maximum displacement 61mm, maximum velocity  $63.3E+3\text{m/s}$  in global X directions, and maximum stress of  $3.87E+06\text{N/mm}^2$  in all the directions, and maximum pressure  $3.88E+06\text{ pa}$ , in the given detonation time.

## V. CONCLUSIONS

The following are the conclusions made in the paper

- The beam model is modelled in Hyper mesh software and material properties are given in LS-Prepost software.
- The explosive mass subjected to the beam is carried out
- The response of the beam is calculated in terms of Displacement, Velocity, stress and pressure.
- The maximum response is calculated.

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