

# International Journal of Innovative Research in Science, Engineering and Technology

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## Behaviour of RCC Structure Subjected To Blasting

Shubham Pathak, Vishal Koli, Vishwambhar Khomane, Sakharam Shelke, Aditya Nalawade,

Prof. Randhir J. Phalke

B. E Students, Department of Civil, JSPM Narhe Technical Campus, Narhe Pune. Savitribai Phule Pune University,  
Pune, India

Assistant Professor, Department of Civil, JSPM Narhe Technical Campus, Narhe Pune. Savitribai Phule Pune  
University, Pune, India

**ABSTRACT:** In the past few years, structures subjected to blast load gained importance due to accidental events or natural events. Generally, conventional structures are not designed for blast load due to the reason that the magnitude of load caused by blast is huge, and the cost of design and construction is very high. The present study is concerned with analysis of blast load considering two variations of charge weights and standoff distance. In this study both regular and irregular buildings are analyzed. The blast parameters are calculated using ATBlast software. Results are compared using ETABS 2015. The parameters considered in this study are joint acceleration, storey shear, inter-storey drift and storey displacements.

**KEYWORDS:** Blast Phenomena, Standoff Distance, Charge Weight/TNT, Positive Phase, Inter-Storey Drift

### I. INTRODUCTION

#### 1. Introduction

Terrorist activities and threats is a growing problem nowadays around the world. Hence the concept blast protection is found to assume an imperative part with the structural engineers. Consideration of blast load along with other dynamic loads like earthquake and wind loads is playing a vital role in the design of structures these days due to increase of terrorist activities happening since few years especially in metropolitan cities. Terrorist attacks targets where human casualties and economic consequences are likely to be substantial. Structural buildings are considered to be attracting targets because of its potential impacts and accessibility on economic activities and human lives.

#### 2. Background

High rise buildings are designed primarily to satisfy the needs of an intended occupancy whether commercial, residential or both hence it makes a major part of targeted structures. These days because of advancement of technology, new construction techniques has made construction of super tall structures. These buildings are constructed just to enhance the prestige of a nation, city or people. Due to rapid growth in population and migration of people from village to cities, high cost of land, desire to preserve land for agricultural purposes and some other factors have contributed driving of buildings upward to create more useable space in less land.

#### 3. Motivation

Understanding the performance of high-rise buildings under explosion is of great importance to provide structures which eliminate damage to building and property in the event of explosion, particularly with the late surge in

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compelling exercises focused at structures with practical business values. A design consideration against explosion is very important in high-rise offices, for example, open and business tall structures, because although there are numerous structures that may be under danger of impact loading although not originally designed for the same. The investigation and configuration of blast safe structures require a definite comprehension of explosives, impact wonders and impact consequences for structures. Therefore, it is important to gather the available literature review on explosives, blast phenomena, blast wave interaction and reaction of structures to impact loads

## 4. Objective of Survey

- 1) Modeling and analysis of high rise building for external (air blast) explosion.
- 2) Analytically and numerically prove the behaviour of tall building affected by blast.
- 3) Assessing of results obtained for high rise buildings subjected to load from the analysis.

## 5. Scope of work:

Ordinary structures are not intended for impact load in light of the fact that the size of burden created by impact is gigantic and the expense of configuration and development is high. Accordingly structure is vulnerable to fall under impact load impact. The impact episodes have set off the psyches of designers, modelers and specialists to discover arrangements and to shield structures and inhabitants from impact calamities and in addition drove numerous organizations, especially those with a global nearness to consider their weakness.

## II. REVIEW OF LITERATURE

The analysis of the blast loading on the structure started in 1960's. US Department of the Army, released a technical manual titled "structures to resist the effects of accidental explosions" in 1959. The revised edition of the manual TM 5-1300 (1990) most widely used by military and civilian organization for designing structures to prevent the propagation of explosion and to provide protection for personnel and valuable Equipments.

The methods available for prediction of blast effects on buildings structures are:

- 1) Empirical (or analytical) methods
- 2) Semi-empirical methods
- 3) Numerical methods.

Empirical methods are essentially correlations with experimental data. Most of these approaches are limited by the extent of the underlying experimental database. The accuracy of all empirical equations diminishes as the explosive event becomes increasingly near field. Semi-empirical methods are based on simplified models of physical phenomena. The attempt is to model the underlying important physical processes in a simplified way. These methods are dependent on extensive data and case study. The predictive accuracy is generally better than that provided by the empirical methods. Numerical (or first-principle) methods are based on mathematical equations that describe the basic laws of physics governing a problem. These principles include conservation of mass, momentum, and energy. In addition, the physical behavior of materials is described by constitutive relationships. These models are commonly termed computational fluid dynamics (CFD) models. [1]

The key elements are the loads produced from explosive sources, how they interact with structures and the way structures respond to them. Explosive sources include gas, high explosives, dust and nuclear materials. The basic features of the explosion and blast wave phenomena are presented along with a discussion of TNT (trinitrotoluene)

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equivalency and blast scaling laws. The characteristics of incident overpressure loading due to atomic weapons, conventional high explosives and unconfined vapors cloud explosions are addressed and followed by a description of the other blast loading components associated with air flow and reflection process. Fertice G. [8] has extensive study of the structures and computation of blast loading on aboveground structures.

A. Khadid et al. [1] studied the fully fixed stiffened plates under the effect of blast loads to determine the dynamic response of the plates with different stiffener configurations and considered the effect of mesh density, time duration and strain rate sensitivity. He used the finite element method and the central difference method for the time integration of the nonlinear equations of motion to obtain numerical solutions.

A.K. Pandey et al. [2] studied the effects of an external explosion on the outer reinforced concrete shell of a typical nuclear containment structure. The analysis has been made using appropriate non-linear material models till the ultimate stages. An analytical procedure for nonlinear analysis by adopting the above model has been implemented into a finite element code

DYNAIB. Alexander M. Remennikov [3] studied the methods for predicting bomb blast effects on buildings. When a single building is subjected to blast loading produced by the detonation of high explosive device. Simplified analytical techniques used for obtaining conservative estimates of the blast effects on buildings. Numerical techniques including Lagrangian, Eulerian, Euler- FCT, ALE, and finite element modelling used for accurate prediction of blast loads on commercial and public buildings.

J. M. Dewey [8] studied the properties of the blast waves obtained from the particle trajectories. First time he introduced the effect of spherical and hemispherical TNT (trinitrotoluene) in blast waves and determined the density throughout the flow by application of the Lagrangian conservation of mass equation which used for calculating the pressure by assuming the adiabatic flow for each air element between the shock fronts. The temperature and the sound speed found from the pressure and density, assuming the perfect gas equation of states.

Kirk A. Marchand et al. [9] reviews the contents of American Institute of Steel Construction, Inc. for facts for steel buildings give a general science of blast effects with the help of numbers of case studies of the building which are damaged due to the blast loading i.e. Murrah Building, Oklahoma City, Khobar Towers , Dhahran, Saudi Arabia and others. Also studied the dynamic response of a steel structure to the blast loading and shows the behavior of ductile steel column and steel connections for the blast loads.

M. V. Dharaneepathy et al. [4] studied the effects of the stand-off distance on tall shells of different heights, carried out with a view to study the effect of distance (ground-zero distance) of charge on the blast response. An important task in blast-resistant design is to make a realistic prediction of the blast pressures. The distance of explosion from the structure is an important datum, governing the magnitude and duration of the blast loads. The distance, known as 'criticalground-zero distance', at which the blast response is a maximum. This critical distance should be used as design distance, instead of any other arbitrary distance.

Ronald L. Shope [5] studied the response of wide flange steel columns subjected to constant axial load and lateral blast load. The finite element program ABAQUS was used to model with different slenderness ratio and boundary conditions. Non-uniform blast loads were considered. Changes in displacement time histories and plastic hinge formations resulting from varying the axial load were examined.

T. Borvik et al. [6] studied the response of a steel container as closed structure under the blast loads. He used the mesh less methods based on the Lagrangian formulations to reduce mesh distortions and numerical advection errors to describe the propagation of blast load. All parts are modelled by shell element type in LS-DYNA. A methodology has

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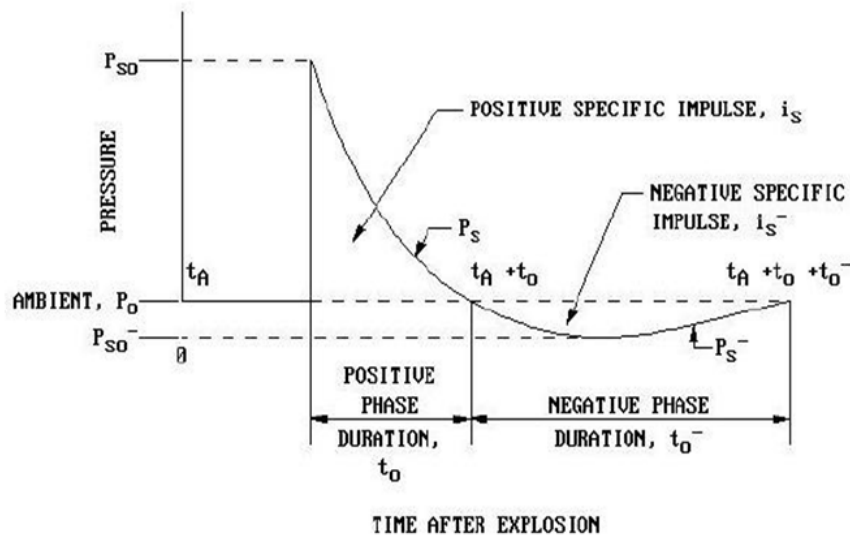
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been proposed for the creation of inflow properties in uncoupled and fully coupled Eulerian–Lagrangian LS-DYNA simulations of blast loaded structures.

TM 5-1300 (UFC 3-340-02) [3] is a manual titled “structures to resist the effects of accidental explosions” which provides guidance to designers, the step-to-step analysis and design procedure, including the information on such items (1) blast, fragment and shock loading. (2) principle on dynamic analysis. (3) reinforced and structural steel design and (4) a number of special design considerations.

### III. METHODOLOGY AND PROJECT PLAN

1. A quick increment in volume and discharge of energy in an extreme way, more often than not with the generation of very high temperature and release of gases is characterized as blast. Explosions either occur in the form of deflagration or detonation depending on burning velocity during the explosion.
2. Deflagration is propagated by the liberated reaction of thermal conductivity, the next layer of cold material is ignited by the hot burning material and burns it and the procedure proceeds like that. Most "fire" found in everyday life, from flares to blasts is deflagration.
3. Detonation is a kind of combustion which involves a supersonic exothermic front quickening through a medium that eventually drives a shock front proliferating directly in front of it



**Fig -1:** Incident and reflected pressures on building Positive phase loads are more powerful and responsible for most of the pressure damages than the negative phase loads.

### IV. RESULT AND DISSCUSSION

In the present work, a five storied reinforced concrete frame building situated in Zone IV, is taken for the purpose of study. The plan area of building is 12 x 10 m with 3.0m as height of each typical storey. It consists of 2 bays of 6m each in X-direction and 2 bays of 5m each in Y-direction. Hence, the building is symmetrical about both the axis. The total height of the building is 15m. The building is considered as a Special Moment resisting frame. The plan of building is shown in fig. and the front elevation is shown in fig. A

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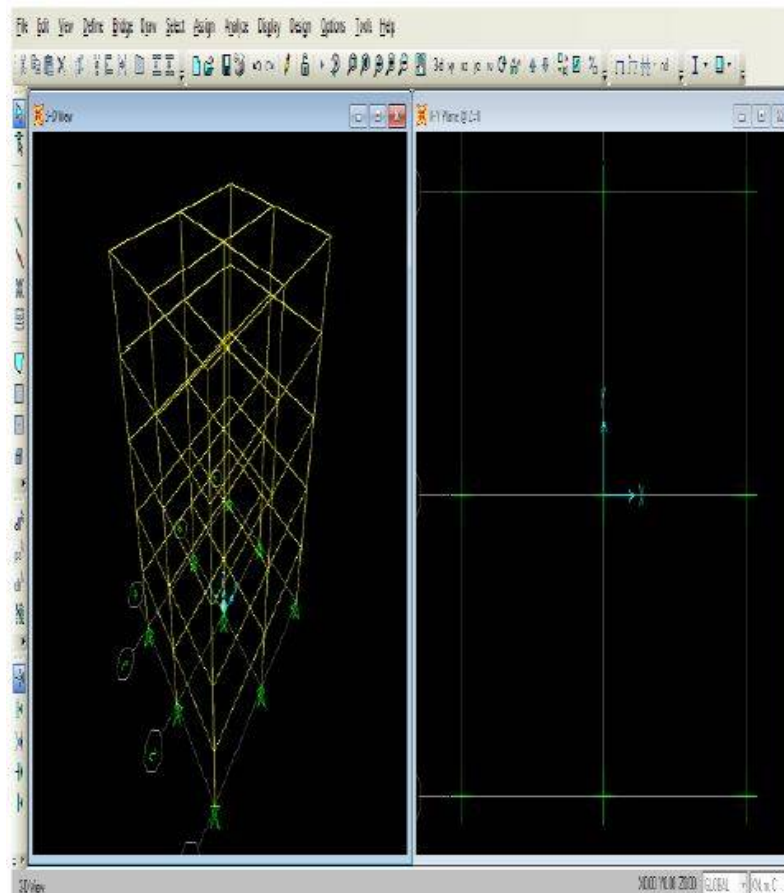
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A. The sectional properties of elements in case of the Basic structure are taken as follows: Size of Column = 400 x 400mm

Size of Beam = 345 x 500 mm

Thickness of Slab = 125mm thick

Soil interaction has not been considered and columns are restrained at the base. Slabs defined area shell element.



B. MATERIAL PROPERTIES:

*For concrete:*

Mass per unit volume= 2.5KN Weight per volume = 25 KN/M<sup>3</sup> Modulus of elasticity,  
Ec=2.5\*10<sup>7</sup> KN/M<sup>2</sup> Damping Ratio=0.05 Poisson's ratio=0.20

Shear modulus=1500

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Coefficient of thermal expansion= $5.5 \times 10^{-6}$  C<sup>-1</sup>. **LOADS**

Live loads have been assigned as uniform area loads on slab elements as per

IS 1893(PART 1)2002 .Live load on all other floors= $3.0 \text{ KN/M}^2$

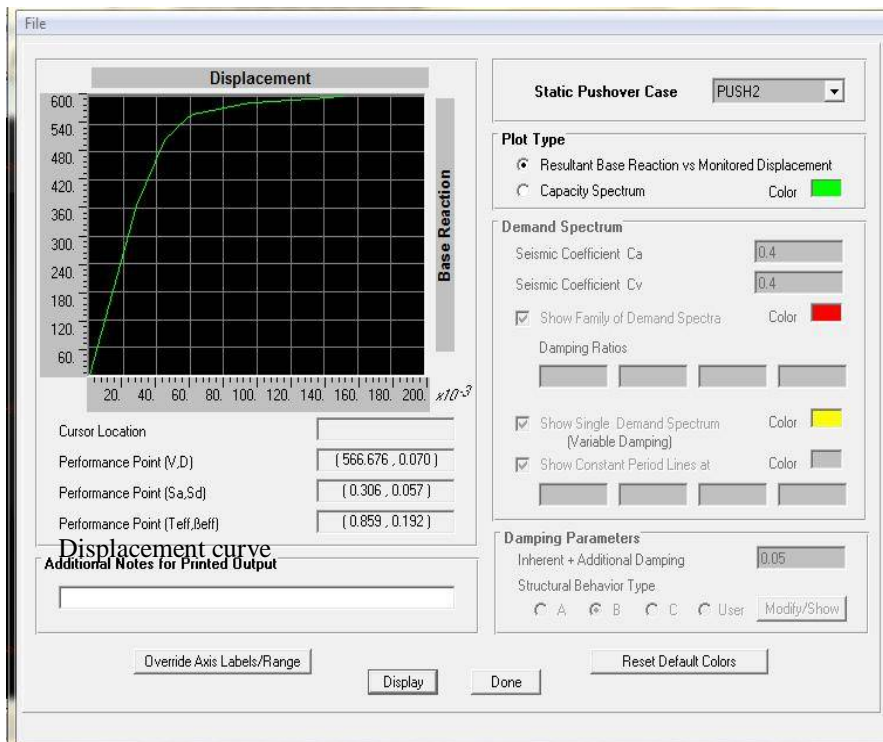
### D. Seismic Loads

The design lateral force at different floor levels have been calculated corresponding to fundamental time period and applied to model. In our case slab have been modeled as rigid diaphragms and in this connections the center of rigidity (mass) and center of gravity of building is considered same in order to neglect the effect of torsion.

EL In Y (U<sub>x</sub>) direction= $8.331 \times 10^4 \text{ kN/M}^2$  EL In Y (U<sub>x</sub>) direction(30%)= $2.5 \times 10^4 \text{ kN/M}^2$

### E. Design of Rubber Bearing:-

1. Thickness of Rubber bearing=19mm
2. Height of Bearing=0.163m
3. No.of steel layers= 6
- 4.Steel =3mm



**Fig No 02 Deformed shape of building**

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Displacement	Fixed Base (mm)	Rubber Isolation(mm)
1 <sup>st</sup> floor	25.9	3.6
2 <sup>nd</sup> floor	41.9	3.4
3 <sup>rd</sup> floor	53.2	3.3
4 <sup>st</sup> floor	61.3	3.2
5 <sup>st</sup> floor	69.3	3.1

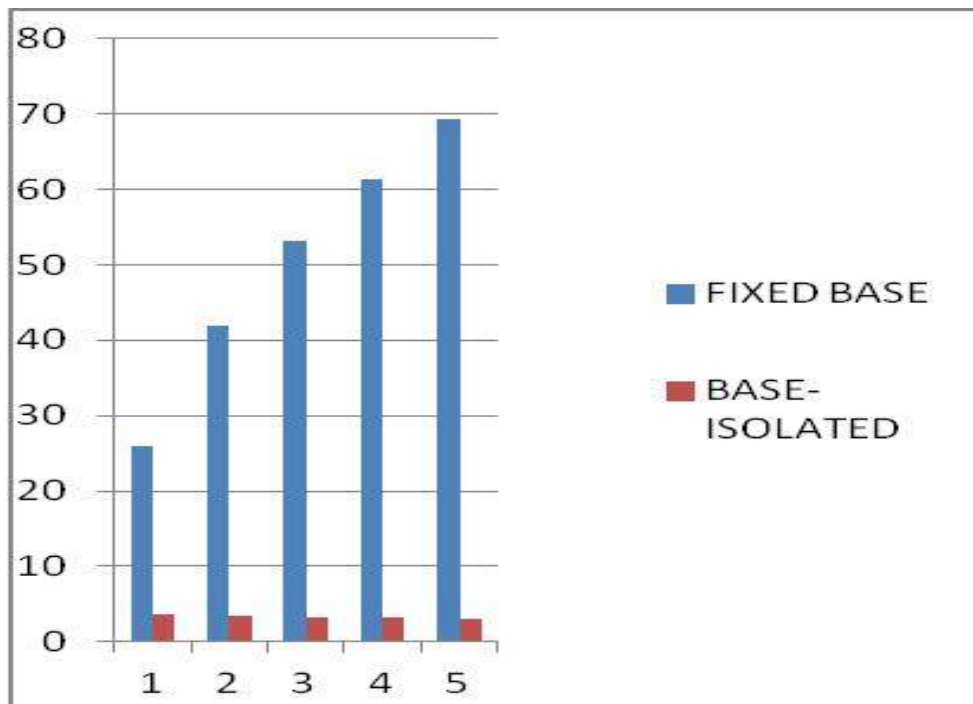


Fig No 03 Comparison of Displacement With and Without Base Isolation

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## V. CONCLUSION

As per results the system is significantly affected with increase in charge weight and decrease in standoff distance. For protecting a structure standoff length is the main criteria which has an impact on the blast pressure. From graphical representation of blast pressure verses storey level, it is observed that intensity of blast pressure reduces with increase in storey height because the explosion occurs at lower storey levels, hence the pressure at this levels are high. From graphs, it's evident that as standoff increase storey drift goes on decreasing and as charge weight increases storey drift increases. It is also observed that, the first storey columns subjected to high pressure undergoes deformation initially and there is a sudden loss of critical load bearing capacity of columns. Hence columns are failed as a result failure of building geometry takes place. The most vulnerable structure is irregular building which shows highest values of Inter-Storey drift. Because of low pressure intensity on upper floors, they are not significantly affected due to increase of standoff distance from lower floors to upper floors. Hence standoff distance will have an impact on the pressure at various floors

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