ANALYSIS OF HIGH RISE RCC BUILDING SUBJECTED TO BLAST LOAD

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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.*

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

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 causalities 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.

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.

1.1 Problem Statement

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.

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 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. .

1.2 Objectives

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.

2. EXPLOSION AND BLAST PHENOMENON

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. 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. 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.

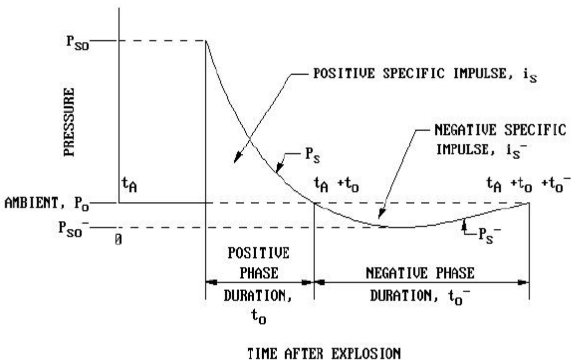

Fig -1: Incident and reflected pressures on building (Remennikov, 2005)

Positive phase loads are more powerful and responsible for most of the pressure damages than the negative phase loads.

3. MODELLING AND ANALYSIS

3.1 Description and Modeling of Building

The aim of this work is to find the s response of regular and irregular building. To understand the behaviour of structure in different condition charge weights of 700lbs and 1400lbs are applied at a standoff distances of 5m and 10m respectively to the structure.

3.1.1 Building description

The structure considered for this study is a 10 Storey building. Total height of building is 30m. Each storey height is 3m. Base dimension of the building is 17.25m X 20.49m. Along longitudinal direction there are six bays and along transverse direction seven bays, with their clear dimensions as shown in the figure below.

3.1.2 Structural elements

Beam size considered is 230mm X 450mm, column size is 230mm X 600mm. Slab thickness used are 100mm, 125mm, 150mm and 175mm. The building is made up of R.C infilled frames. Wall thickness is 230mm.

3.2 Computer Modeling and Analysis

ETABS software is used for modeling. Beams, columns are modeled as frame elements, slabs are modeled as shell elements. Rigid diaphragm is assigned to all floors. Fixed support condition is applied.

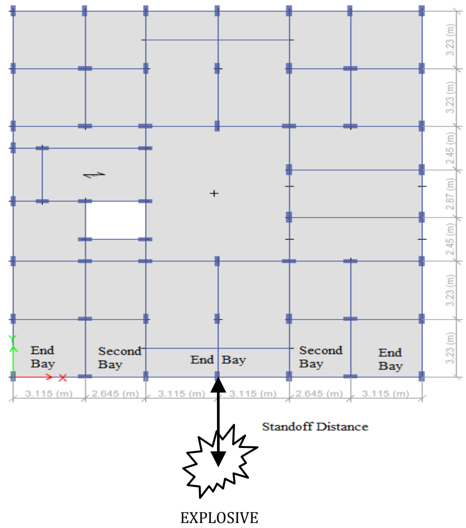

Fig -2: Typical location of explosive along Face 1(F1) & typical layout of Regular Building

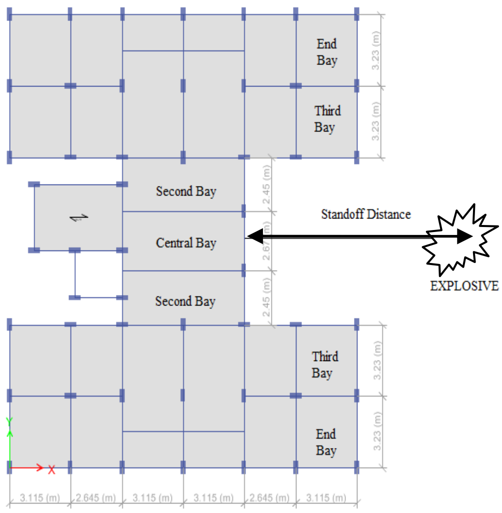

Fig -3: Typical location of explosive along Face 3(F3) & typical layout of Irregular Building

Blast load calculations are carried out as per the procedures outlined in section 5 of TM5 – 1300. The blast loads are distributed on all the structural elements on the front face as well as right face of the building. Following procedures and TM 5-1300 charts, software named ATBlast was developed by ARA (applied research associates) which calculates blast loads for given values of charge weights and standoff distances. This software calculates blast load dynamic parameters like shock front velocity, impulse, duration and time of arrival.

Table -1: Model Description

Model No.	Type of Building	Charge Weight (lbs)	Standoff Distance (m)
M1	Regular	700	5
M2	Regular	700	10
M3	Regular	1400	5
M4	Regular	1400	10
M5	Irregular	700	5
M6	Irregular	700	10
M7	Irregular	1400	5
M8	Irregular	1400	10

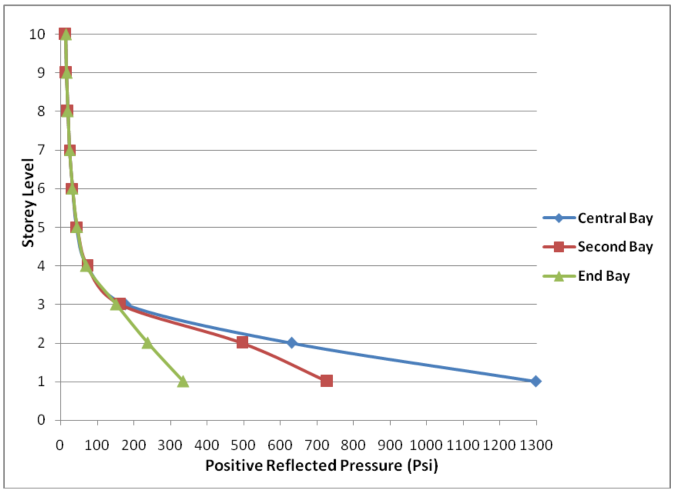

Chart -1: Blast pressure variation with respect to storey level for M1 (F1)

Table -2: Blast load parameters of Central Bay for M1 (F3)

Storey Level	Time of arrival Ta (ms)	Load Duration Td (ms)	Blast Pressure (Psi)	Blast Load (kN)
1	2.2	1.1	1647.04	90898.33
2	3.72	1.49	655.9	36198.40
3	5.9	3.48	179.88	9927.38
4	9.32	5.9	77.08	4253.96
5	13.66	7.9	45.46	2508.89
6	18.78	9.14	32.69	1804.13
7	24.57	10.34	24.9	1374.20
8	30.88	11.57	19.62	1082.81
9	37.59	12.75	15.97	881.37
10	44.65	12.52	14.11	778.72

4. RESULTS AND DISCUSSIONS

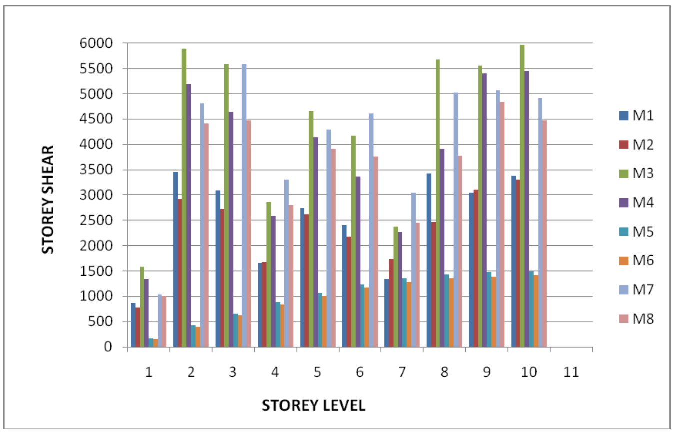

Chart -2: Storey Shear (F1)

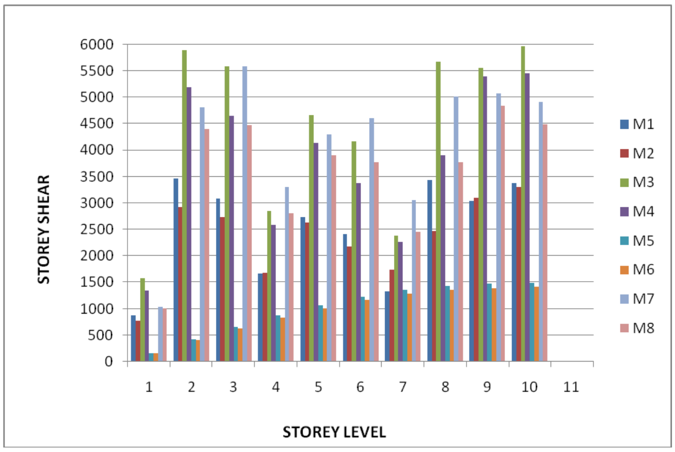

Chart -3: Storey Shear (F3)

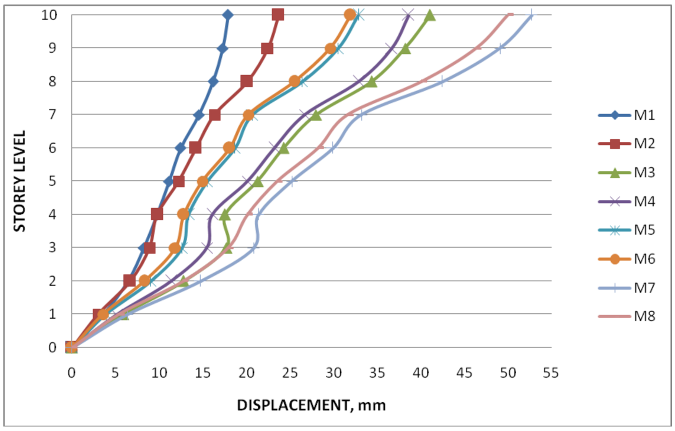

Chart -4: Storey Displacement (F1)

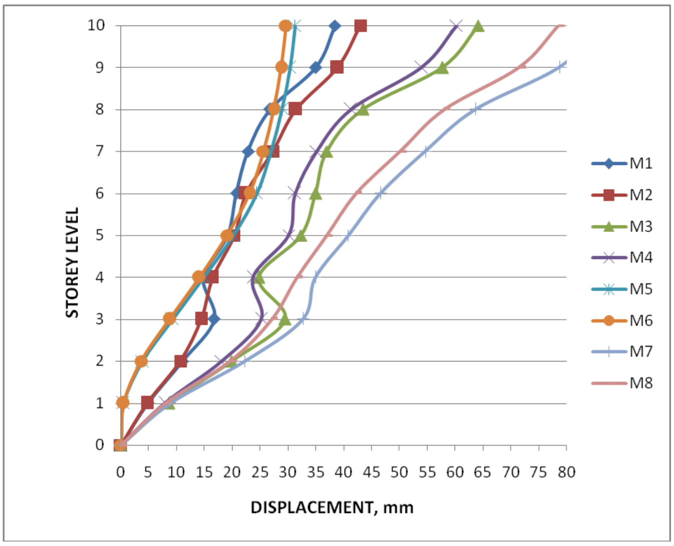

Chart -5: Storey Displacement (F3)

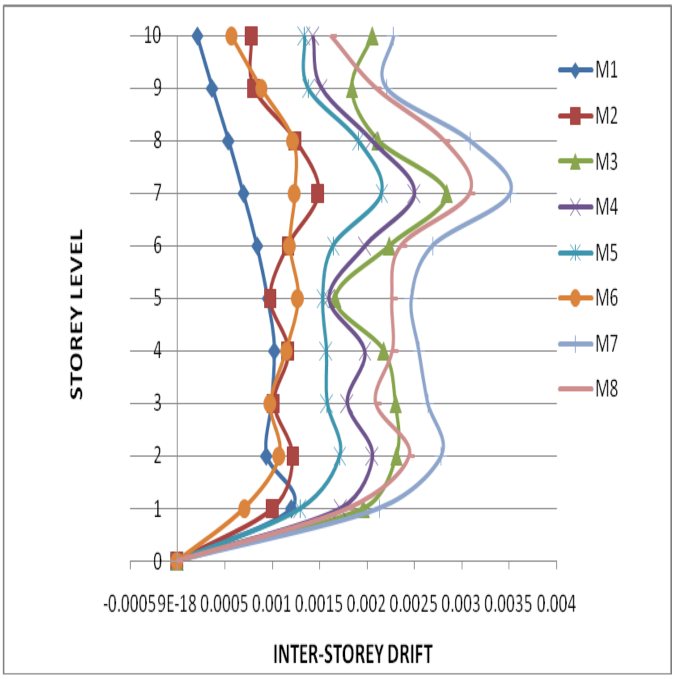

Chart -6: Inter-Storey Drift (F1)

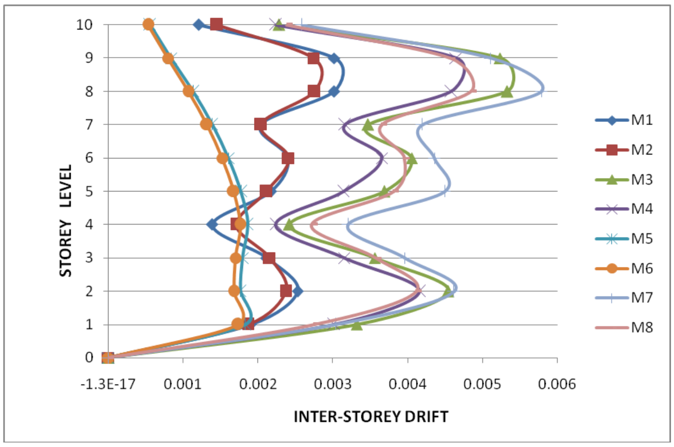

Chart -7: Inter-Storey Drift (F3)

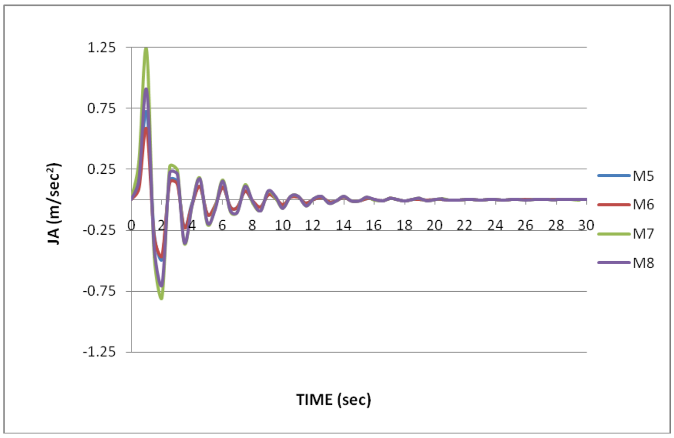

Chart -8: Joint Acceleration (F1)

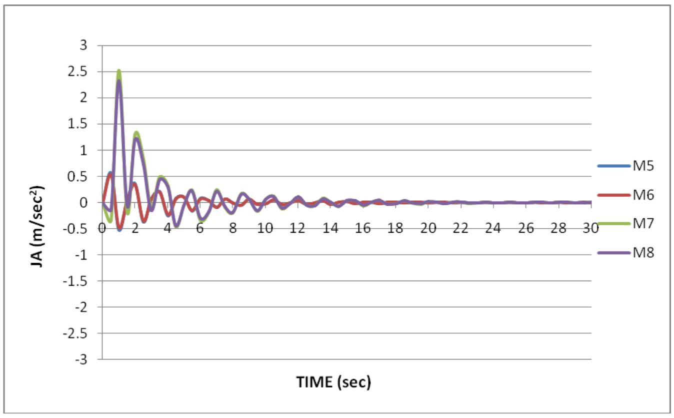

Chart -9: Joint Acceleration (F3)

From graphs following points are noted

Storey Shear

-Along F1 maximum storey shear is observed for M3 at all storey levels except at 4th and 5th maximum value is observed for M7.

-Along F3 for 6th and 7th storey maximum value is observed for M7 and for remaining stories observed for M3.

-Minimum values of storey shear are obtained for M6 along F1 and F3

Storey Displacement

-Maximum storey displacement is observed at 10th storey level for M7 along F1 and F3.

-Minimum storey displacement is observed at 1st storey level for M2 along F1 and M6 along F3.

Inter – Storey Drift

-Maximum Inter -Storey drift is observed for M7 at 7th storey level along F1 and at 8th storey level along F3.
-Minimum Inter-Storey drift is observed at 1st storey levels for M6 along F1 and for M5 along F3.

Joint Acceleration

-Highest value is observed for M3 along F1 and F3

5. CONCLUSIONS

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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