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Parametric Study of Multi-Storey Buildings for Blast Load

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Abstract: An explosive is a mixture of compounds which, when initiated by heat, impact, friction, or shock, undergoes a rapid decomposition in the form of heat and gas where tremendous amounts of energy are released. Full or partial collapse of buildings, minor and major cracks are the most perceptible type of failure that may result from a blast load. The level of damage produced in a structure depends on charge weight, a distance of building from point of explosion. This work deals with the study of nature of blast loading and its effects on regular and irregular multi-storey building with and without shear wall opening.

Keywords: Blast Load, Staad Pro, Trinitrotoluene, Storey Displacement, Storey Drift.

I. INTRODUCTION

Many terrorists these days have been using the technique of vehicle bombing attacks against buildings. Blast load is also used in mining. A blast wave is the pressure resulting from the expulsion or ejection of a large amount of energy in a localised volume. The process lasts only for very less milliseconds. It is harmful especially when one is very close to the centre or at a location of constructive interference. The main objective of this project is to analyse the structures against the abnormal loading conditions like blast loads, requiring detailed understanding of blast phenomenon. To compare the storey displacement and storey drift between structures without shear wall, shear wall with and without opening for irregular structure. Trinitrotoluene of 0.04 tonne is used as an explosive material .

II. BLAST PHENOMENON

A blast wave is the pressure resulting from the expulsion or ejection of a large amount of energy in a localised volume. The blast loading is well-defined by two fundamentals. They are

- Stand-off distance R among the source of the blast and target,
- The bomb magnitude (charge weight W).

There exists two phases in pressure time profile–

- Portion beyond the ambient atmospheric pressure is called positive phase of duration. It remains for shorter duration with large magnitude when compared to negative phase
- Portion under ambient atmospheric pressure is called negative phase of duration. The negative phase has an extended duration and a lesser intensity compared to the positive duration.

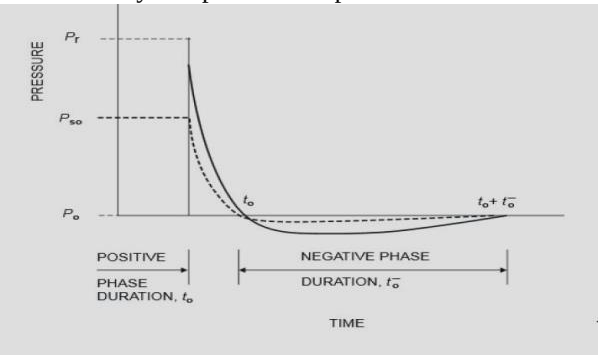

Fig. 1 Comparison of free field and reflected blast loads

Side on overpressure P_{so}: It is the maximum pressure due to shock waves from a blast without reflecting.
Peak reflected overpressure P_{ro}: Maximum overpressure caused when shock wave is reflected by sticking an obstacles
Ambient atmospheric pressure $P_{o:}$ Value of the ambient air pressure may be taken as 1 kg/cm^2 at mean sea level.

III.TRINITROTOLUENE

Trinitrotoluene is generally known as TNT. This man made compound is yellow and odourless solid. It neither absorbs nor dissolves in water. It can also be a constituent of many other explosives such as amatol and composition B. The chemical formula for tri nitro toluene is $C_6H_2(NO_2)_3CH_3$. In order to overcome these uncertainties it is suggested that the mass of TNT equivalent is increased by 20 %. This exaggerated value of the charge weight is called the "effective charge weight".

Fig. 2 Structural formula for TNT

IV. MODEL DEVELOPMENT AND METHODOLOGY

Salient features assumed for the building are :

Plan dimension:	35mX35m
Total height of the building:	30.2m
No of bays :	8
Spacing	5m on both the direction
Type of concrete used:	M_{30}
Type of rebar:	HYSD 500
Column dimension:	450mmX450mm
Beam dimension:	450mmX450mm
Thickness of the slab:	150mm
Thickness of wall:	200mm
Typical storey height:	3.02m
Bottom storey height:	3.02m
Support:	Fixed

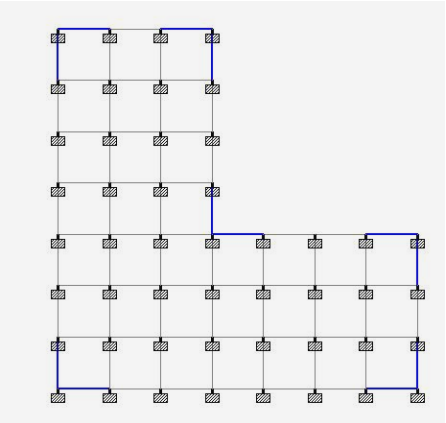

Fig. 3 Plan of unsymmetrical building with shear walls

Distinct model is considered in this project are :
Model 1: unsymmetrical building without shear wall
Model 2: unsymmetrical building with shear wall without opening
Model 3: unsymmetrical building with shear wall with opening

Reflected over pressure, Dynamic over pressure and blast load is calculated for each front face nodes for different Stand off distance and Charge Weight. Blast load is calculated by referring IS code 4991-1968. In this project charge weight of TNT is 0.04 tonne with standoff distance of 30m from the face of the building. Scaled distance is calculated for each node.

$Z=\frac{R}{\sqrt[3]{W}}$

Where Z is scaled distance
R Standoff distance
W charge weight.

Live load and super dead load are applied according to IS CODE 875 part 2

V. RESULT AND DECISION

Irregular structure without shear wall, with shear wall and shear wall with opening is compared for storey displacement and storey drift for 0.04tonnes /40kg s of weight.

TABLE 1
STOREY DISPLACEMENTS FOR IRREGULAR BUILDINGS

	Displacement		
Storey	**W/O Shear wall**	**With Shear Wall**	**Shear Wall With Openings**
0	0	0	0
1	3.183	1.732	5.089
2	7.412	3.433	11.502
3	11.334	5.078	16.876
4	14.734	6.653	21.097
5	17.595	8.146	24.354
6	19.932	9.538	26.835
7	21.764	10.814	28.685
8	23.126	11.946	30
9	24.044	12.899	30.876
10	24.378	13.503	31.186

TABLE 2
STOREY DRIFTS FOR IRREGULAR BUILDINGS

	Drift		
Storey	**W/O Shear wall**	**With Shear Wall**	**Shear Wall With Openings**
0	0	0	0
1	1.061	0.5773	1.6963
2	1.4096	0.567	2.137
3	1.307	0.548	1.791
4	1.133	0.5254	1.4073
5	0.9537	0.4977	1.085
6	0.7792	0.4644	0.8274
7	0.610	0.425	0.61666
8	0.4543	0.377	0.4383
9	0.3064	0.3177	0.2922
10	0.11133	0.201333	0.1033333

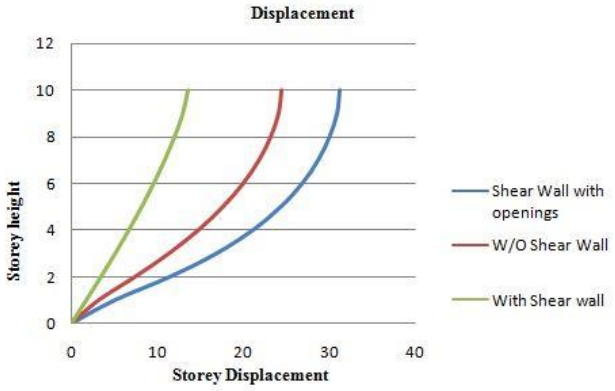

Fig. 4 Comparison for storey displacement between unsymmetrical buildings without shear wall, with shear wall and shear with openings

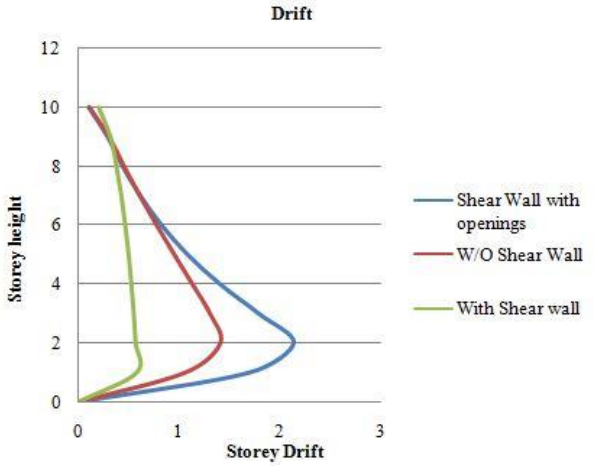

Fig. 5 Comparison for storey drift between unsymmetrical buildings without shear wall, with shear and shear wall with opening.

CONCLUSIONS

Positive pressure depends upon standoff distance and charge weight of explosive. When the charge weight increases, positive pressure also increases and positive pressure decreases with increase in standoff distance.

When charge weight increases, storey drift and storey displacement increases. Blast load is maximum at first floor. Hence storey drift is maximum at first floor. At higher level, storey drift gradually decreases.

The displacement for the G+10 storey irregular building with shear wall was found to be less compared to that of the irregular building without shear walls and shear wall with openings.

Building with shear wall shows better performance when compared to building without shear wall and building with shear wall with opening.

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