EFFECTS OF BLAST LOADING ON BUILDING FRAMES

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Abstract - *In the past few years, terrorist attack such as bomb explosion and blast of important structures has become a very common. The pressure generated due to blast is very high and for very short duration which can cause catastrophic failure of buildings internally as well as externally. Firstly, detail knowledge and better understanding of explosives will enable us to make blast proof building design much more efficiently. Blast load is a dynamic in nature so calculation should be done carefully just like earthquake and wind loads. In this study effects of blast loads on 6 storey R.C.C building was examined. Effect of variable blast source weight is calculated by considering various distances from point of explosion and also considers effect of blast loading after some modification in structural geometry or elements. Blast pressure wave parameters and blast loads are manually calculated with the help of IS: 4991-1968 and Time history dynamic analysis is carried out in STAAD Pro. The influence of blast pressure wave parameters is compared by considering different models in the form of certain parameters like storey displacements, drift and time-history functions such as peak displacements, velocity, acceleration etc.*

***Key Words*: Charge weight, Standoff distance, beam-column joint, Force Time-history, storey displacement, story drift, Time- functions.**

1. INTRODUCTION

In the past few years, blasting and its effects on important structures and public buildings has become a very common. Due to different terrorist activities and various explosions, the behaviour of structural components subjected to blast loading has been the subject of considerable research effort in recent years.

Protection of human life and structural components from blast is prime important and necessary conditions for structural engineers. Amol B. Unde, et al. [1] studied the effects of the stand-off distance on different heights of buildings, also carried out with a overview of study the effect of distance of charge weight on the blast response. M. Meghanadh, et al. [2] studied on systematic approach to assessing the calculated blast load and provides the framework that how to analyse and design the blast resisting structures using software work in Staad Pro. Quazi Kashif, et al. [3] for their study on “Effect of Blast on G+4 RCC Frame Structure”. Effect of variable blast source weight is find out by considering 30 m distance from point of explosion. These blast loads were analytically determined as a pressure-time history and numerical models of the structure was created in computer software i.e. SAP2000. T. Ngo, et al. [4] presenting an background to deal with blast explosive structures, gives an idea to analyse and design of structures subjected to blast loading and also give background about understand the effects of blast loads. Demin George, et al. [5] studied various aspects of blast loadings on framed structures using ETABS by the use of steel bracings, shear wall etc. Zeynep Koccaz, et al. [6] studied “Architectural and Structural design for blast resistant buildings” This study is motivation for making buildings in a blast resistant way. P. Karthikeyan, et al. [7] Prediction of blast loading and its impact on buildings is determined by using ETABS 2015 and for various blast charge variation of various time-history functions are compared. Variation in displacement, velocity, acceleration w.r.t. time in various storeys is analysed and compared. Based on above studies present study is based on considering different building models and perform the variation of blast wave parameters, blast load, storey displacements, drifts, and time-history functions such as peak displacements, velocity, acceleration etc. Analysis is performed in Staad Pro. Finally effect of blast loading on structural elements is made.

1.1 OBJECTIVES

1) Study the effects of blast loading on RCC buildings at its different beam-column joints and finally force time history concept is used to achieve the desired results from STAAD Pro software
2) To study the dynamic response of structure against blast loading, various structural models are taken and dynamic analysis is carried out using Time history analysis.

2 BLAST TIME HISTORY

Blast loading is a type of dynamic loading in which variation of blast force for different time. As per relevant data given in Table 1 of IS 4991:1968 and example A-1 of Appendix A in IS code blast force are manually calculated and thereafter variation of force versus different time intervals is also manually calculated for each node on front face under the effect of blast.

Along with blast load time-history apply at beam column junction, with dead and live loads are also applied and analysis is performed in STAAD pro software which is a finite element analysis software. Time history load is having very high magnitude and intensity and it is act for very less fraction of time nearly for few milliseconds, its intensity is gradually decreases in few milliseconds. So blast load calculation need not be possible without using Time history definitions.

2.1 LOADS AND MEMBER SPECIFICATIONS

A 6 storey RCC building is considered having each storey is of 3m height.The size of beam used is 300x400mm. The size of column used is 300x300mm, thickness of outer wall is taken as 230mm and inner wall thickness is considered as 100mm. Slab is taken as 120mm thick.

Dead load (IS 875-Part 1) : 3.75 KN/m2 for slab
: 12.6 KN/m2 for outer walls
: 5.46 KN/m2 for inner walls
Live loads (IS 875-Part 2) : 3 KN/m2 for slab
Blast loads (IS 4991:1968) : calculated manually
Combination Load : 1.5(D.L+L,L)
: 1.2(D.L+L.L+B.L)

2.2 BUILDING DESCRIPTION

In this Present study of blast load dimension of 6 storey building residential building having 3 bays in both X and Z directions having overall span length of 10.5 m in both X and Z directions. The height of each storey is considered as 3m and complete overall height of building is should be as 18m from the level of ground floor.

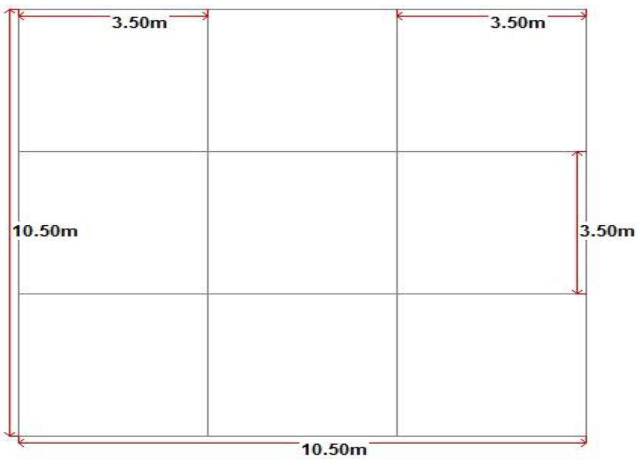

Fig- 1: Top view of Proposed Plan

There is total seven models are generated to get deep and useful information about the analysis of blast loading.

Table - 1: Model Descriptions

Model No.	Building Description	Charge weight (kg)	Standoff distance (m)
Model 1	Dimensions as per Fig-1	100	20
Model 2	Dimensions as per Fig-1	100	30
Model 3	Dimensions as per Fig-1	100	40
Model 4	Dimensions as per Fig-1	200	30
Model 5	Dimensions as per Fig-1	300	30
Model 6	Addition of shear wall and dimensions as per Fig-1	100	30
Model 7	Bay length along X-direction is 4m rest all dimension as per Fig -1	100	30

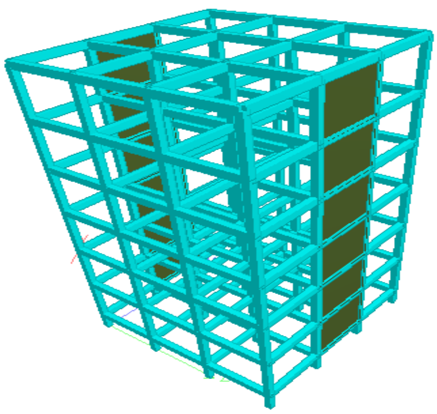

Fig-2: Isometric view of Model 6

3. CALCULATIONS OF BLAST LOADS

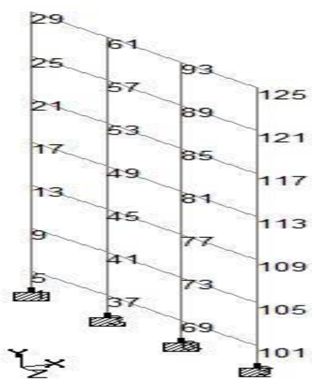

Fig-3 : Node number of blast face of building

In the proposed plan we consider that blast is occur at 1.5 m above the ground level at some distance from the centre of the building front face. The blast load is applied at each and every group of beam column joints. The distance between source of blast and the beam column joint is calculated manually by using distance formula between two points having coordinates (X_1,Y_1,Z_1) and (X_2,Y_2,Z_2) as shown in Table below:

Table -2: Distance from blast source and Target Point

Node number	X coordinate	Y coordinate	Z coordinate	Actual Distance
41 and 73	30	1.5	1.75	30.09
9 and 105	30	1.5	5.25	30.49
45 and 77	30	4.5	1.75	30.39
13 and 109	30	4.5	5.25	30.79
49 and 81	30	7.5	1.75	30.97
17 and 113	30	7.5	5.25	31.37
53 and 85	30	10.5	1.75	31.83
21 and 117	30	10.5	5.25	32.22
57 and 89	30	13.5	1.75	32.94
25 and 121	30	13.5	5.25	33.31
61 and 93	30	16.5	1.75	34.28
29 and 125	30	16.5	5.25	34.64

Table -3: Blast load for 0.1Tonne explosive at R=20m

Floor	Loads acting on joint	Scaled time t_d(ms)	Over pressure P_{ro}(Kg/cm²)	Area (m²)	Force P(KN)
1st/ GF	Edge	21.44	1.695	5.25	872.97
	Centre	20.84	1.828	10.5	1882.93
2nd	Edge	21.82	1.621	5.25	834.86
	Centre	21.28	1.730	10.5	1781.99
3rd	Edge	22.48	1.500	5.25	772.54
	Centre	22.03	1.582	10.5	1629.54
4th	Edge	23.35	1.342	5.25	691.16
	Centre	22.97	1.411	10.5	1453.40
5th	Edge	24.43	1.177	5.25	606.18
	Centre	24.07	1.228	10.5	1264.90
6th	Edge	26.39	1.011	2.625	260.35
	Centre	25.83	1.054	5.25	542.84

Table -4: Blast load for 0.1Tonne explosive at R=30m

Floor	Loads acting on joint	Scaled time t_d(ms)	Over pressure P_{ro}(Kg/cm²)	Area (m²)	Force P(KN)
1st/ GF	Edge	28.66	0.79	5.25	406.87
	Centre	28.39	0.80	10.5	824.04
2nd	Edge	28.82	0.77	5.25	396.57
	Centre	28.59	0.78	10.5	803.44
3rd	Edge	29.02	0.74	5.25	381.12
	Centre	28.88	0.76	10.5	782.84
4th	Edge	29.34	0.71	5.25	365.67
	Centre	29.18	0.73	10.5	751.94
5th	Edge	29.82	0.67	5.25	345.07
	Centre	29.66	0.69	10.5	710.73
6th	Edge	30.61	0.63	2.625	162.23
	Centre	34.28	0.64	5.25	329.62

Table -5: Blast load for 0.1Tonne explosive at R=40m

Floor	Loads acting on joint	Scaled time t_d(ms)	Over pressure P_{ro}(Kg/cm²)	Area (m²)	Force P(KN)
1st/ GF	Edge	32.26	0.500	5.25	257.51
	Centre	32.20	0.507	10.5	522.24
2nd	Edge	32.43	0.496	5.25	255.45
	Centre	32.24	0.502	10.5	517.09
3rd	Edge	32.79	0.486	5.25	250.30
	Centre	32.54	0.493	10.5	507.81
4th	Edge	33.32	0.472	5.25	243.09
	Centre	33.08	0.478	10.5	492.36
5th	Edge	34.11	0.448	5.25	230.73
	Centre	33.84	0.456	10.5	469.70
6th	Edge	34.90	0.424	2.625	109.19
	Centre	34.76	0.428	5.25	220.43

Table -6: Blast load for 0.2Tonne explosive at R=30m

Floor	Loads acting on joint	Scaled time t_d(ms)	Over pressure P_{ro}(Kg/cm^2)	Area (m^2)	Force P(KN)
1st/ GF	Edge	24.08	1.227	5.25	631.94
	Centre	23.85	1.259	10.5	1296.83
2nd	Edge	24.25	1.203	5.25	619.58
	Centre	24.02	1.235	10.5	1272.11
3rd	Edge	24.58	1.157	5.25	595.88
	Centre	24.35	1.189	10.5	1224.73
4th	Edge	25.32	1.092	5.25	562.41
	Centre	24.94	1.121	10.5	1154.69
5th	Edge	26.38	1.012	5.25	521.21
	Centre	26.02	1.039	10.5	1070.22
6th	Edge	26.55	0.951	2.625	244.89
	Centre	26.51	0.967	5.25	498.03

Table-7: Blast load for 0.3Tonne explosive at R=30m

Floor	Loads acting on joint	Scaled time t_d(ms)	Over pressure P_{ro}(Kg/cm^2)	Area (m^2)	Force P(KN)
1st/ GF	Edge	21.80	1.623	5.25	835.89
	Centre	21.58	1.665	10.5	1715.03
2nd	Edge	21.96	1.594	5.25	820.95
	Centre	21.75	1.633	10.5	1682.07
3rd	Edge	22.28	1.536	5.25	791.08
	Centre	22.06	1.576	10.5	1623.36
4th	Edge	22.74	1.452	5.25	747.82
	Centre	22.54	1.490	10.5	1534.77
5th	Edge	23.29	1.354	5.25	697.34
	Centre	23.10	1.387	10.5	1428.68
6th	Edge	23.95	1.245	2.625	320.60
	Centre	23.77	1.270	5.25	654.08

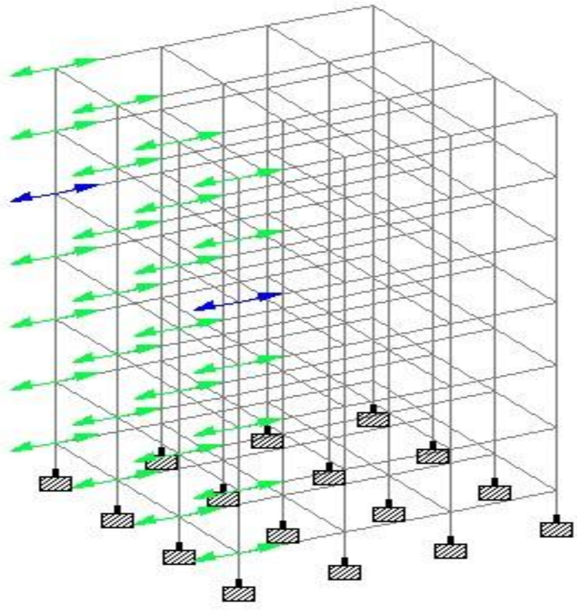

Fig-4 : Application of Blast load

4. RESULTS AND DISCUSSIONS

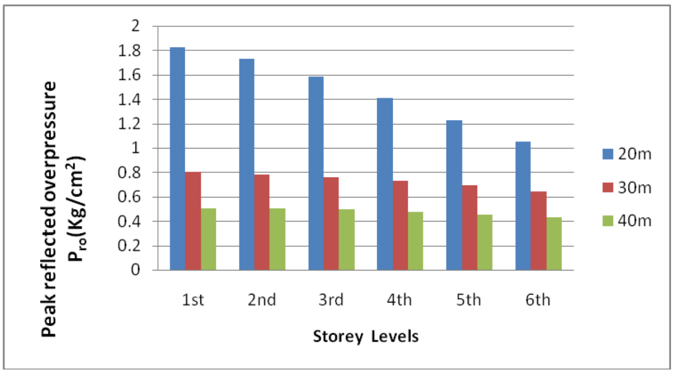

Chart-1: Blast pressure variation with standoff distance

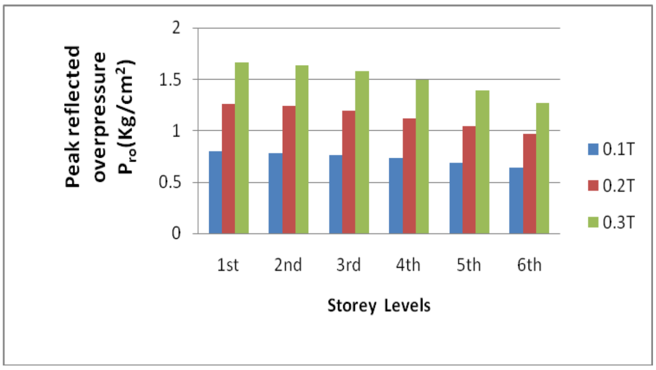

Chart-2: Blast pressure variation with Charge weight

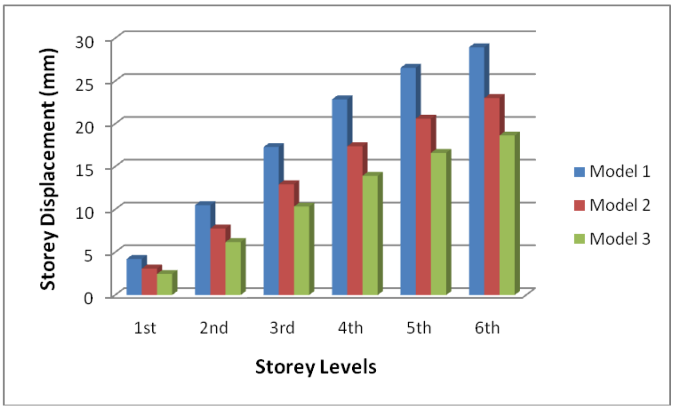

Chart-3: Storey Displacement Variation of Model1,2 and 3

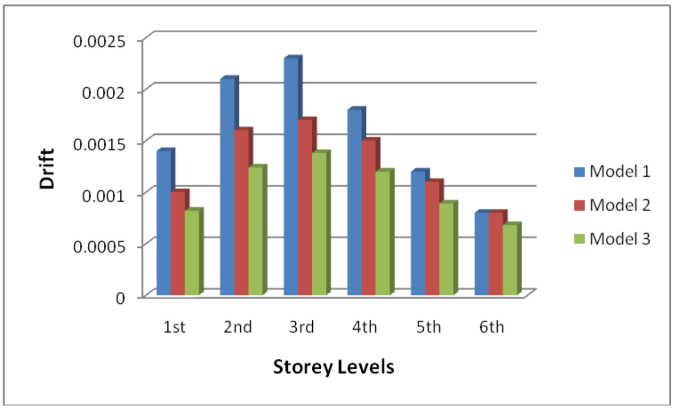

Chart-6: Storey Drift Variation of Model1,2 and 3

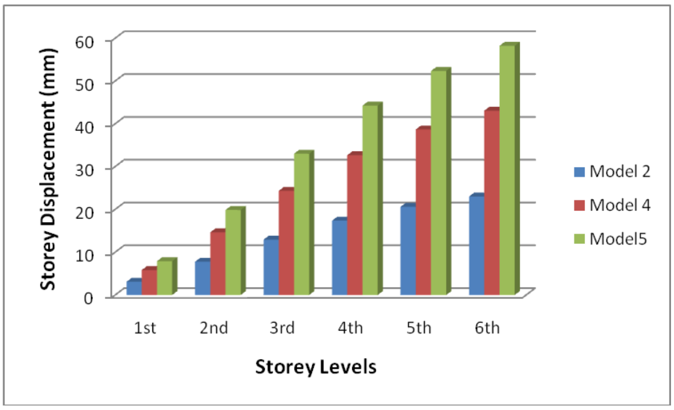

Chart-4: Storey Displacement Variation of Model2,4 and 5

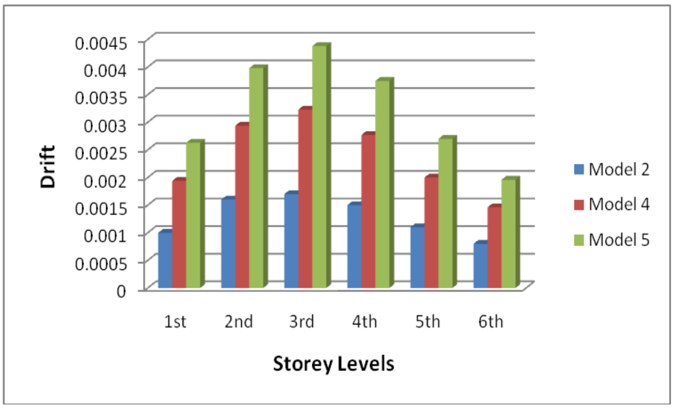

Chart-7: Storey Drift Variation of Model2,4 and 5

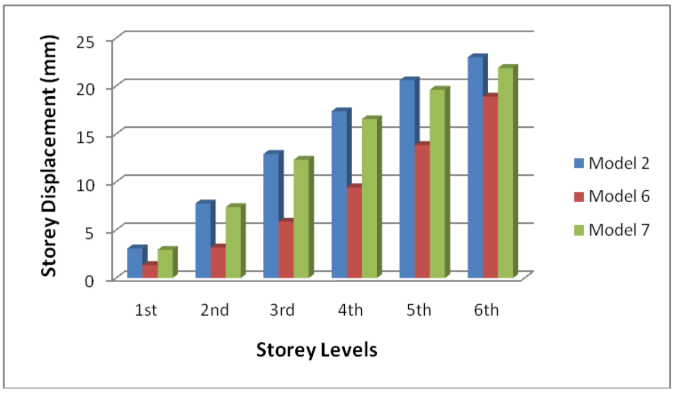

Chart-5: Storey Displacement Variation of Model2,6 and 7

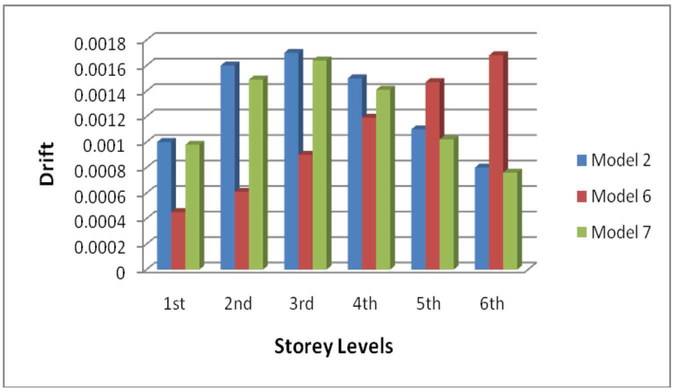

Chart-8: Storey Drift Variation of Model2,6 and 7

From chart 1 and 2 concluded that as charge weight increases overpressure is increases and as standoff distance increases overpressure decreases and vice-versa.

From chart 3,4 and 5 as storey displacement is minimum in case of shear wall i.e. for model 6, and also as charge weight increases storey displacement is increases. And as standoff distance increases storey displacement decreases. From chart 5 for same charge weight and standoff distance as bay length increases Storey displacement decreases.

From chart 6,7 and 8 as storey drift is minimum in case of shear wall i.e. for model 6 and it increases continuously as storey levels increases. And as charge weight increases storey drift is increases and as standoff distance increases storey drift decreases. . From chart 8 for same charge weight and standoff distance as bay length increases Storey drift decreases.

4.1 TIME-HISTORY FUNCTIONS

Time-history results are represents in form of graphs of time-displacement, time- velocity, time-acceleration for model 1 as below:

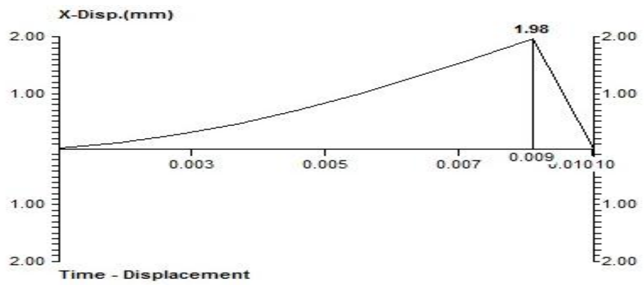

Fig-5: Average nodal time-displacement variation of top storey Model 1

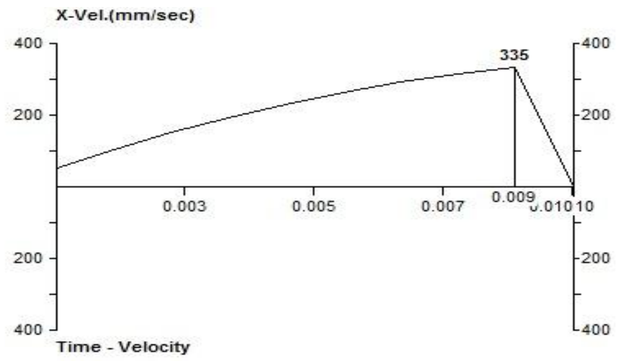

Fig-6: Average nodal time-velocity variation of top storey Model 1

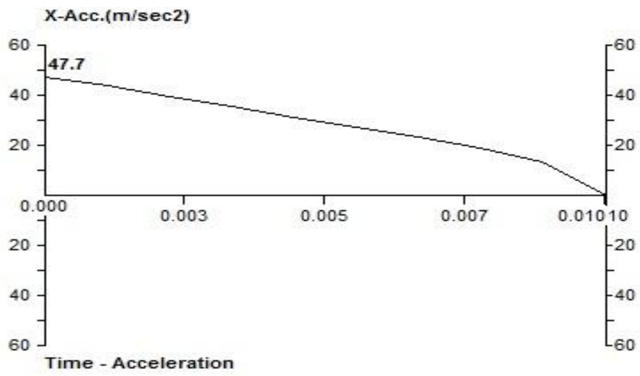

Fig-7: Average nodal time-acceleration variation of top storey Model 1

5. CONCLUSIONS

- Peak Reflected Overpressure P_{ro}, Storey displacement and Drift is increases with increase in the weight of blast and decreases as increase in standoff distance.
- Peak Reflected Over pressure is reduces as moved from ground story to upper story.
- As standoff distance increases, the maximum nodal displacement, the maximum velocity and the maximum acceleration decreases.
- As weight of blast increases, the maximum nodal displacement, the maximum velocity and the maximum acceleration increases.
- As the bay length increases there is decrease in storey displacement and drift.
- It is observed that shear wall is most effective in resisting blast effect. With the use of shear wall storey displacement is decreases by huge amount.
- Immediately after application of blast load uplift forces are acts on the supports, but their magnitude is so small that they can easily resist by the dead weight of structure.

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