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RESPONSE OF GRID SLAB MULTISTOREY BUILDINGS SUBJECTED TO BLAST LOAD

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Abstract: *The experimental investigation deals with the Response Of Grid Slab Multi storey Buildings Subjected To Blast Loads. ETABS software was selected for model and Response Spectrum Method of analysis is carried out to know the performance of the structure. Here, the model withG+5 and G+10 are compared with the blast load stand-off distance and their results are studied. The buildings are subjected to explosive charge weights with stand-off distances of 20m, 40m, 60m, 80m and 100m which are positioned on frontal side of building. The bang loads were computed according to UFC-3-340-02 (2008). The calculated blast pressures are multiplied with tributary areas and pressures are converted into point forces and assigned as static joint loads at frontal face(X-axis) of buildings. The results of structures when subjected to blast load is analyzed and results are compared to their safe stand of distance to both the buildings of G+5and G+10, the graphs are extracted for storey displacements, storey drift, story force & base shear.*

1. INTRODUCTION

Due to the increase in terrorist and explosion activities and even the natural activities, their effect on structure has become a severe issue that lead to damage of the structures, death of people and economical loss as well. The Explosions are termed as a sudden chemical response which happens in few millisecs ensuing in fast issue of energy and very hot gases in the nearby atmosphere. That marks in generating high pressure and temperature. In the blast the hot gases that were produced lodge the space nearby, that result in wave propagation over space which is spread spherically over a near by area.

These Explosions (blasts/bang) are distinguished on the basis of nuclear, chemical and physical disorder,

Physical Explosion – is Energy released is due to dangerous bang of compressed gases cylinders with high heat etc.

Nuclear Explosion -the Energy is lost by redistribution of protons and neutrons within in nucleus that result in creation of atomic nuclei.

Chemical Explosion –the Energy is lost by high rate of oxidation of hydrocarbon element such as carbon(C) and hydrogen(H) atom.

Bang Load on the structure The destruction caused by explosive depend on 1. Charge weight(W) in Kgs of TNT 2) the Stand of distances between the bang source & the structure. Threat on to a building a fixed van weapon located in purlieu. Fig 1 show van with weapon bang placed in the purlieu of building. The fig also show us that safe standoff distance. The propagation and the nature of the bang wave is also shown. The van can carry many kgs of TNT and depends on the building to be demolished.

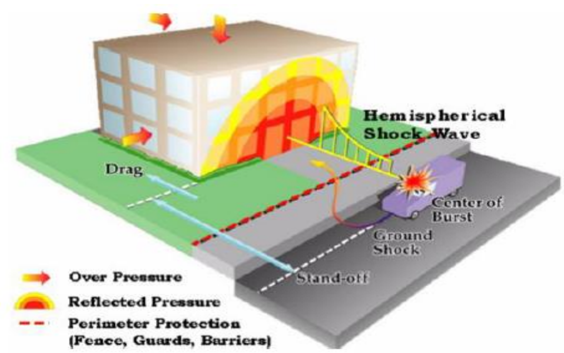


Fig 1 Vehicle Weapon Blast

It is impossible to say the propagation of wave is only in one direction. Therefore safety preparation should be meat in all the four way. The basement beams and columns are highly affected and so safety should be meat in all 4 way. So these have to be given more strength. Another possible way of protecting the building is by compound wall on all 4 way of the structure. The bang wave may affect window, outer wall, outer column, rising of floors, thrust on roofs etc.,

Grid Slab

Grid slab (waffle slab/slab) this form of slab are very popular this days and are used mostly in airports, hotels, banquet hall, car parks etc. the voids so formed can be used for architectural lightings. The slabs are more stable without must material usage. This makes it more applicable in large flat areas like foundations/floors. These types of foundations are crack resistant and sagging also can be controlled considerably than concrete slabs. The performance of these slabs is modified by the occurrence of these opening. But by putting opening it reduces the power of slabs.

HMX Explosives

HMX, also called octogen, is a powerful and relatively insensitive nitroamine high explosive, chemically related to RDX. Like RDX, the compound's name is the subject of much speculation, having been variously listed as High Melting Explosive, Her Majesty's Explosive, High-velocity Military Explosive, or High-Molecular-weight RDX.[1]

The molecular structure of HMX consists of an eight-member ring of alternating carbon and nitrogen atoms, with a nitro group attached to each nitrogen atom. Because of its high molecular weight, it is one of the most potent chemical explosives manufactured, although a number of newer ones, including HNIW and ONC, are more powerful.

OBJECTIVES

1. A G+5 and G+10 Storey Grid slab with blast point and distance are varied from 20m to 100m, these structures are modeled and the models are analyzed for blast load and the results are compared.
2. The detailed analysis is done on grid-slab structure for 100kg of HMX explosive charge.
3. The building models with grid slab with blast load are modeled and analyzed using ETABS Software.
4. To study the response of grid slab with blast load model with A G+5 and G+10 Storey models for base shear, storey drift, storey displacement, storey stiffness axial load and bending moments.
5. In order to know the behavior of the grid slab with blast load building.
6. In order to know the performance of the building and the safe blast load distance.

2. LITERATURE SURVEY

Naveen kumar Khatavakar et.al, in this paper it throws light on the importance of standoff distance. Here 2 multistorey building are considered and are subjected to blast loads with safe stand dist of 0.03km, 0.05km, 0.07km, 0.09km, 0.11km & 0.15km respectively. It is shown in distat which the building is safe against the bang load was found out for 2 cases. A F.E analysis ETABS was used. The study is limited to land blast only. Blast loads were estimated accordingly. At last the study concluded that at 0.07km for closed and 0.09km for RC frame building was the safe standoff distance.

Megha S. et.al, in this thesis a G+5 storey building exposed to 200,400 & 600kg of blast material with a standoff distance of 20, 40 and 60m was modeled. A code ofIS:4991 –1968 was used to find bang parameters. Analysis was done with ETABS with Time history analysis process. The responses of the building were shown with graphs. With source of the bang load and the charge weight of the explosive, response of the structure and safe standoff dist was found out. Shear wall and steel bracings were implemented on to structure in order to make the structure resistant to bang. It was conclude that for shear wall and steel bracing made the structure more resistible.

Shubham Pathak et.al, in this study two disparities,i.echarge weights and standoff distance was considered for analysis. Regular and irregular structures were considered for analysis. Blast load parameters were calculated and analyzed using ETABS. The responses were tabulated. It was conclude that for irregular structure showed higher Inter-Storey drift values, because of low pressure intensity on upper floors.

Thejashwini S et.al, in the study charge weights of 100 to 250kg with an interval of 50kgand safe standoff dist b/w 15 to 24 m with a constant interval of 3m where compared. The IS: 4991 specifications were used. By the graphical representation showed that as the blast intensity increased number of structural elements failed in the building. It was concluded as the magnitude and stability of the building increases as the standoff distance increase.

3. MODELLING AND ANALYSIS

The model & the analysis of the structure are carried-out in ETABS. Time History Method was used for the analysis of structure.

Grid slab building Model

Number of stories = G+5 and G+10
C/C distance b/n columns in X-direction= 6m
C/C distance b/n columns in Y-direction = 6m
Foundation level to ground level = 3.2m
Floor to floor height= 3.2m
Live load on all floors= 3kN/m^2
Floor Finish (dead load) = 1.5kN/m^2
Materials= M25 and Fe415
Size of column= 500x500mm
Soil Type = II

Grid slab properties
Type of steel = Fe 415
Grade of concrete= M25
Overall depth = 400mm
Slab thickness = 100mm
Stem width at top = 125mm
Stem width at bottom = 125mm
Spacing of ribs along X-direction = 1000mm

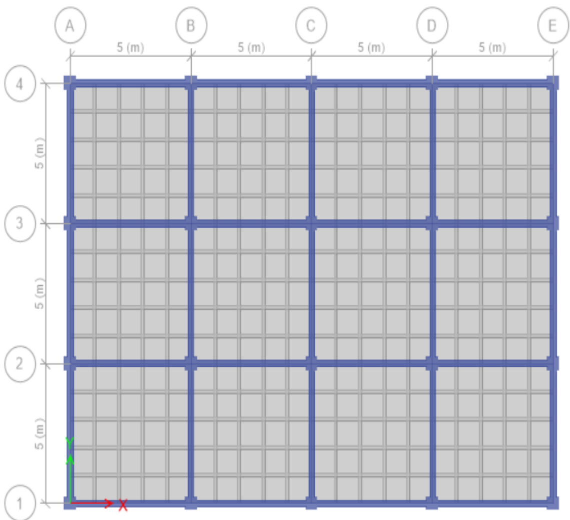


Fig 2 Plan of Model

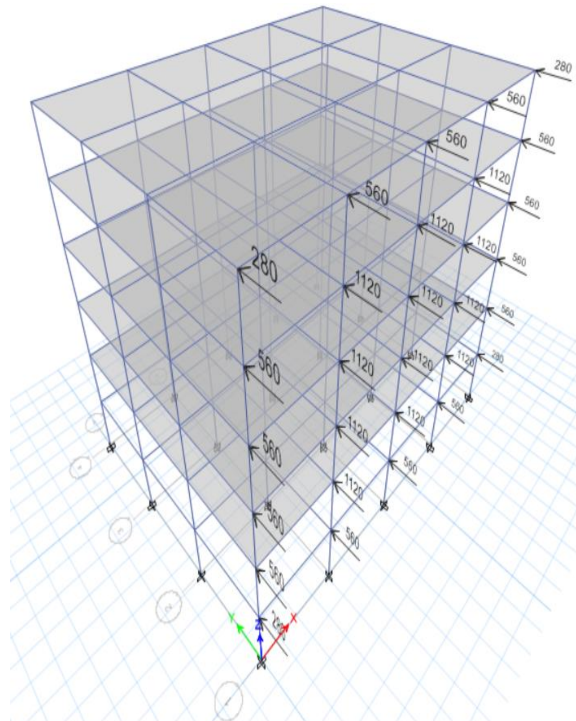


Fig 3 Blast loads on frontal face of (G+5) Grid-slab structure at 10m

Table 1 Blast load acting on front face of the building for (G+5) grid-slab structure

Stand-off Distance (m)	Pressure on front face wall(kN/m^2)	Joint 1		Joint 2		Joint 3		Joint 4	
		Area (m^2)	Load (kN)	Area (m^2)	Load (kN)	Area (m^2)	Load (kN)	Area (m^2)	Load (kN)
10	70	4.0	280	8.0	560	8.0	560	16	1120
20	45	4.0	180	8.0	360	8.0	360	16	720
30	31	4.0	124	8.0	248	8.0	248	16	496
40	22	4.0	88	8.0	176	8.0	176	16	352

Table 2 Static-joint loads on front side of (G+10) Grid-slab structure

Stand -off Distance (m)	Pressure on front face wall (kN/m^2)	Joint 1		Joint 2		Joint 3		Joint 4	
		Area (m^2)	Load (kN)	Area (m^2)	Load (kN)	Area (m^2)	Load (kN)	Are a (m^2)	Load (kN)
10	50	4.0	200	8.0	400	8.0	400	16	800
20	33	4.0	132	8.0	264	8.0	264	16	528
30	27	4.0	108	8.0	216	8.0	216	16	432
40	20	4.0	80	8.0	160	8.0	160	16	320

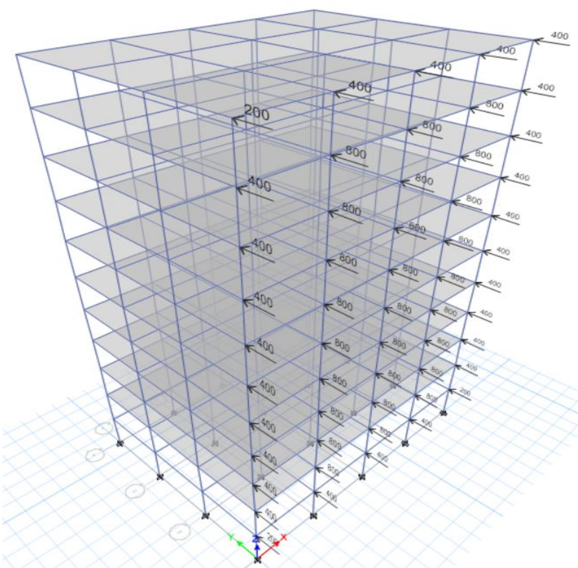


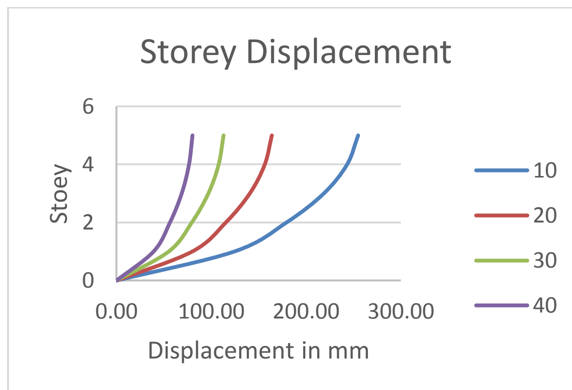
Fig 4 Blast loads on frontal face of (G+10) Grid-slab structure at 10m

4. RESULTS AND DISCUSSIONS

a. Storey Displacement

Table 3 Storey Displacement

Storey	Stand-off distance (m)			
	10	20	30	40
5	254.87	163.85	112.87	80.10
4	243.26	156.38	107.73	76.45
3	218.69	140.59	96.85	68.73
2	179.27	115.25	79.39	56.34
1	124.34	79.93	55.07	39.08
0	0.00	0.00	0.00	0.00



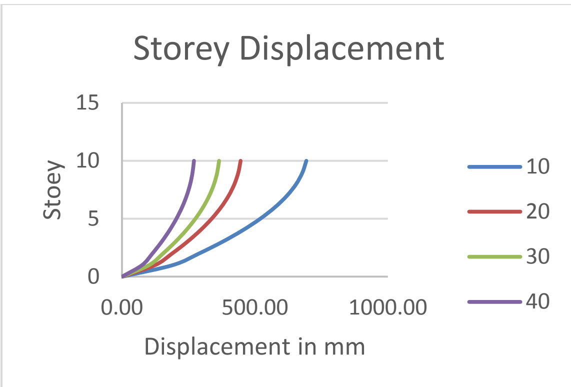
Graph 1 Storey Displacement

The graph of G+5 storied building when subjected to blast with varying stand of distances, it can be seen that as the stand of distance increases its impact on the building reduces hence the response of the building also to blast loads also decreases. It was seen that the top storey displacement of building with stand of distance 40m was seen to be 3.17 times more than the building which is at 10m stand of distance.

Table 4 Storey Displacement

Storey	Stand-off distance (m)			
	10	20	30	40
10	692.88	445.75	364.70	270.15
9	678.60	437.26	357.76	265.01
8	654.86	422.69	345.83	256.17
7	620.52	401.13	328.20	243.11
6	575.45	372.49	304.77	225.75
5	519.70	336.81	275.57	204.13

4	453.39	294.15	240.67	178.27
3	376.64	244.59	200.12	148.23
2	289.49	188.15	153.94	114.03
1	191.20	124.36	101.75	75.37
0	0.00	0.00	0.00	0.00



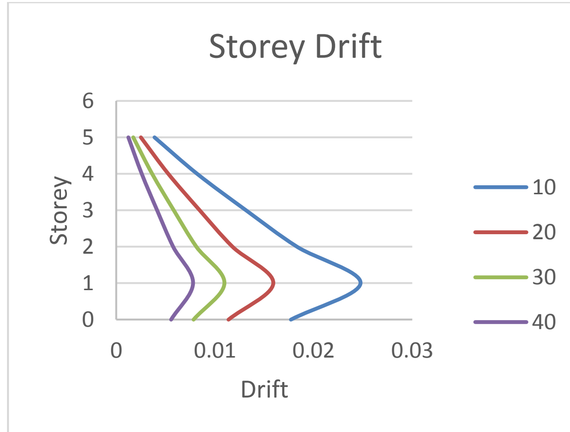
Graph 2 Storey Displacement

The graph of G+10 storied building when subjected to blast with varying stand of distances, it can be seen that as the stand of distance increases its impact on the building reduces hence the response of the building also to blast loads also decreases. It was seen that the top storey displacement of building with stand of distance 40m was seen to be 2.56 times more than the building which is at 10m stand of distance.

b. Storey Drift

Table 5 Storey Drift

Storey	Stand-off distance (m)			
	10	20	30	40
5	0.003869	0.002487	0.001713	0.001216
4	0.00819	0.005265	0.003627	0.002574
3	0.01314	0.008447	0.005819	0.00413
2	0.018311	0.011772	0.008109	0.005755
1	0.024748	0.015907	0.010956	0.007773
0	0.017692	0.011368	0.007827	0.005551

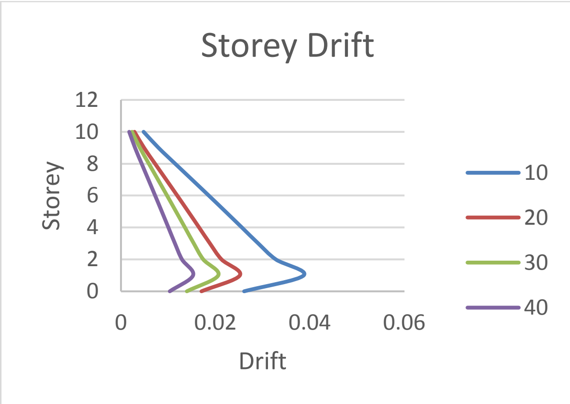


Graph 3 Storey Drift

The graph of G+5 storied building when subjected to blast with varying stand of distances, it can be seen that as the stand of distance increases its impact on the building reduces hence the response of the building also to blast loads also decreases. It was seen that the top storey drift of building with stand of distance 40m was seen to be 3.18 times more than the building which is at 10m stand of distance.

Table 6 Storey Drift

Storey	Stand-off distance (m)			
	10	20	30	40
10	0.004761	0.002828	0.002314	0.001714
9	0.007912	0.004859	0.003975	0.002945
8	0.011448	0.007185	0.005879	0.004355
7	0.015024	0.009545	0.00781	0.005785
6	0.018581	0.011894	0.009732	0.007209
5	0.022103	0.014221	0.011635	0.008619
4	0.025584	0.016521	0.013517	0.010013
3	0.029052	0.018812	0.015392	0.011401
2	0.032763	0.021262	0.017396	0.012886
1	0.038673	0.025146	0.020572	0.015237
0	0.026056	0.017025	0.013927	0.010312



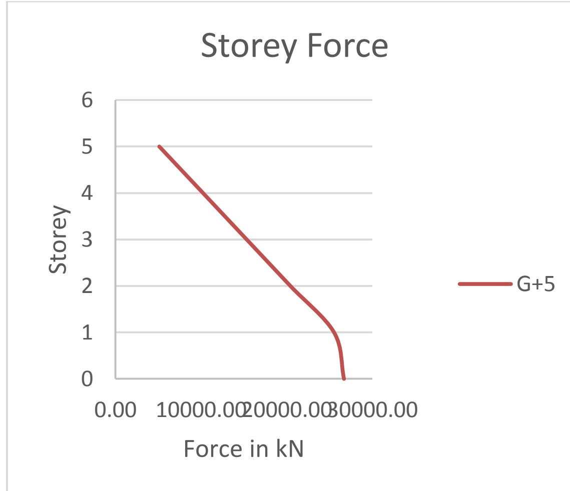
Graph 4 Storey Drift

The graph of G+10 storied building when subjected to blast with varying stand of distances, it can be seen that as the stand of distance increases its impact on the building reduces hence the response of the building also to blast loads also decreases. It was seen that the top storey drift of building with stand of distance 40m was seen to be 2.77 times more than the building which is at 10m stand of distance.

c. Storey Forces

Table 7 Storey Forces

Storey	Force
	G+5
5	5104.20
4	10208.40
3	15312.60
2	20416.80
1	25521.00
0	26684.75

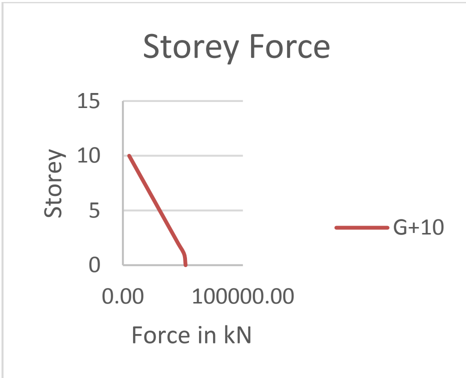


Graph 5 Storey Forces

The graph of G+5 storied building when subjected to blast with varying stand of distances, it was seen that with varying standoff distances the storey forces remained constant.

Table 8 Storey Forces

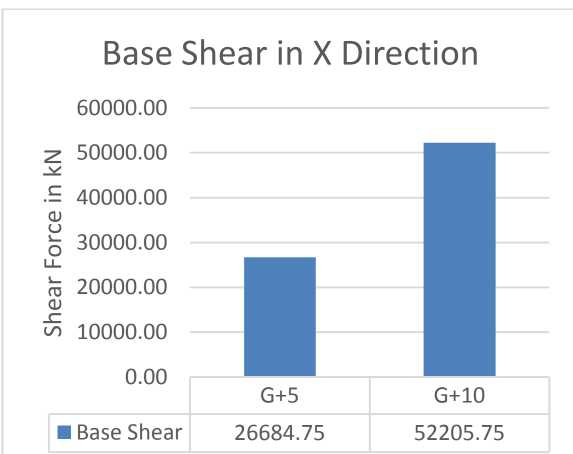
Storey	Force
	G+10
10	5104.20
9	10208.40
8	15312.60
7	20416.80
6	25521.00
5	30625.20
4	35729.40
3	40833.60
2	45937.80
1	51042.00
0	52205.75



Graph 6 Storey Forces

The graph of G+10 storied building when subjected to blast with varying stand of distances, it was seen that with varying standoff distances the storey forces remained constant.

d. Base Shear



Graph 7 Base Shear

The graph of G+5 and G+10 storied building when subjected to blast with varying stand of distances, it was seen that has the height of the building increases base shear was seen to be increases. The base shear value of G+10 storied building is seen to be 1.95 times more that the G+5 storied building.

CONCLUSION

1. The results show that the buildings when subjected to blast load, the storey displacement of the G+5 building is seen to be comparatively less when compared to that of G+10, it was observed that as the stand off dist increases the structure is less prone to damages.
2. The storey drift values of the building is also seen to be comparatively less in G+5 in comparison to that of G+10 building, it was observed that as stand off dist increases structure is less prone to damages.
3. The storey forces in the building is seen to be much higher in G+10 building to that of G+5 storied building. As height of structure increase the shear force offered by the building also increases.
4. The base shear is also seen to be higher in the G+10 as compared to G+ 10 storied structures, as the height of the structure increases base shear also increases.
5. The magnitude and stability of the structure surges with the increase in the standoff distance.
6. The Significant structures such as banks, hospitals, Embassies, monumental buildings, historical buildings, government buildings, federal buildings etc. are to be taken care while designing and analysis to withstand blast effect within permissible limits.
7. A proper making use of guidelines one could make buildings more resistant to blast, but these guidelines are very rarely used as it makes the buildings robust in nature.
8. It is seen that by make simple symmetric frame structures damage can be minimized as they offer greater resistant to external loads.

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