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Analysis and Design of Blast Resistant Structures

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Abstract: To design structures to resist blast is becoming important these days. Although designing structures to blast is well understood to obtain the effect of attenuation through soil on buried structures using the certain existing software is to be explored, therefore a point worth highlighting in this paper is a novel technique of an imaginary boundary is created on which the overpressure from the explosive is determined based on distance and yield of the explosive. The pressure on the imaginary boundary is thus applied which furthers transferred to the building model through the soil which is modeled in SAFE SOFTWARE. The pressure which reaches the model would have been subjected to the soil properties like attenuation. The above novel technique is developed in order to obtain the effect of soil on buried structures.

Keyword: attenuation

I. INTRODUCTION

Blast resistant materials or Blast resistance design might be a costly affair. Its knowledge is far beyond the reach of common people. But, the common people are not far from the reach of blast attacks.

To help common people and our armed forces too to survive these kinds of blast. We have tried to find an affordable and accessible solution.

Buildings get displaced enormously during blasts, due to which lives are lost.
So considering this aspects of Blast, after doing lot of research and experiments
We have developed a solution.
We found out that instead of Blast resistant Structures or design, we can minimize the response and effects due to blast by the way we construct it.
We have made an attempt to find out the responses of the structures situated above ground level and also structures situated below ground level using ETABS and SAFE software.

II. ABOUT : SAFE

This paper describes blast response analysis results of a single storey (RCC and STEEL) using ETABS above ground level and is compared the analysis result with those from a SAFE below ground level.

We have used SAFE mainly for soil modeling.

III. LITERATURE REVIEW

Sourish Mukherjee et.al (2017)[1]
The main aim of this paper is to study the review paper and its work on the effect of the blast loading on the structures that has previously done and is continuing till now. For designing the blast resistant structures would be uneconomic. It describes information about explosion.

Gautam.C,pathak. R (2013)[2]
They designed and developed a shock blast resistance structures capable of withstanding dynamic loading of 12psi and a static pressure of 1.5m earth cover due to blast.and evaluated it experimentally.

Abhroop goswami, alaukk Singh satadru Das abhikary(2017)[3]
In this journal experiment had proved that ultra-high performance Fiber concrete is effective in resisting blast load.

Sajal Verma, mainak choudhury purnachandra Saha (2015)[4]
In this paper they made an attempt to review the different methods which are been applied to various type of structures like concrete, steel and masonry. In this paper they discussed FRP retrofit technique to protect the blast made of steel structures with dampers due to which no cracks are visible and there is no damage occurred in any of the walls and steel structures as the internal energy is dissipated by the dampers.

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IV. OBJECTIVE:

The main aim of this work is to find out the responses of the structure situated below and above the Ground level. Thus analyzing which structure is more blast resistant.

V. METHODOLOGY

Two similar models of plan dimensions 5m*4m*3m are considered. The thickness of wall and slab are 200mm and 150 mm respectively. The plan of structure situated above ground level is as shown in figure 1. To this structure an over pressure is applied to the side of the model and also a soil pressure is applied to the model and is analyzed. The plan of a structure situated below ground level is as shown in figure 2. To this structure an over pressure is applied considering an imaginary line away from the model and a soil pressure is applied around it and is analyzed. Thus analyzing which structure is more blast resistant. The calculations are based on **IS: 4991-1968** which is the criteria for blast resistant design of structures for explosions above ground. Basically the manual calculation is done using code **IS: 4991-1968** keeping the same blast load and varying the standoff distance the overpressure is calculated and then the manually calculated overpressure is applied to the models. The analysis is carried out using ETABS (2016) and SAFE

VI. MODELING AND ANALYSIS

A single storey building of plan dimension 5*4*3m the size of beam 200*300 and size of column 300*300 for concrete structures are used for modeling. For steel structures ISWB is used for column and ISLB is used for beams. In the above structures the models are made using ETABS and below structures are made using SAFE software's.

The analysis was carried out for the model as described as follows.

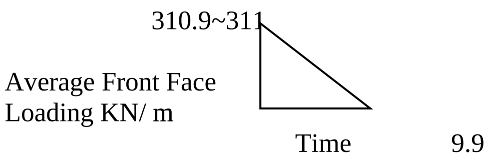
Model 1: Reinforced structure situated above ground level
Model 2: Reinforced structure situated below ground level
Model 3: Steel structure situated above ground level
Model 4: Steel structure situated below ground level

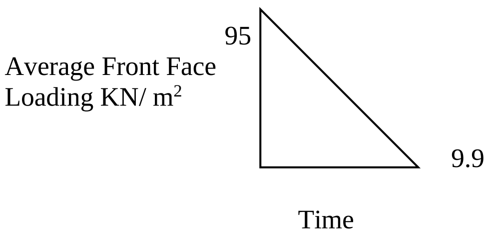
Different Models:

MODEL1.1- Blast load of 200kg yield at 20m standoff distance
MODEL1.2- Blast load of 200kg yield at 40m standoff distance
MODEL1.3- Blast load of 300kg yield at 20m standoff distance
MODEL 1.4- Blast load of 300kg yield at 40m standoff distance

MANUAL CALCULATION

200kg yield used from 20m standoff distance.
x= actual distance/$w^{1/3}$
x=20/$(0.2)^{1/3}$
x=34.199m
From IS 4991-1968
P_{so}=1.12006kg/cm^2
P*ro*=3.17kg/cm^2
qo=0.388kg/cm^2
Scaled time to and td
to =25.65*$(0.2)^{1/3}$=15.002
td =16.9614*$(0.2)^{1/3}$=9.919
M=1.396
a =344m/s u=480.224=0.48m/millisecond
Pressure on building
H=3m L=4m B=5m
S=H or B/2 whichever is less
tc= 3S/u=3*2.5/0.4802=15.6184millisecond
tt =L/u=4/0.4802=8.329millisecond
tr=4s/u=4*2.5/0.4802millisecond
tr> td no pressure on back face and is zero
For roof and sides cd=-0.4
P_{so}+cdqo= 1.120+ (0.4)*0.388=0.964kg/cm^2
Conversion from kg/cm^2 t kN/m^2
P_{so}+cdqo =94.56kN/m^2
3.17kg/cm^2=3.17*9.81 N/cm^2
= (31.09N)/ (10^{-4}m^2)
=310.9kN/m^2
Pressure diagram





Pso= Peak side-on overpressure
Pro =Peak reflected overpressure
M= Mach number for incident shock front

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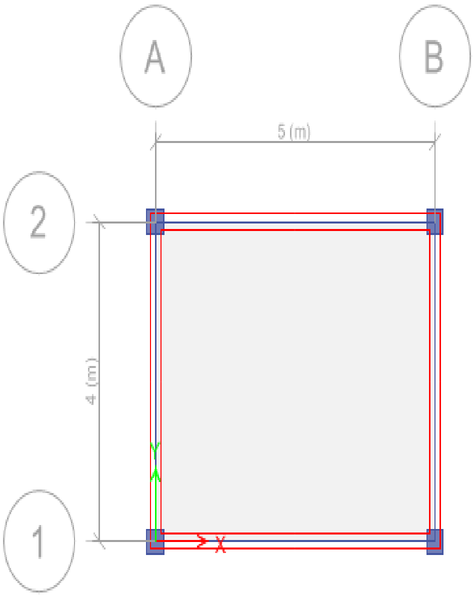
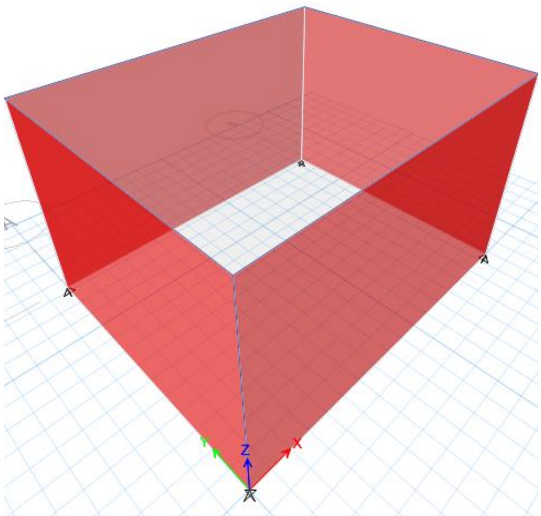


Plan of the structure above ground level



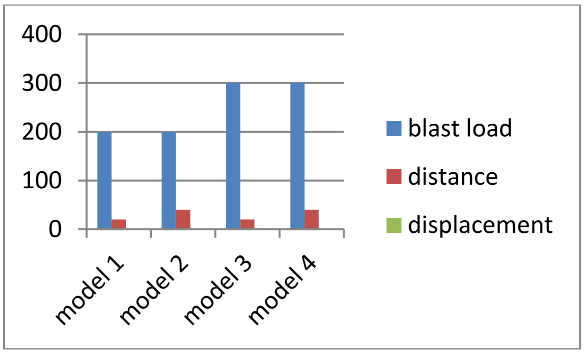
3-D view of a structure above ground level

VII. ANALYSIS AND RESULTS:

The overpressure is applied to the models and is analyzed. The analysis results are tabulated below

Response values for concrete above ground level

Blast load (Kg)	**standoff distance (m)**	**Overpressure (kN/m2)**	**displacement (mm)**	**Moment (kN-m)**	**Max stress**	**Shear force (kN)**
200	20	311	0.0629	0.0635	-0.08	-0.0262
200	40	72	0.01421	-0.0094	0.0255	0.0044
300	20	419	0.0827	-0.0547	-0.15	-0.0254
300	40	91.88	0.018135	0.012	-0.022	-0.0056



	Blast load	**distance**	**displacement**
Model 1	**200**	**20**	0.0629
Model 2	**200**	**40**	0.01421
Model 3	**300**	**20**	0.0827
Model 4	**300**	**40**	0.018135

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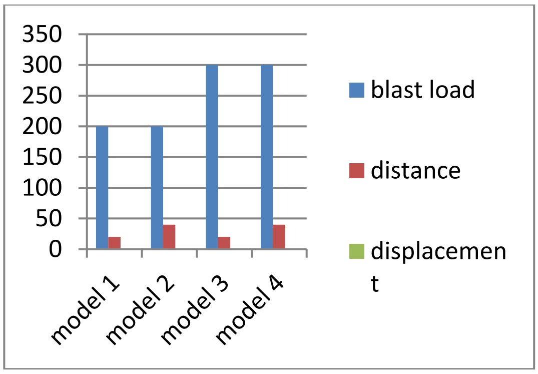
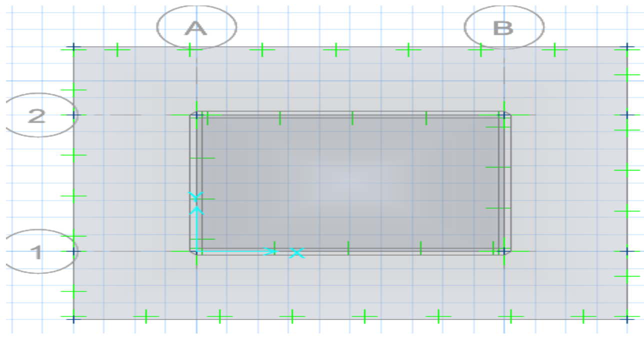
Response values for steel above ground level

Blast load (Kg)	**standoff distance (m)**	**Over pressure (kN/m2)**	**displacement (mm)**	**Max stress**	**Moment (kN-m)**	**Shear force (kN)**
200	20	311	0.0075	-0.24	0.0914	-0.0516
200	40	72	0.00174	-0.028	-0.0212	-0.0119
300	20	419	0.0101	-0.48	0.1231	-0.0695
300	40	91.88	0.00222	-0.068	-0.027	-0.0152



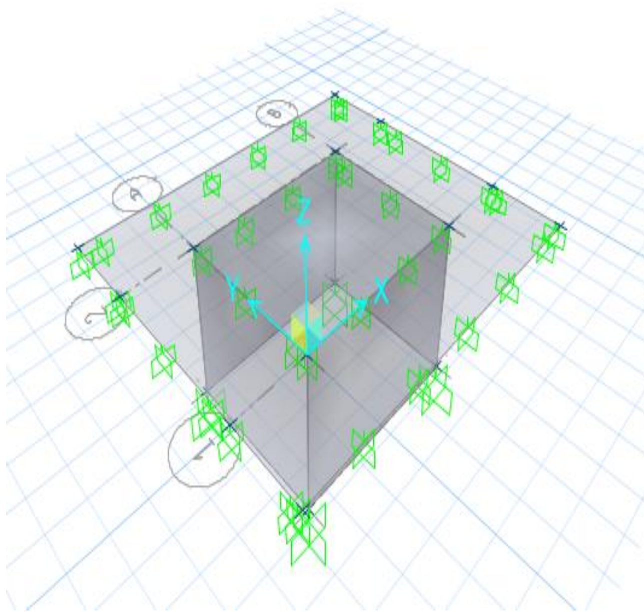
	Blast load	**distance**	**displacement**
Model 1	**200**	**20**	0.0075
Model 2	**200**	**40**	0.00174
Model 3	**300**	**20**	0.0101
Model 4	**300**	**40**	0.00222

Response values for structures below ground level



Plan of a structure above ground level

Here we considered imaginary line away from structure; soil pressure is applied around it and An overpressure is applied to the side of a structure



3-D view of a structure below ground level

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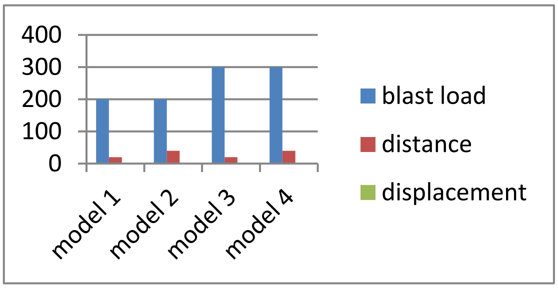
Response value of concrete below ground level

Blast load(Kg)	stand off distance(m)	Overpressure (kN/m	Nodal displacement (mm)	Max stress	moment	Shear force
200	20	311	0.0093	107.54	740.36	199.80
200	40	72	0.0045	11.905	23.5649	-82.817
300	20	419	0.0088	72.168	57.1206	-566.02
300	40	91.88	0.0087	15.312	30.1223	-108.24

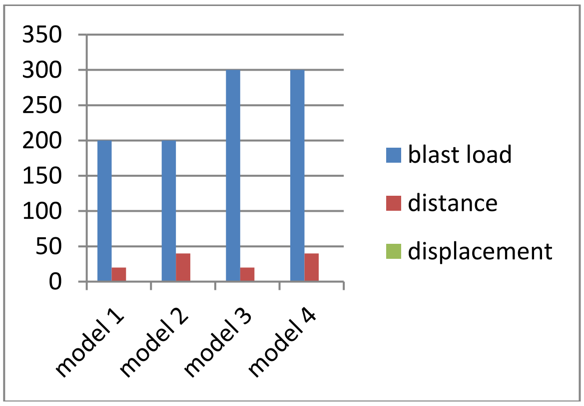


	Blast load	distance	displacement
Model 1	**200**	**20**	0.0093
Model 2	**200**	**40**	0.0045
Model 3	**300**	**20**	0.0088
Model 4	**300**	**40**	0.0087

Response value of steel below ground level

Blast load(Kg)	stand off distance(m)	Overpressure (kN/m2)	Nodal displacement (mm)	Max stress	moment	Shear force
200	20	311	0.01085	62.25	113.81	-333.65
200	40	72	0.014732	14.43	26.94	-77.316
300	20	419	0.01102	86.16	153.34	-456.56
300	40	91.88	0.014736	18.0167	34.24	-95.31

	Blast load	distance	displacement
Model 1	**200**	**20**	0.01085
Model 2	**200**	**40**	0.014732
Model 3	**300**	**20**	0.01102
Model 4	**300**	**40**	0.014736



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VIII. CONCLUSIONS

1. Although, effect of blast loads on structures above ground is well understood, the effect of buried structures is not so well understood because to model and soil which attenuates the blast effect is very complex.
2. Very important structures like government offices, historical structures and malls should be analyzed and designed to withstand blast load.
3. With the advent of the modern software such as SAFE which can model soil effectively it has been possible to set the effect of attenuation through soil.
4. But even modeling using SAFE is not very straightforward, a new technique of creating an imaginary boundary on which the overpressure are obtained .then the effect of attenuation of the blast effect from the imaginary boundary onwards towards the building is obtained.
5. In the present work, using SAFE the soil has been modeled and the effect of a attenuation has been obtained.
6. It is found that the effect of the blast loads on buried structures is significantly less compared to that on above structures.

IX. ACKNOWLEDGMENT

I would like to thank Professor B.K. RAGHUPRASAD and also our principal R V PRAVEENA GOWDA who gave me a chance for doing this innovative technique on ANALYSIS AND DESIGN OF BLAST RESISTANT STRUCTURES .At last I would like to thank my loved parents and friends.

X. REFERENCES

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