ANALYSIS OF RCC BUILDING SUBJECTED TO SURFACE BLAST LOADING

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ABSTRACT : The aim of the project is to analysis and design a building to an adequate level of blast resistance. The blast explosion nearby or within structure is due to pressure or vehicle bomb or quarry blasting. These causes catastrophic damages to the building both externally and internally (structural frames).Resulting in collapsing of walls, blowing out of windows, and shutting down of critical life-safety system. Buildings, bridges, pipelines, industrial plant dams etc are the life structure and they an important role in the economy of the country and hence they have to be protected from dynamic and wind loading.

***Key Words*: (Analysis, Design, safety)**

1. INTRODUCTION

World occasions happening in ongoing history have added to a making an open impression of the essence of expected dangers. The prime thought of frailty despite likely dangers. The prime thought in numerous examples is the explosion of a touchy gadget inside, or in the region of the structure. As of late, in light of expanded enthusiast exercises, common structure are presented to dangers from impact – initiated incautious burdens. A few such episode have occur the world over, making genuine danger life and property.

1.1 Explosive

A hazardous (or unstable material) is a receptive substance that contain a lot of potential vitality that can deliver a blast whenever discharged out of nowhere, normally joined by the creation of light, warmth, sound, and weight.

Dangerous material might be ordered by the speed at which they grow. Material that explode are supposed to be high touchy and material that deflagrate are supposed to be low unstable

Detonation-It is a form of reaction of explosive which produces high intensity of shock waves.

Deflagration-The explosive decomposes at a rate much below the speed of sound in the material.

They can also be classified on the basis of their sensitivity to ignition as secondary or primary explosive. The latter is one that can be easily denonated by simple ignition from a spark, flames or impact. Material such as mercury fulminate and lead azide are primary explosive. Secondary explosive when detonated create blast waves which can result in widespread damage to the surrounding . Example include trinitrotoluene (TNT)

TNT is accepted as a standard or reference explosive, since the preponderance of effects data used for analysis and prediction are based on the explosive.

1.2 Explosion

An explosion is a rapid increase in volume and release of energy in an extreme manner, usually with the generation of high temperature and release of gases. Supersonic explosion created by high explosive created by high explosive are known as detonation and travel via supersonic shock waves

Physical–Eruption of volcano, catatrophic failure of cylinder of compressed gas and pressure vessel, violent mixing of two liquids at different temperature

Nuclear-This includes fission and fusion which release large amount of energy.

Chemical-Rapid oxidation of fuel element contained within the explosive compound

Unconfined blasts, outer to structure can be recognized in three essential sorts, which rely upon the general situation of the hazardous source and the structure to be secured , i.e on the stature H over the ground where the explosion of a charge W happens, and on the even separation RG between the projection of the unstable to the ground and the structure. These three blast types are-

a) Free air burst-The explosive charge is detonated in the air, the blast waves propagate spherically outward and impinge directly onto the structure without prior interaction with other obstacle or the ground.

b) Air burst-The explosive charge is detonated in the air, the blast waves propagate spherically outward and impinge onto the structure after having interacted first with the ground ,a mach wave is created

c) Surface burst-The explosive charge is detonated almost at ground surface, the blast waves immediately interact locally with the ground and they propagate hemispherically outward and impinge onto the structure.

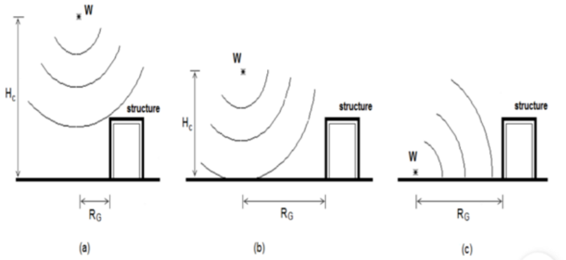


Fig.1 Types of external explosion

2. PROBLEM STATEMENT

The impact blast close by or inside structure is because of weight or vehicle bomb or quarry impacting. The reason cataclysmic harm to the structure both remotely and inside. Result in falling of dividers, smothering of windows, and closing down of basic life-security. Building, spans, pipelines, modern plants dam and so on are the help structure and they assume significant a significant job in the economy of the nation and consequently they must be shielded from dynamic and wind stacking.

2.1 Blast wave

Impact wave happen when a high hazardous explodes in a free field, that is, with no surface close by with which it can connect. Impact waves have properties anticipated by the material science of waves. They can diffract through a restricted opening, and refract as they go through material. like light or sound waves, when an impact wave arrives at a limit between two material, some portion of it is transmitted, some portion of it is reflected. The impedance of the two material decides the amount of each happens.

2.2 Blast wave propogation

The fast development of hot gases coming about because of the explosion of a touchy charge offers ascend to a pressure wave called stun wave, which propogates through the air. The front of stun wave can be viewed as boundlessly steep, for every commonsense reason. That is, the time required for pressure of the undisturbed air only in front of the wave to full weight simply behind the wave is basically zero. From the figure 1 it very well may be reasoned that if the dangerous source is circular, the subsequent stun wave will be round, since its surface its surface is consistently expanding, the vitality per unit territory ceaselessly diminishes.

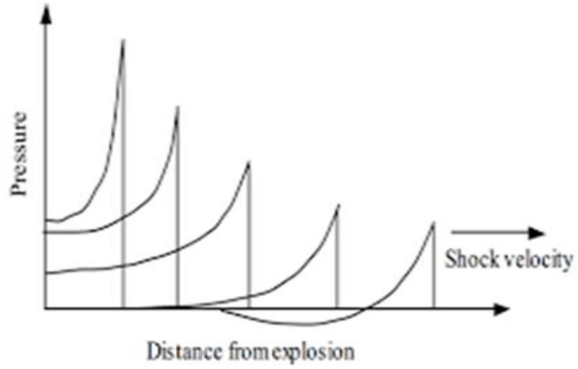


Fig.2 Blast wave propagation

2.3 Blast wave time-pressure history

Thusly, as the stun travel outward from the charge, the weight in the front of the wave, called the pinnacle pressure, consistently diminishes. At huge span from the charge, the pinnacle pressure is little, and the wave can be treated as sound wave. Behind the stun wave front, the weight in the wave diminishes from its underlying pinnacle esteem. At some good ways from the charge, the weight behind the stock front dividers to an incentive underneath that of the air and afterward rises again to a consistent worth equivalent to that of the climate is known as the positive stage and, quickly tailing it, the part wherein the weight is not as much as that of the air is known as the negative or pull stage.

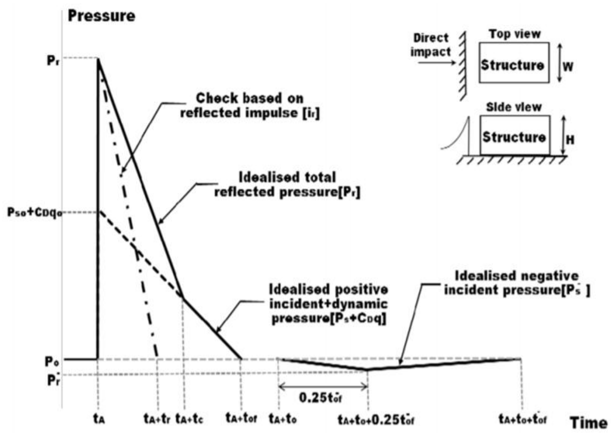


Fig.3 Blast pressure time-history

3. RESEARCH METHODOLOGY

3.1 Planning schedule/flow chart

This chapter deals with methodology that was adopted for progression of the project work.

Topic Selection.

Study of ETABS Software.

Modeling and analysis of the building with help of ETABS Software

Computing the results

3.2 Study of ETABS software

ETABS is a designing programming item that takes into account multi-story building investigation and plan. Displaying apparatuses and layouts, code-based burden remedies, investigation strategies and arrangement methods, all facilitate with the network like geometry novel to this class of structure. Fundamental or propelled frameworks under static or dynamic conditions might be assessed utilizing ETABS. For a refined evaluation of seismic execution, modular and direct-reconciliation time-history investigations may couple with P-Delta and Large Displacement impacts.

Key to ETABS displaying is the speculation that multi-story structures commonly comprise of indistinguishable or comparative floor designs that rehash in the vertical bearing. Clients may determine a boundless number of burden cases and blends. Investigation abilities at that point offer progressed nonlinear strategies for portrayal of static-weakling and dynamic reaction. Dynamic contemplations may incorporate modular, reaction range, or time-history examination. P-delta impact represent geometric nonlinearity

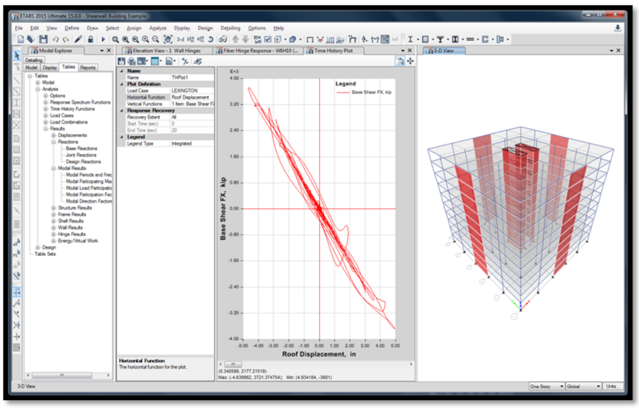


Fig.4 Typical window of ETABS 2015

4.MANUAL CALCULATION

Analysis of Building subjected to surface blast loading with charge of 100TNT and sight-off distance 20meters.

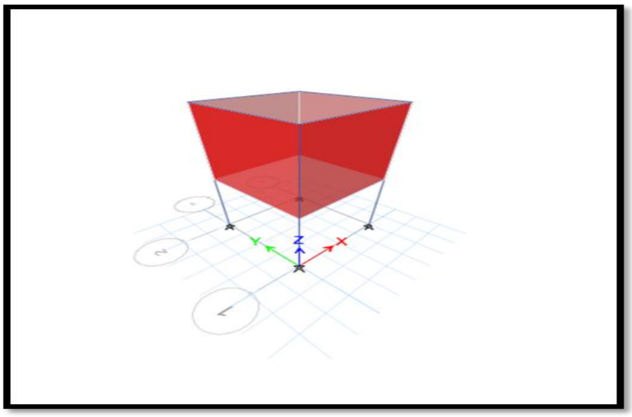


Fig.5 Sample Model

4.1 Specification of model

Standoff distance-20 meters.
Dimension of building -3m X 3m X 3m
TNT weight-100 kg
Thickness of slab-120mm
Beam dimensions-230mm X 300mm
Column dimension- 300mm X 300mm

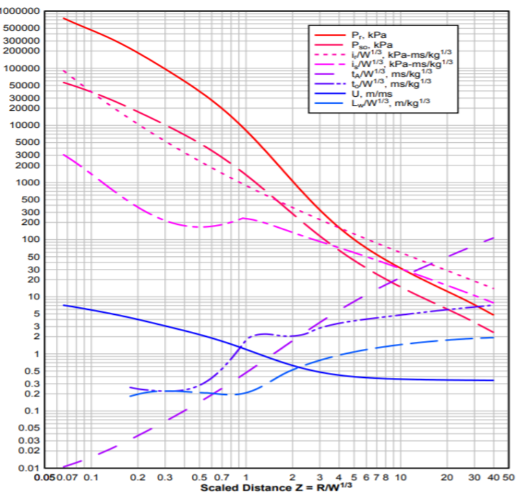


Fig.5 Graph to calculate positive phase blast loads from surface burst

4.2 Manual Calculation for Model

Height of the sample building = 3m
Stand -off distance =20m
Front wall pressure =1.5m
Distance from blast surface $(R_h) = (20^2 + 1.5^2)^{0.5}$
$= 20.056$ m
Scaled distance $(z) = R_h / w^{1/3}$
$= 20.06/100^{1/3}$
$= 4.31$ m
For the scaled distance of 4.32 m , the value for pressure impulse parameter & that for time can be obtained by interpolation from the graph

- POSITIVE PHASE

1. Reflected pressure (P_r) = 269.1Kpa
2. Incident pressure (P_{so}) =53.6 Kpa
3. Positive incident impulse (i_s)=56.8Kpa
4. Positive reflected impulse (i_r)=174.4 Kpa
5. Arrival time (t_A) =6.64Kpa
6. Shock wave pressure (U)=0.4m
7. Wave length (l_w)=1 m
8. Positive duration (t_o) =3.64ms

Now the velocity of sound obtained from graph

C_r =0.3776

Again by interpolation from graph of C_r, Vs, P_{so} for an incident pressure of 53.6 kpa , the value of C_r is as above

- Fictious positive phase duration (t_{of}) = 2 X i_s /P_{os} = 2X56.8 /53.6

=2.11ms

- Fictious duration of reflected pressure (t_{rf}) = $2i_r/P_{ro}$ =2X174.4/168 =2.075ms
- Now for peak dynamic pressure

1. Peak dynamic pressure (q_o) = 10.44kpa
2. Considering the drag coefficient (C_D) =1.0

- Reduced peak pressure from equation P_{so} + $C_D.q_o$ is 165.14 kpa
- NEGATIVE PHASE

1. Reflected negative pressure (P_{r-}) = 0.06Mpa
2. Incident negative pressure (P_{so-}) =0.051Mpa
3. Negative incident impulse (i_{s-})=0.263 Mpa.ms
4. Negative reflected impulse (i_{r-})=0.383 Mpa.ms
5. Negative duration (t_{o-}) =10ms
6. Negative wavelength (l_{w-}) = 1.98 m

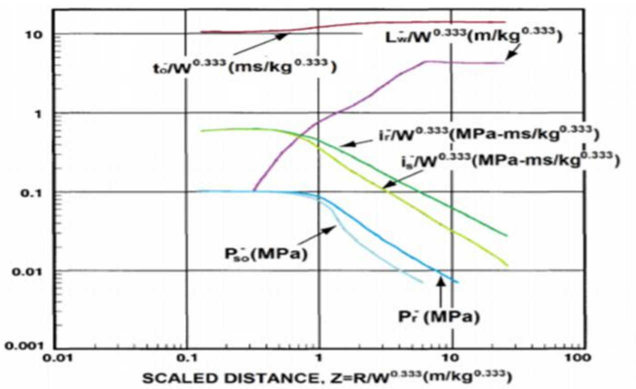


Fig.6 Negative phase of blast loads from surface burst

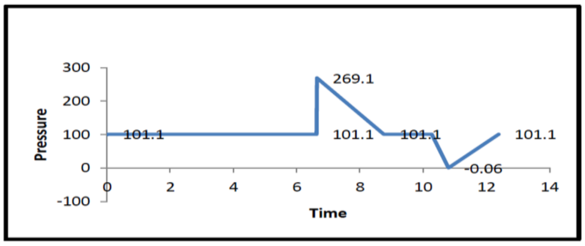


Fig.7 Time Pressure History from Manual Calculation

4.3 Results

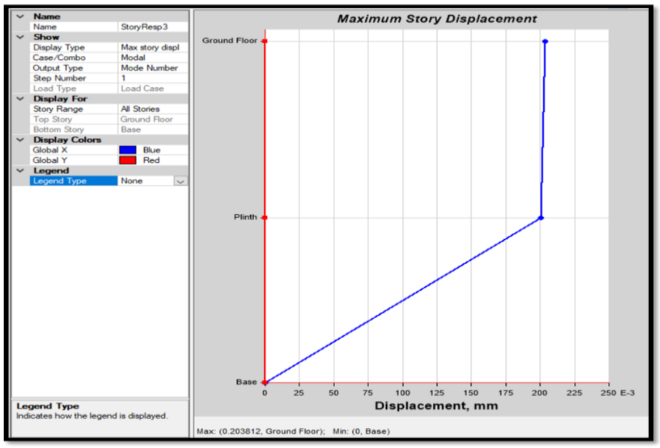


Fig.8 Analysis of model in ETABS subjected to blast load.

Story	Elevation	X-Dir	Y-Dir
	M	mm	mm
Ground Floor	5.8	0.204	2.45E-05
Plinth	2.8	0.201	2.411E-05
Base	0	0	0

Results from ETABS for storey displacement.

5. PROBLEM STATEMENT

Analysis and Design of (P+5) structure subjected to surface blast loading located at Swargate, Pune

5.1 Building specification

1. Column size-300mmX300mm
2. Beam size-300mmX450mm(width*depth)
3. Slab Thickness-150mm
4. Shear wall thickness-300mm
5. Plinth level from base-2500mm
6. Parking Height-2700mm

7. Floor to floor height- 3000mm
8. Grade of concrete- M30

❖ **EARTHQUAKE DATA-(considered in X and Y direction)**

1. Site Location- Pune
2. Zone-III
3. Z-0.16
4. Soil type- Medium

IS 1893(Part1) :2016

Analysis is done by Response Spectrum Method

5.2 Response Spectrum Method

Response-spectrum analysis (RSA) is a linear-dynamic statistical analysis method which measures the contribution from each natural mode of vibration to indicate the likely maximum seismic response of an essentially elastic structure. Response-spectrum analysis provides insight into dynamic behavior by measuring pseudo-spectral acceleration, velocity, or displacement as a function of structural period for a given time history and level of damping. It is practical to envelope response spectra such that a smooth curve represents the peak response for each realization of structural period. Response-spectrum analysis is useful for design decision-making because it relates structural type-selection to dynamic performance. Structures of shorter period experience greater acceleration, whereas those of longer period experience greater displacement. Structural performance objectives should be taken into account during preliminary design and response-spectrum analysis. Tension-only and compression-only behavior are nonlinear effects which should be evaluated using nonlinear time-history analysis. Response-spectrum analysis (RSA) is a linear method which does not consider nonlinear assignments during formulation. Links represent another nonlinear assignment which does not affect RSA. RSA uses effective stiffness and effective damping according to the stiffness used in the corresponding modal analysis case. Stiffness may be based on zero initial conditions or that at the end of the nonlinear case. These options are shown in Figure

5.3 Analysis of structure subjected to surface blast loading with 100TNT at sight-off distance of 10m:

Results from Manual Calculation

Positive Phase

1. Reflected pressure (P_r) = 300 Kpa
2. Incident pressure (P_{so}) =103 Kpa
3. Positive incident impulse (i_s)=348.119 Kpa
4. Positive reflected impulse (i_r)=932.95 Kpa
5. Arrival time (t_A) =18.56 ms
6. Shock wave pressure (U)=0.54
7. Wave length (l_w)=3.713 m
8. Positive duration (t_o) =9.283 ms

Negative Phase

1. Reflected negative pressure (P_{r-}) = 0.007 Mpa
2. Incident negative pressure (P_{so-}) =0.005Mpa
3. Negative incident impulse (i_{s-})=0.250 Mpa .
4. Negative reflected impulse (i_{r-})=0.300 Mpa
5. Negative duration (t_{o-}) =10 ms
6. Negative wavelength (l_{w-}) = 1.98 m

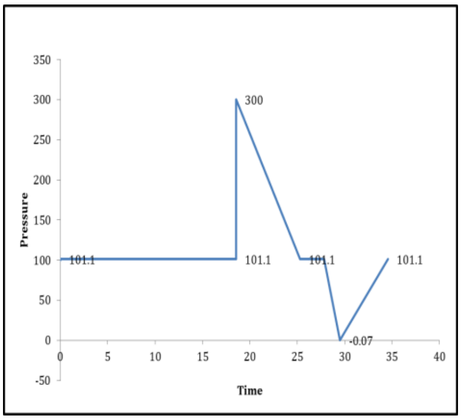


Fig9 Time history for sight-off distance 10m

Story Displacement for 10 m

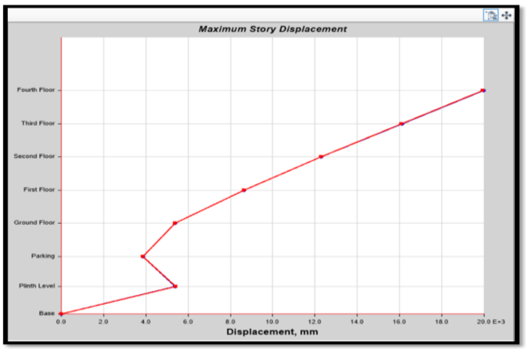


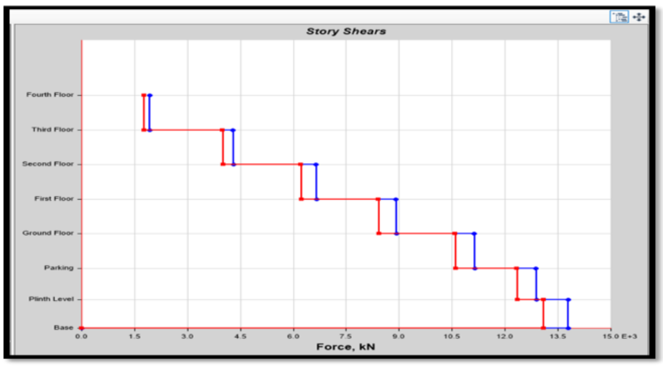
Fig.10 *Storey Displacement*

Story Displacement Values

Story	Elevation	Location	X-Dir
	m		mm
Fourth Floor	20.2	Top	19900.1
Third Floor	17.2	Top	16085.102
Second Floor	14.2	Top	12250.8
First Floor	11.2	Top	8620.105
Ground Floor	8.2	Top	5380.8
Parking	5.2	Top	3860.9
Plinth Level	2.5	Top	5380.8
Base	0	Top	0

Results from ETABS on Storey Displacement.

Story Shear for 10 m



Storey shear

6. CONCLUSION

As sight-off distance increases surface blast effect on the building decreases. Storey shear, storey displacement and overturning moments on higher magnitude in surface blast as compared to conventional loadings (DL, LL, EQ).Surface blast load parameters are dependent on blast load and stand-off distance. Due to decrease in stand-off distance the effect on structure causes it to collapse suddenly.

7. REFERENCS

1. Sam Noli, Devon Wilson, "Effectiveness of progressive collapse resistance criteria against blast loading", ASCE.

2. Manmohan das Goel, Vasant A Matsagar, "Blast resistant design of structure", ASCE

3. Yang Li, Hassan Aoude, "Response of high strength reinforced concrete beams under shock tube induced blast loading", ELSEVIER, Construction and Building Materials 189 (2018) 420–437.

4. Feng Fu, "Dynamic response of robustness of tall buildings", ELSEVIER, Journal of Constructional Steel Research 80 (2013) 299–307.

5. Jiji Madonna, Mrs. Vijaya G S, "Analysis of high-rise RCC building subjected to blast loading", IRJET (Volume 3, Issue-8) ISSN- 2395 -0056.

6. B.M.Luccioni, R.D.Ambrosini, "Analysis of building collapse under blast loads", ELSEVIER.

7.Yufeng Shi, Mark G Stewart, "Spatial reliability analysis of explosive blast load damage to reinforced concrete column", ELSEVIER, Structural Safety 53 (2015) 13–25.

8. Umesh Jamakhandi, Dr. S.B.Vanakundre, "Design and Analysis of Blast Load on Structure", IRJET (Volume2, Issue-7) ISSN- 2395-0056.