TECH-CHRONICLE
AN INTERNATIONAL E-JOURNAL ON
EMERGING TRENDS IN SCIENCE, TECHNOLOGY AND MANAGEMENT

# Analysis of vulnerary aspects of R. C. Structure under shock wave condition: A REVIEW

[1]Ganesh N. Khadse, [2]Prof. Aasif M. Baig

[1]*Reserch Scholars, Dept.of Civil Engineering , Tulsiramji Gaikwad patil College of Engineering & Technology , Nagpur, Maharashtra, India.*

[2]*Asst.Prof.Dept of Civil Engineering,Tulsiramji Gaikwad patil College of Engineering &Technology, Nagpur, Maharashtra, India.*

*Ganeshkhadse6@gmail.com*

***Abstract*** **-** Designing and implementing a critical analysis of the performance of RCC structures under various blast conditions is the primary goal of this paper. Recent technological developments have made it necessary to load blasts like wind and earthquake loads dynamically. The main objectives of this study are to acquire relevant materials pertaining to the generation of blast loads, to evaluate vulnerabilities and to offer recommendations for designing structures that will economically lessen the impact of explosions on buildings and protect people and infrastructure. An RC column that has been subjected to blast loading is used as a case study to examine the effects of force, stress rate, and deflection over time. The alternative path approach is used to study the compression mechanism in order to determine the minimal design load for buildings and other structures. The impact of displacement, blast loading, and standoff distance on floor vehicles is examined in the analysis of a two-story building, where the addition of X-type brackets and shear walls aims to enhance its resistance against explosions.The study also covers the structural, architectural, and management components of the design so that the structures can withstand blasts.

Keywords—shock wave, Vulnerary aspect, Blast loading, ETAB

## I.INTRODUCTION

As technology has advanced, more terrorist attacks have occurred in recent years, necessitating consideration of the dynamic effect of shock wave loading in addition to wind and seismic load. The main goal of this research is to review existing literature on the shock wave loads that a structure might be exposed to, assess its vulnerability, and give designers advice on how to economically reduce the impact of shock waves on buildings while still protecting people and infrastructure from explosions. An RC column that was subjected to shock wave loading was the topic of a case study to examine the effects of strength on deflection over time and strain rate on ductility. The alternative path technique for Minimum Design Loads for Buildings and Other Structures is used to study the cause of collapse. With the inclusion of X-type bracings and shear walls to make the structure shock wave resistant, an analysis of an RCC building is conducted, and the impact of shock wave loading and standoff distance on the displacement and storey drift is explored. This paper also covers the structural, architectural, and management aspects of designing a structure that can withstand seismic waves.

Early on, blast loading wasn't as significant. With the development of technology, the rise in terrorist attacks over the past few decades highlights the necessity of considering the dynamic effects of blast loading in the design of unstable structures like wind and earthquake. Attacks are unusual occurrences; the likelihood of a man-made calamity cannot be precisely predicted. Additionally, terrorist actions are unstoppable. Extremists pose major risks to both life and property by using more modern chemicals and technologies.

The explosion resistant design was made public with regard to the safety of people and property. To construct a completely blast-proof structure is not only uneconomical but also unrealistic. But as technical and architectural expertise has advanced, different approaches can now be used from the planning stage on. In both new and existing structures, the impact of the blast can be greatly reduced.

## II. LITERATURE REVIEW

Mir.M.Ali looked into a number of building-related topics. Accordingly, the concrete casing on both sides of the member is effective in resisting explosions, even if the concrete was crushed, but the steel should be in tact so as to prevent the collapse of the entire structure. He adhered to the design recommendation for RCC design as per TM-5-1300. Similar requirements include the use of steel of grade 60 and ASTMA A, concrete with a strength greater than 400 psi (28 MPa), a total size restriction of 1 inch (25.4 mm), slab reinforcement in both directions, and reinforcement that is continuous in either direction. He also used a case study from the well-known Blast in his work.

There were also typical instances of resistance in the frame, and if a resistive frame was utilised at a specific time, the loss might be cut in half to eighty percent. Second, during the Gulf War, Riyadh, Saudi Arabia, and Amjad kept an eye on how the skyscraper responded structurally to missile attacks. They generally gave the structure a two- to five-story RC frame.

Buildings were built to withstand both normal and wind loads, and the damage earthquakes inflicted to buildings was similar. Explosion loading, standoff distance, incidence, and pressure reflection were all investigated. Shortly after noon, a bomber detonated in front of a Saudi military base. He gave an overview of current studies on concrete slabs subjected to heavy dynamic stress. It was discovered that the dynamic final load capacity was 22-27% higher than the static final load capacity.

P. S. Ramesh, Dr. Devraj, and colleagues (2017) explore the behaviour of a G+4 RCC building when subjected to explosive (RDX) of 100 kg, which is analysed by ETAB 2015 and for various standoff distances using UFC 3-340-02. Positive phase parameters of explosive are obtained. He looked into the meaning of standoff distance. Responses in beams and columns are calculated using drift, displacement, and force. At an 80-meter standoff distance, the structure is deemed to be secure. Explosion loads as well as shock wave interactions with structures are explored. Axial load vs storey, drift versus storey, displacement versus storey, SF versus storey, and BM versus storey graphs are obtained.

M. Meghanadh, T. Reshma (2017) In this, the impact of shock wave loads on a five-story R.C.C. building is explored. The impact of a shock wave source containing 100 kg of trinitrotoluene (TNT) located 40 metres from the structure is taken into account. Using IS: 4991-1968, side on over pressures and shock wave loading are computed. STAAD Pro is used to analyse the force time history of the structure. It is calculated the maximum displacement, velocity, and how they change over time. The building is safe from the perspective of the resonance effect because its natural frequency does not coincide with any mode form frequency.

B. Murali Krishna, et al. (2015) explore the non-linear dynamic response of a 2-D building by studying and analysing a (G+14) storey tall building with a total height of 52m and a storey height of 4m. Calculations are made for a number of parameters, including scaled ground distance, peak positive incident pressure, reflected pressure, and shock front velocities. Pressure time history analysis is used to determine loads analytically, and the TM-5 1300 is used to analyse them. For each storey, graphs of the peak impulsive pressure vs time are obtained. The distribution of reflected pressure is shown to be decreasing with height.

Demin George (2016) examined how ETAB was used to complete the two-story building. Here, four instances involving various explosive kinds and standoff distance are taken into consideration. In addition, four models—normal frame, normal frame with a cross section between the beam and the column, common frame connecting the shear wall, and X-type braking—are taken into consideration. The pressure on the building, the load on the front face, the roof, and the side walls are fixed, and the load is computed in accordance with IS-4991-1968. In terms of maximum floor displacement, the effects of the model with shear wall and X-type brakes will be decreased by 95% to 80%, respectively. The resistance will also be improved by enlarging the beam and column, but this will also have a negative impact on serviceability due to the enormous cross section.

Pandey, A. K. examined how external explosions might affect a typical detachable container structure's outside reinforced concrete shell. The model has been used to analyse the linear content that is unsuitable for the last stage. By using the aforementioned model dynamic, the analytical procedure for nonlinear analysis has been built in the finite component code.

## III. BLAST ANALYSIS

Knowing how to forecast the blast load is crucial if you want to withstand or lessen the effects of the blast on the structure. This section provides a quick introduction of blast load computation methods. It is crucial for this that you first comprehend the properties of blast waves, the blast pressure brought on by air blasts, and the techniques that different researchers have used to determine blast overpressure. A substantial quantity of energy is spontaneously released during an explosion, accompanied with the generation of gas that expands at a fast rate of speed, creating a blast wave that applies pressure and momentum to the structure. The main effect of a blast wave is incident pressure or ambient overpressure, which happens when the blast wave propagates and compresses the surrounding air. Whereas, dynamic or pressure due to drag load accounts for secondary effect of blast wave.

Figure 1 shows blast wave profiles, including real pressure blast wave profiles that have been somewhat normalized to provide idealized and idealized pressure curves.

The curved section of the blast wave is modelled as a triangle pulse to make the load calculation easier, and it is shown in the same picture with the impulse and dynamic pressure profile. According to the dynamic pressure curve shown in figure, dynamic pressure often has a much lower amplitude than positive overpressure and lasts much longer.

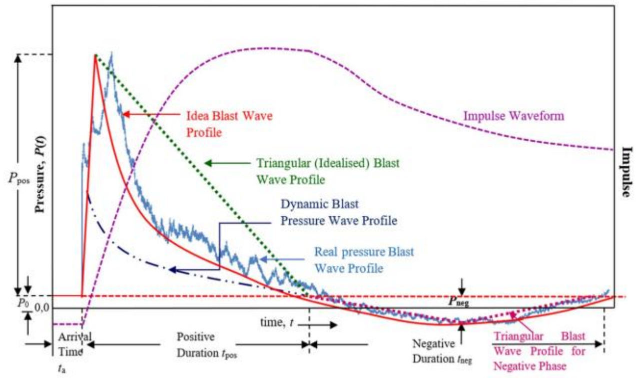


Figure 1: Blast wave profiles and impulse wave form diagram

This blast wave only lasts for a few milliseconds or microseconds, yet it produces a dynamic blast load with a very high magnitude and very high frequency. The nature of a blast load is impulsive, i.e., high pressure for a brief period of time. The following variables control the blast load: peak positive pressure (Ppos), positive phase duration (tpos), under pressure (Pneg), negative duration (tneg), wave decay parameters (b), and impulse (I). Utilising blast wave parameters and reflected pressures, one may determine the blast loading on a structure.
It depends on the incidence angle at which the blast wave interacts with the structure to produce reflected pressure, which is always greater than incident pressure. To obtain the reflected pressure pulse, the incident pressure is multiplied by the appropriate reflected pressure coefficient. Positive and negative phases primarily distinguish the time history of blast pressure. In the subsections, these stages and the computation of the controlling parameters related to blast load have been thoroughly examined.

## IV. MODELING TECHNIQUES

There are various methods that can be used to replicate the loading conditions caused by a bomb. In this section, several strategies are briefly explained. The complete explosive event can be examined using numerical simulation, and the response of the structure can be identified. For simulating the response of the structure subjected to blast stress, several analytical techniques are available in various software (e.g., LS-DYNA, ABAQUS, AUTODYN, ANSYS AUTODYN, Air3D, DYNA3D, BLASTX, ALE3D, etc.). For efficient study of fracture pattern in blasting problems in tunnels, some current methodology that couples the finite element method (FEM) with the discrete element method (DEM) technique is utilised. With embedded mesh, immersed body, and body-fitted techniques, 3-dimensional FEM-FCT technology may be used to analyse complicated situations like blast structure interaction. The accuracy of these embedded approaches under blast loads was examined by Löhner et al. Experimental testing becomes unprofitable every time, hence numerical techniques are utilised to reduce the number of tests.

In a Lagrange simulation, the mesh is included into the material and moves with it. This method, also known as the load blast enhanced (LBE) method, uses CONWEP to calculate the air blast. Large experimental data are the foundation of lagrangian simulation. Since air is not explicitly modelled with explosives and structure, the pure Lagrangian technique is computationally efficient. Due to the load blast feature's lack of consideration for the shadowing effect seen in Fig. 2, the pressure estimated using this method is relatively less accurate.

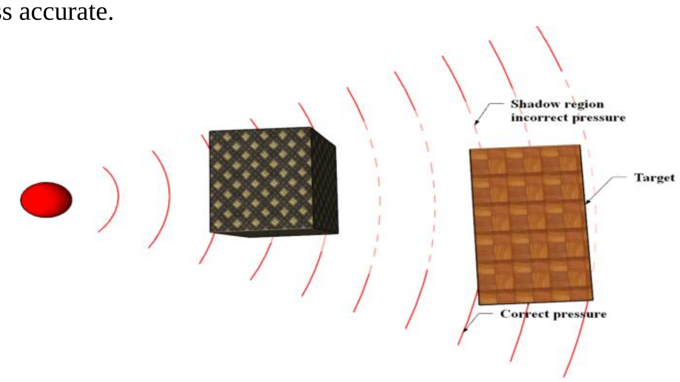


Figure 2: Shadowing effect in load blast enhanced method

Due to mesh distortion at high strain rate, the Lagrangian approach produces poor solutions. Frequent remeshing with the aid of interpolation is required to address this distortion issue, which lengthens computational time. Fig. 3 shows a pure Lagrangian formulation with substantial mesh Deformation

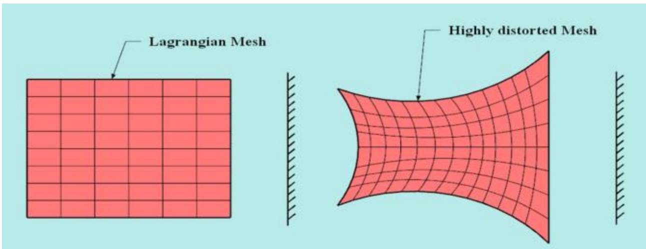


Figure 3: Pure Lagrangian formulation

## V. BLAST MITIGATION TECHNIQUES

Inadequate protective capacity causes structural damage under blast loads, which causes economic loss in addition to life losses. Therefore, numerous mitigation techniques must be implemented in order to protect the structure from both primary and secondary damages. The major goal of this section is to identify various blast mitigation tactics. The goal of a blast mitigation technique is to reduce structural damage and improve the structure's capacity to continue operating even after the blast. Due to the fact that the pressure caused by the blast wave decays quickly with standoff distance, standoff distance is one of the crucial and most cost-effective criteria in the mitigation method. Structures must be toughened when standoff distance cannot be provided, which renders the structure unprofitable. When a building must meet both seismic and blast load design requirements, it must use materials that are lightweight and energy-absorbing. Thus, the development of various lightweight energy-absorbing materials is required.

Another crucial factor is defence in depth, which refers to the several barriers that attackers must overcome before accessing the asset's core. In order to prevent access to the structure, physical barriers including blast walls, anti-ram barriers, and vehicle barriers can also be built. Building orientation and shape, appropriate landscaping, and architectural features that protect the structure from blast hazard reduce the effective pressure.

## VI. SUMMARY

The present terrorist attack scenario and its effects on both persons and items point to the necessity of implementing blast-resistant or mitigation measures. The primary goal of the current study is to define key words and ideas related to the phenomena of blast so that novice researchers and structural designers may begin their work in the subject. In order to quantify the explosion overpressure and reduce the possibility of structural damage, many numerical methodologies put out by various researchers have also been compiled. The elements of the blast wave's positive and negative phases are also covered in the study. In the current work, the impact of angle of incidence and other blast characteristics, such as standoff distance, explosive charge weight, and Mach stem phenomena, have also been fully reviewed. More focus has been placed on blast response reduction techniques and the role that lightweight materials play in these efforts. In the current study, a brief discussion of physical barriers such as sacrificial cladding, blast walls, and other mitigation devices that can be used to lower blast pressure is provided.

## REFERENCES

[1]B. Murali Krishna, Dr. V. Sowjanya Vani; (2015) “Determination of blast load parameters for 2D framed over the faÃ§ade of structure” International Journal of Engineering Research; Vol.3., Issue.3; ISSN: 2321-7758

[2]Mir M. Ali (2002), 2012,” II. “Protective design of concrete buildings under blast loading; structures under shock and impact” International Journal of Engineering Research & Technology (IJERT) [Vol -5, Issue-10, Oct- 2018]

[3]T. Borvik et al.(2009) “Response of structures to planar blast loads– A finite element engineering approach” Computersand Structures 87, pp 507–520,

[4]Dannis M. McCann, Steven J. Smith (2007), “Resistance Design of Reinforced Concrete Structures”, STRUCTURE magazine, pp 22-27, April issue.

[5]T.Ngo,P.Mendis,A.Gupta&J.Ramsay,“BlastLoadingandBlastEffectsonstructure”,TheUniversityofMelbourne,Australia,2007

[6]A. Khadid et al. (2007), “ Blast loaded stiffened plates” Journal of Engineering and AppliedSciences,Vol. 2(2) pp. 456- 461.

[7]A.K. Pandey et al. (2006) “Non-linear response of reinforced concrete containment structure under blast loading” Nuclear Engineering and design 236. pp.993-1002.

[8] P. S. Ramesh, Dr. Devraj et. al. (2017)” Performance of G+4 RCC building subjected to explosive (RDX) of 100Kg, analysed by ETAB 2015 International Journal of Engineering Research & Technology.(IJERT)

[9] M. Meghanadh, T. Reshma (2017) International Journal of Engineering Research & Technology(IJERT)

[10] Demin George, Varnitha M.S; (2016) “Structural analysis of blast resistant structures”IJSRD – International Journal for Scientific Research & Development| Vol. 4, Issue 05, | ISSN (online):2321- 0613

[11] Soto OA, Baum JD, Togashi F, Löhner R, Frank R, Amini A
(2016), The simulation of dust effects from fragmenting charges. Int J Numer Methods Heat Fluid Flow 26:999–1026

[12]Ding Y, Chen Y, Shi Y (2016) Progressive collapse analysis of a steel frame subjected to confined explosion and post-explosion fire. Adv Struct Eng 19(11):1–17

[13]Eskew EL, Jang S (2014) Damage assessment of a building subjected to a terrorist attack. Adv Struct Eng 17(11):1693–1704

[14]Singh AK, Ditkofsky NG, York JD, Abujudeh HH, Avery LA, Brunner JF, Sodickson AD, Lev MH (2016) Blast injuries: from improvised explosive device blasts to the Boston Marathon bombing. Radio Graph 36:295–307

[15]Larcher M, Valsamos G, Karlos V (2018) Access control points: reducing a possible blast impact by meandering. Adv Civ Eng 2018:1–12
[16] Smith PD, Hetherington JG (1994) Blast and ballistic loading of structures. Butterworth-Heinemann, Oxford
[17] Cullis IG (2001) Blast waves and how they interact with the structures. J R Army Med Corps 147:16–26
[18] Neff M (1998) A visual model for blast waves and fracture. Master's dissertation, Department of Computer Science, University of Toronto
[19]Remennikov AM (2002) Blast resistant consulting: a new challenge for structural engineers. Aust J Struct Eng 4:121–135
[20]Baum JD, Soto OA, Togashi F, Löhner R, Giltrud ME, Bell (2017) An investigation of stationary and moving cased charge detonations in stone lined pipes. In: 31st international symposium on shock waves, vol 1, pp 117–126
[21]Togashi F, Baum JD, Soto OA, Löhner R, Zhang F (2012) Numerical simulation of TNT-Al explosives in explosion chamber. In: Seventh international conference on computational fluid dynamics (ICCFD7), Big Island, Hawaii, July 9–13, 2012
[22]Department of the Army, Navy, and Air Force (1990) Structures to resist the effects of accidental explosions (with addenda). Army Technical Manual (TM 5-1300) Washington, DC
[23]Hao H, Hao Y, Li J, Chen W (2016) Review of the current practices in blast-resistant analysis and design of concrete structures. Adv Struct Eng 19(8):1–31
[24]Department of Defense (2008) Unified facilities criteria: structures to resist the effects of accidental explosions. UFC 3-340-02. Washington, DC
[25] Remennikov A, Carolan D (2005) Building vulnerability design against terrorist attacks. In: Proceedings of the Australian structural engineering conference, pp 1–10
[26]Ullah A, Ahmad F, Jang HW, Kim SW, Hong JW (2016) Review of analytical and empirical estimations for incident blast pressure. KSCE J Civ Eng 21(6):1–15
[27]Ngo T, Mendis P, Gupta A, Ramsay J (2007) Blast loading and blast effects on structures—an overview. EJSE Spec Issue 7:76–91
[28]Jeremic R, Bajic Z (2006) An approach to determining the TNT equivalent of high explosives. Sci Tech Rev L VI 1:58–62
[29]Eichinger WE (1985) Mach stem modeling with spherical shock waves. M.S. Thesis Airforce Institute of Technology, US army
[30]Karzova MM, Khokhlova VA (2015) Mach stem formation in reflection and focusing of weak shock acoustic pulses. J Acoust Soc Am 136:436–442
[31]Rigby SE, Fay SD, Tyas A, Warren JA, Clarke SD (2015) Angle of incidence effects on far-field positive and negative phase blast parameters. Int J Prot Struct 6(1):23–43
[32]Lofquist C (2016) Response of buildings exposed to blast load. Master's Dissertation, Structural Mechanics, Lund University, ISSN 0281-6679:1-88.