Stimulation of Blast Effect on Multi-Story Building Using Ansys – A Review

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Abstract - *This study summarizes the literature reviews of several papers that were exposed to blast loading with various sorts of materials. It discusses the technique taken by the many authors and materials chosen for testing, as well as the behaviour of that material during blast loading. As a result, we may learn about the many materials that can withstand blast loading as well as the behaviour of various materials during blast loading. so that we can determine the best materials to withstand blast action and build structures using those materials, as well as determine the strength and resistance of those materials under blast loading in future analytical studies utilizing ANSYS software.*

***Key Words*: Blast Effect, Finite Element Method, ANSYS**

1. INTRODUCTION

Due to the sheer increasing number of terrorist attacks and unintentional explosions, the design of structures for blast resistance is becoming increasingly important in construction, as structures fail catastrophically as a result of blast action. As a result, the study of buildings subjected to blast loads is becoming more popular and attracting more.

The blast effect is a potentially hazardous event in which a building fails catastrophically as a result of intense heat radiation. The main purpose of the research is to use the software ANSYS to assess the behaviour of multi-story buildings by employing different heat-resistant materials to resist blast action. Stimulation of the behaviour of structural components with different thermal resistant materials by finite element method using ANSYS software with different temperature changes can shed some light on the available reinforcing materials that are best suitable to resist sudden blasphemy. It provides a concept for constructing blast-proof buildings as well as information on various heat resistant materials and their behaviour under different temperatures, and the best material to endure high temperatures by analyzing material properties with ANSYS software. High-Security structures that are under threat from an explosion can be built using these principles, providing security to the structures.

Stimulation of the behaviour of structural components with different thermal resistant materials by finite element method using ANSYS software with different temperature changes can shed some light on the available reinforcing materials that are best suitable to resist sudden blasphemy

1.1 Blast Phenomenon

When heavy explosives are detonated, considerable pressure is generated, which propagates to the surrounding region and forms a powerful shock wave known as a blast wave. From ambient pressure to peak incident pressure, the velocity of this blast wave increases fast. Figure 1 depicts an idealized blast wave based on pressure versus time history at the structural fixed point from the site of detonation. [1] Yusof et al. (2014)

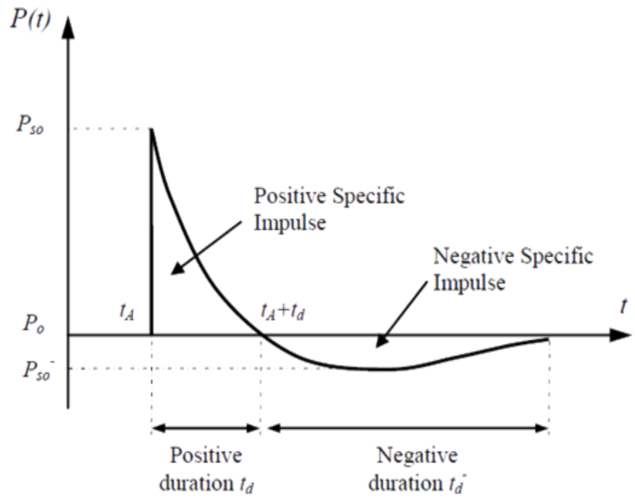

Fig:1 Blast wave pressure v/s time history

Detonation takes place at time t= 0. After time t_A, the blast wave arrives at the point and pressure instantaneously increases from ambient pressure, P_0 to peak overpressure, P_{so} caused by the detonation. At time t_A+ t_d, the pressure returns to ambient pressure, P_o which is a positive phase, is over and followed by a negative phase, P_{so}^-

2. LITERATURE REVIEW

Magnusson & Hallgren (2004) studied the reinforced high strength concrete beams subjected to air blast loading [2]. A total of 49 reinforced concrete beams were tested, including high strength concrete (HSC) and, for comparison, normal strength concrete (NSC). In a shock tube, 38 beams were exposed to air blast loading, while the remaining eleven beams were examined statically for reference. Concrete with nominal compressive cube strengths of 40, 100, 140, 150, and 200 MPa was utilized, and a few beams additionally had steel fibres. Beams with two concrete layers of varying strength were also tested. In flexure, all beams exposed to static stress failed. Shear failure was seen in beams without fibres and with high reinforcement ratios during dynamic testing. The incorporation of steel fibres in the matrix was shown to boost the shear strength and ductility of the beams. According to the findings of this study, beams subjected to air blast loading have a higher load capacity than equivalent beams subjected to static loading.

Ngo et al. (2007) studied the behaviour of ultra-high-strength prestressed concrete panels subjected to blast loading [3]. This report describes the findings of an experimental study on the blast resistance of concrete panels formed of ultrahigh-strength concrete UHSC material in Woomera, South Australia, in May 2004. For testing concrete panel targets against blast loading, a unique concrete supporting structure was constructed. Four 2 m1 m panels with varying thicknesses and reinforcing features were evaluated at 30 and 40 m standoff distances under a 6 t TNT equivalent explosion. Blast pressures and panel deflections were among the data acquired from each specimen. The test results were studied in order to determine the performance of UHSC and normal-strength concrete NSC panels. Reactive Powder Concrete (RPC) is a UHSC material composed of cement, sand, silica fume, silica flour, steel fibres, admixture, and water with strengths of up to 200 MPa. RPC has the potential to be a very good material for blast resistance. The 75-mm-thick UHSC panel was moderately damaged, but the 100-mm-thick NSC panel was shattered.

Tabatabaei et al. (2013) entitled experimental and numerical analyses of long fibre reinforced concrete panels exposed to blast loading [4]. The insertion of long carbon fibres into typical reinforced concrete is recommended as a solution to increase the concrete's blast spalling resistance. A series of experiments were carried out to assess the blast resistance of panels made of standard reinforced concrete (RC) with long carbon fibre-reinforced concrete (LCFRC). As control specimens, conventional reinforced concrete panels were examined. For each panel, pressure sensors detected both the free-field incident pressure and the reflected pressure. Furthermore, an LS-DYNA finite element model was developed to simulate both a control panel and an LCFRC panel in order to see if the models could anticipate the observed damage. The LCFRC panels all had less material loss and surface degradation than the control panels. The LCFRC panels all had less material loss and surface degradation than the control panels. The use of long carbon fibres considerably boosted the blast resistance of the concrete and reduced the degree of cracking associated with the concrete panels.

Xu et al. (2016) studied the behaviour of ultra-high-performance fibre-reinforced concrete columns subjected to blast loading [5]. UHPFRC is a cement-based composite material that is reinforced with reactive powder and steel fibres. It is distinguished by its high strength, ductility, and toughness, and these properties enable it to have significant potential in protective engineering against extreme loads such as impact or explosion. A series of field experiments were carried out in the current study to investigate the behaviour of UHPFRC columns subjected to blast loading. Four 0.2 m0.2 m2.5 m UHPFRC columns were tested under various planned explosions, but all at a 1.5 m standoff distance. To analyze their behaviour under identical stress circumstances, four high strength reinforced concrete (HSRC) columns with the same size and reinforcement as UHPFRC columns were subjected to blast tests. Three significant damage modes were detected, including flexural, shear, and concrete spalling failure mechanisms. Post-blast fracture patterns, permanent deflections, and varying levels of damage observations revealed that UHPFRC columns outperformed HSRC columns in blast loading resistance. Ultra-High Performance Fiber Reinforced Concrete (UHPFRC) specimens can efficiently withstand the overpressures and shock waves caused by high explosives, minimizing the maximum and residual displacements of columns when subjected to similar blast loads and significantly improving blast-resistant capacity.

Ngo & Mendis (2017) studied blast and blast effects on structures [6]. Major disasters caused by gas-chemical explosions result in high dynamic loads on many buildings that are bigger than the initial design loads. Because of the threat posed by such intense loading conditions, efforts have been made over the last three decades to develop techniques of structural analysis and design that can withstand blast loads. The study and design of structures subjected to blast loads need a thorough understanding of blast phenomena as well as the dynamic response of diverse structural components. Blast loading impacts on structural elements can cause both local and global reactions associated with various failure scenarios. The kind of structural reaction is determined primarily by the loading rate, the target's orientation about the direction of blast wave propagation, and the boundary conditions. Flexure, direct shear, or punched shear are the most common failure types associated with blast stress. Local responses are characterized by localized bleaching and spalling and are primarily caused by the close-in impacts of explosions, whereas global responses are frequently shown as a flexural failure.

Lan et al. (2018) studied on blast response of continuous-density graded cellular material based on the 3D Voronoi model [7]. The one-dimensional blast response of continuous-density graded cellular rods was theoretically and statistically explored. The blast response of density-graded cellular rods was predicted using an analytical model based on the rigid-plastic hardening (R-PH) model. A novel model based on the 3D Voronoi approach was used for finite element (FE) analysis. The FE findings correspond well with the analytical expectations. Under varied blast loads, the blast response and energy absorption of cellular rods with the same mass but varying density distributions were investigated. Cellular materials with high energy absorption and low impulse transmission are appealing as blast resistance structures. However, modifying the density distribution cannot accomplish high energy absorption and low impulse transmission at the same time. The initial blast pressure and the characteristic duration of the exponentially decreasing blast loading improve the energy absorption capacity. When utilized as a blast protective device, the capacity of cellular material to absorb energy while managing the loading sent to the protected structure makes it appealing. A positive density gradient, on the other hand, accomplishes the most energy absorption and transmits a relatively high impulse to the protected structure, whereas a negative one transmits a relatively low impulse but achieves the lowest energy absorption.

Maseko et al. (2018) studied the characterization of ceramic reinforced titanium matrix composites fabricated by spark plasma sintering for anti-ballistic applications [8]. Spark Plasma Sintering (SPS) is a powerful process for producing Ti-ZrB2 binary composites at low sintering temperatures. The approach adopted in this study was efficient in producing a dispersion strengthening effect on the composites, as all of the composites improved in hardness as a result of the dispersion of the ceramic particles throughout the matrix material. TiB was easily synthesized through the in-situ interaction of Ti and B species, resulting in strong interfacial bonding between the Ti matrix and the TiB reinforcing phase. The strong interfacial connections between the titanium matrix and the boride-based reinforcements will improve titanium's anti-ballistic characteristics.

Jahami et al. (2019) studied the efficiency of using CFRP as a strengthening technique for reinforced concrete beams subjected to blast loading [9]. The performance of reinforced concrete beams made of carbon fibre reinforced polymer (CFRP) when subjected to blast loading is investigated in this research. The experimental data, including damage and deflection, were gathered from a prior inquiry and numerical analysis was carried out using ABAQUS software. In addition, the single degree of freedom (SDOF) model was employed to supplement the results of the numerical analysis. Following the strong connection between the experimental and numerical results, a further examination of reinforced concrete beams enhanced with carbon fibre-reinforced polymer was done (CFRP). It was discovered that using CFRP improved load capacity, energy absorption, and reduced central deflection. Furthermore, Iso-Damage curves were generated for each beam, allowing damage to be forecast. When reinforced concrete beams were exposed to blast loads, the use of Carbon Fiber Reinforced Concrete (CFRP) decreased the level of damage. The mid-span deflection increased as the number of CFRP layers increased. The mid-span deflection of beams with four layers of CFRP is 30% less than that of a beam with no CFRP. Using more than two layers, on the other hand, does not result in a further decrease in deflection. In the presence of CFRP, a reinforced concrete beam may withstand larger blast loads. When compared to a beam without CFRP, strengthening the beam with four layers of CFRP can raise the TNT quantity by 50% to generate the same damage.

Badiger et al. (2021) studied the seismic performance of hybrid and non-hybrid fibre-reinforced concrete-based beam-column joints [10]. Experimentation is commonly used to investigate individual component components and concrete strength under varied stress circumstances. These structural components are also analyzed using finite element analysis. The use of FEA has been the favoured approach for studying the behaviour of concrete since it is faster and less expensive than the experimental method. Because of the development of advanced numerical analysis techniques such as the finite element method (FEM), it is now possible to describe the complicated behaviour of reinforced concrete beams using Finite Element modelling. The finite element approach is a numerical analytical method that separates a structural element into smaller components and then simulates static loading situations to assess concrete response. The non-linear analysis is a method that stimulates the exact behaviour of the material to assess strength in the inelastic range and to find the possibility of the high load-carrying capacity of the components through redistribution, tensile, and shear strength.

3. METHODOLOGY

3.1 The Scaling Law of Blast Waves

The mechanical ratio of tensile reinforcement (ω_s) was determined to the beams according to the equation [2] Magnusson & Hallgren (2004)

$$\omega_s = \frac{A_s f_{sy}}{b d f_{cc}}$$

where A_s is the area of tensile reinforcement, b and d are the widths and the effective depth of the beam respectively, f_{sy}

the yield strength of the rebars and f_{cc} is the compressive cylinder strength of concrete.

3.2 Blast Pressure Prediction

To express the fundamental explosive input or charge weight W, as a mass of TNT equivalent. The outcomes are then shown as a function of the dimensional distance parameter (scaled distance). [6] Ngo & Mendis (2017) [9] Jahami et al. (2019)

$$Z = \frac{R}{W^{\frac{1}{3}}}$$

Where:

R is the actual effective distance from the explosion.

W is generally expressed in kilograms.

Z is Scaled distance.

Estimations of peak overpressure due to spherical blast based so scaled distance $Z = \frac{R}{W^{\frac{1}{3}}}$ were introduced by Brode (1955) as: [6] Ngo & Mendis (2017)

$$P_{so} = \frac{6.7}{Z^3} + 1\ bar\ (P_{so} > 10\ bar)$$

$$P_{so} = \frac{0.975}{Z} + \frac{1.455}{Z^2} + \frac{5.85}{Z^3} - 0.019\ bar$$

$$(0.1\ bar < \ P_{so} < 10\ bar)$$

Newmark and Hansen (1961) proposed a relationship to determine the maximum blast overpressure, Pso, in bars, for a high explosive charge detonates near the ground surface as follows: [6] Ngo & Mendis (2017)

$$P_{so} = 6784\frac{W}{R^3} + 93\left(\frac{W}{R^3}\right)^{\frac{1}{2}}$$

Mills (1987) introduces another equation for peak overpressure in kPa, in where W is the equivalent charge weight in kilograms of TNT and Z is the scaled distance. [6] Ngo & Mendis (2017)

$$P_{so} = \frac{1772}{Z^3} - \frac{114}{Z^2} + \frac{108}{Z}$$

The air behind the shock front is travelling outward at a lesser velocity as the blast wave propagates into the atmosphere. The velocity of the air particles, and hence the wind pressure, is determined by the blast wave's peak overpressure. The dynamic pressure q_r, is connected with the later velocity of the air. The greatest value q_r, is given by [6] Ngo & Mendis (2017)

$$q_r = \frac{5P_{so}^2}{2(P_{so} + 7P_0)}$$

If the blast wave reaches an impediment perpendicular to its propagation path, reflection raises the overpressure to a maximum reflected pressure P_r as [6] Ngo & Mendis (2017)

$$P_r = 2P_{so}\left(\frac{7P_o + 4P_{so}}{7P_o + P_{so}}\right)$$

Mays and Smith (1995) and TM5-1300 provide a comprehensive explanation and detailed tables for forecasting blast pressures and blast durations (1990). Table 1 shows some sample numerical values of peak reflected overpressure. [6] Ngo & Mendis (2017)

R \ W	100 kg TNT	500kg TNT	1000Kg TNT	2000kg TNT
1m	165.8	354.5	464.5	602.9
2.5m	34.2	89.4	130.8	188.4
5m	6.65	24.8	39.5	60.19
10m	0.85	4.25	8.15	14.7
15m	0.27	1.25	2.53	5.01
20m	0.14	0.54	1.06	2.13
25m	0.09	0.29	0.55	1.08
30m	0.06	0.19	0.33	0.63

Table:1 Peak reflected overpressures Pr (in MPa) with different W-R combinations

Reflected overpressure may be modelled for design reasons by an analogous triangular pulse with maximum peak pressure P_r and period t_d, yielding the reflected impulse i_r. [6] Ngo & Mendis (2017)

$$i_r = \frac{1}{2} P_r t_d$$

Duration td is related directly to the time taken for the overpressure to be dissipated. Overpressure caused by wave reflection decreases when the disturbance propagates to the obstacle's edges at a velocity proportional to the speed of sound (U_s) in the compressed and heated air behind the wavefront. Using S to represent the greatest distance from an edge (for example, the lesser of the height or half the breadth of a standard building), the extra pressure due to reflection is assumed to decrease from $P_r - P_{so}$ to zero in time $3S/U_s$. Conservatively, the U_s may be defined as the usual speed of sound, which is around 340 m/s, and the extra impulse to the structure can be calculated using the assumption of linear decline.

3.3 Reflected Pressure and Positive Phase Duration

Peak pressures at the four characteristic spots of the beam are used to compute the peak equivalent uniform blast load. [11] Liu et al. (2018)

$$P = \left[-P_{S1}\frac{1}{2} + P_{S2} + P_{S3}\frac{7}{6} - P_{S4}\frac{2}{3} \right]$$

The corresponding blast load impulse is set to be the centre blast load impulse. [11] Liu et al. (2018)

$$t_d = \frac{2I_{S1}}{P}$$

4. CONCLUSION

We can conclude from the literature reviews of various papers studied by different authors that ultra-high-strength prestressed concrete, ultra-high-strength fibre reinforced concrete, long carbon fibre reinforced concrete, reactive power concrete, and Ti-ZrB2..., etc., have higher blast resistance than conventional reinforcement. These results will be used in subsequent research, using these materials in the studies of a multi-story structure with different temperature changes for blast loading using ANSYS software.

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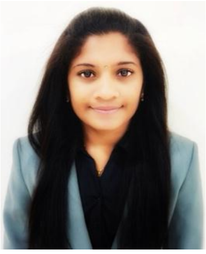
BIOGRAPHIES



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