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Simulations Study of Blast Wall Effectiveness: Comparing Concrete and Polymer Composites in Pressure Wave Mitigation

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Abstract

Walls play a crucial role in protecting structures and people from explosion hazards, especially in industrial and military environments. This study examines the blast resistance performance of T-shaped wall constructed from concrete composite (CONC-35MPa) and polymer matrix composite (PMC, EPOXY RES) materials using ANSYS Explicit Dynamics simulations. The concrete wall showed a maximum deformation of 0.97m about half that of the epoxy composite's 1.92m, and experienced peak shear stresses up to 1.2GPa at critical joints. Directional velocity reached 3651 m/s for concrete versus 6139m/s for the polymer composite, demonstrating concrete's superior stiffness and energy absorption. These results confirm that concrete provides better resistance to blast induced deformation and stress. Comparing to most studies that look at fiber-reinforced concrete or polymer composites separately, this work combines material behavior and structural geometry in a single explicit dynamics simulation. It offers practical improvements like reinforcement methods and shape changes for T-shaped walls, backed by clear blast response data. The study also suggests future research on adding sensors for real time blast monitoring, a topic rarely covered before. Overall, it links material mechanics with engineering design to help create safer, stronger protective structures using validated simulations for real blast conditions.

1. Introduction

The primary function of a blast wall is to absorb and redirect the energy generated by an explosion, effectively lowering the peak overpressure experienced by nearby structures. Existing research on blast wall design often focuses on material choice and simple geometry but lacks systematic, multi-objective optimization that balances safety and cost. Few studies optimize wall dimensions and material distribution together, especially for complex shapes like T-shaped walls. Research indicates that well designed blast wall can significantly reduce the intensity of shockwaves, protecting sensitive equipment and infrastructure [1]. Additionally, comparisons between traditional materials like concrete and advanced composites within a unified simulation framework are rare. This study addresses these gaps by presenting a simulation-based optimization method using advanced algorithms to create cost-effective, high-performance blast walls tailored to various threat scenarios. Furthermore, the impact of specific geometric shapes, like T-shaped walls, on stress concentrations and deformation under dynamic blast conditions remains poorly understood [2]. Addressing these gaps is essential for developing safer and more efficient blast protection tailored to different threat environments.

Despite their importance, there is still a lack of understanding of how material properties and complex structural geometries together affect the dynamic response of blast walls under realistic explosions [3]. Many studies depend on empirical data or simplified models that fail to capture key nonlinear behavior and fluid structure interactions during blasts. Additionally, experimental blast tests are costly and limited, restricting the study of diverse materials and designs. These gaps slow progress in developing optimized blast walls that balance performance, durability, and cost. Advanced numerical simulations, especially explicit dynamic analyses, are increasingly vital for conducting detailed and cost-effective investigations of blast wall behavior [4].

In this context, the present study focuses on a simulation-based evaluation of blast wall performance by comparing traditional concrete walls with polymer matrix composite alternatives. Utilizing ANSYS Explicit Dynamics, the investigation examines the interaction between pressure waves and analyzing their effectiveness in mitigating blast loads. The materials selected for this study include particulate composites represented by concrete with a compressive strength of 35 MPa, and polymer matrix composites modeled as epoxy resin materials. These simulations consider the dynamic response of the walls—such as deformation, stress distribution, and damage progression—under specified blast loading conditions, specifically referencing charge types like C4. The material behavior for polymer composites is modeled based on orthotropic elasticity, while nonlinear properties characterize the concrete composite. This approach enables a detailed comparison of how material properties influence the distribution and attenuation of blast pressures, providing insights applicable to real-world engineering applications [5, 6].

When designing and situating blast walls, critical factors include the nature of potential hazards, expected blast wave directions, and the vulnerability of surrounding structures. Accounting for these elements ensures optimal wall placement and enhances protection effectiveness. Furthermore, the study aims to contribute actionable insights toward advancing protective structure development, updating engineering standards related to blast mitigation, and reducing reliance on costly physical experiments through validated simulation techniques [7, 8]. By quantifying pressure wave mitigation characteristics of different materials, this research seeks to significantly improve the safety margins of blast walls, thereby reducing injury and infrastructural damage risks [9, 10].

In summary, this study compares the blast resistance of modern polymer matrix composites and traditional concrete walls numerically using explicit dynamic simulations. For industrial, military, and urban applications, the work provides important insights to inform the design of more robust and efficient blast barriers by filling in empirical knowledge gaps and capturing complex material behavior under explosive pressures.

2. Methodology

The methodology of this study involves developing a detailed three-dimensional numerical model of a T-shaped blast wall using ANSYS SpaceClaim to simulate and compare the response of particulate composite and polymer matrix composite (PMC) materials under blast loading. Initially, material properties are representative of concrete with a compressive strength of 35 MPa, based on experimental data and literature values. For the PMC, orthotropic elastic properties reflecting fiber orientations and epoxy resin characteristics are input to accurately capture anisotropic behavior.

The geometric model is discretized using solid finite elements appropriate to each material type. A refined mesh is employed to ensure accurate resolution of stress gradients, particularly near regions of expected stress concentration. To conduct convergence research, the mesh density was systematically changed with element sizes raging from coarse to fine. As mesh size shrank, key output parameters such as directional velocity, total deformation, and peak stress were tracked to evaluate solution stability. A refined mesh was used near stress concentration zones, with systematic mesh size reduction to ensure convergence. Key parameters stabilized within 2% variation, confirming mesh accuracy and computational efficiency. The mesh design ensured accurate resolution of transient blast effects and nonlinear material response, validating the simulation's reliability and supporting confident conclusions on blast wall performance.

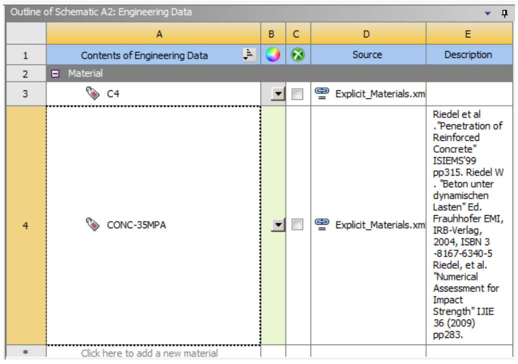
Boundary conditions are applied by fixing on the wall to stimulate realistic support constraints. To accurately replicate rigid foundation support and avoid rotation and displacement, fixed boundaries were imposed at the wall base. Alternative supports were tried, but this added complexity and had little impact on the results. For this study, fixed circumstances were the most practicable option since they offered reliable, conservative predictions of blast reaction.

Blast loading is modeled as a transient pressure-time history mimicking the characteristics of a C4 explosive. This dynamic load is applied to the relevant surfaces of the wall to replicate the effect of an explosive event. The simulations utilize the Explicit Dynamics solver within ANSYS to effectively handle the high strain rates, material nonlinearities, and complex contact interactions inherent in blast scenarios.

The total simulation duration is set to capture the blast impulse and subsequent structural response, typically within milliseconds. Outputs requested include stress distributions, total deformation magnitudes, and directional velocity data sampled at multiple time steps. These data facilitate comprehensive analysis of the wall's dynamic behavior. Post-processing focuses on evaluating shear stress distribution, deformation patterns, and velocity vectors to compare the blast resistance performance of the particulate composite and PMC walls. Failure zones are identified, and energy absorption capabilities assessed, providing insight into the relative effectiveness of each material in mitigating blast-induced damage and deformation.

2.1 Material Selection

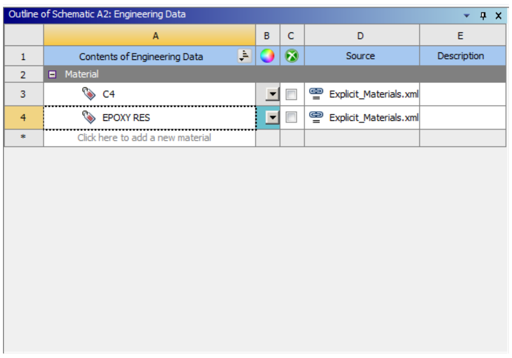
Three materials were selected for this study to comprehensively represent both structural and explosive components involved in blast events, as illustrated in Fig. 1. The primary structural material is CONC-35MPa concrete, chosen for its widespread use as a standard grade construction material in blast resistant applications. This concrete grade, with a compressive strength of 35 MPa, offers a balance of mechanical strength and availability, making it a relevant baseline for comparative analysis. Its mechanical properties, including isotropic elasticity and high compressive capacity, enable it to effectively resist compressive loads generated during explosions. The material data for this concrete was sourced from a reputable, validated database to ensure the fidelity of simulation inputs. This choice facilitates direct comparison with alternative materials under blast loading conditions and provides insight into how traditional construction materials perform during high strain rate impacts.



(a)

Fig. 1 *Engineering data (a) Concrete composite*

Fig. 2 depicts the engineering data for the third material, a polymer matrix composite (PMC) represented by epoxy resin. The concrete composite exhibits high compressive strength and isotropic mechanical properties, while the epoxy resin-based PMC is more flexible with orthotropic behavior due to fiber orientations. Key material properties that include density, mechanical behavior, tensile strength, detonation velocity, volume, and mass that are summarized in Table 1. These parameters were obtained from datasheets to ensure accurate representation within the simulation environment.



(a)

Fig. 2 *Engineering data (a) Epoxy resin*

Table 1 *Material properties of concrete, epoxy resin based and C4*

Material properties	CONC-35MPa	EPOXY RES	C4
Density	2314kg/ m^3	1186kg/ m^3	1601kg/ m^3
Material behavior	Nonlinear Isotropic	Orthotropic	-
Tensile strength	3.5MPa	-	-
Detonation velocity	-	-	8193m/s
Volume	3.6 m^3	3.6 m^3	64 m^3
Mass	8330.4kg	4269.6kg	1.0246x10^5kg

The explosive used to generate the blast load in the simulations is C4, characterized by a high detonation velocity of approximately 8193 m/s. its sharp, high pressure shock wave profile makes it suitable for blast testing and demolition scenarios. The blast load applied replicates the pressure-time history typical of a C4 detonation, ensuring realists blast conditions for evaluating wall response. To prepare for the nonlinear, rate dependent behavior of brittle materials under high strain rate loading, which is characteristic in blast and impact events, the Riedel constitutive model more especially, the Riedel-Hiermaier-Thoma (RHT) model was developed. Realistic modelling of dynamic fracture and deformation is made possible by the incorporation of crushing, tensile failure, strain rate effects, and damage progression. Concrete's reaction to explosive loads has been properly predicted by this model, which has undergone thorough validation. Its basic formulation includes yield function, where σeq is the equivalent stress, ρ is the pressure, fc is the uniaxial compressive strength, and α is pressure sensitivity parameter.

$$f(\sigma) = \left(\frac{\sigma_{\mathrm{eq}}}{f_c}\right)^2 + \alpha\frac{p}{f_c} - 1 \leq 0 \tag{1}$$

Damage evolution, the damage variable D envolves with plai=stic strain εp and reduces the effective stress.

$$\sigma = (1 - D) \cdot \sigma_{\mathrm{eff}} \tag{2}$$

Strain rate dependence, the strength parameters are adjusted based on strain rate ε using a rate multiplier C(ε).

$$f_c(\dot{\varepsilon}) = f_c \cdot C(\dot{\varepsilon}) \tag{3}$$

Where C(ε) is typically defined empirically as below where ε0 is a reference strain rate, and m is a material parameter.

$$C(\dot{\varepsilon}) = \left(\frac{\dot{\varepsilon}}{\dot{\varepsilon}_0}\right)^m \tag{4}$$

Due it can manage the rate sensitive plasticity and damage processes common in composite materials subjected to dynamic loading; its formulation is also appropriate for polymer matrix composites (PMC). The RHT model is suitable for comparative blast wall simulation because it captures important variations in stiffness, strength, and failure modes while guaranteeing consistent treatment of the two materials unique mechanical behavior. All materials are characterized using constitutive models and parameters developed by Riedel-Hiermaier-Thoa., which have been extensively validated for dynamic impact and blast simulations. These models incorporate well-established research on reinforced concrete penetration and dynamic behavior under high strain rates, ensuring reliable and accurate representation of material responses during explosive loading.

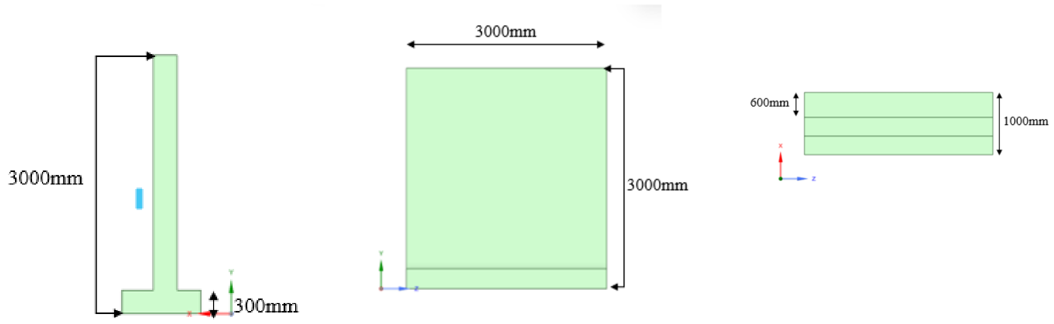
2.2 Geometry and Model Construction

Geometry and model construction provide the essential foundation for understanding designing and optimizing blast walls. Understanding the structural layout allows engineers to identify critical stress concentrations areas, optimize wall thickness, and introduce reinforcements or geometric features like fillets and bracing to enhance strength. Effective geometry also influences blast wave diffraction and pressure mitigation. They enable precise simulations and analyses that lead to safer, more effective protective barriers against explosive threats.

2.2.1 Geometry

Sketching is a fundamental step in the initial design phase of the blast wall, serving to visually define and communicate essential parameters such as the standoff distance between the wall and the explosive source. These initial sketches are not only valuable for conceptualizing the overall the overall configuration but also play a critical role in integrating safety features—such as protective elements and warning indicators—directly into the design, thereby minimizing operational risks. As depicted in Fig. 3, these blueprints ensure that each component aligns with the specific requirements for effective blast mitigation and provide a reference for both planning and risk management during subsequent stages.

Following the preliminary sketch, the wall's geometry and spatial layout are developed in detail using ANSYS Geometry SpaceClaim. This software enables the creation of precise and accurate three-dimensional models, including exact wall dimensions and placement relative to the explosive charge. All relevant measurements are documented in millimeters for consistency and accuracy. This level of detail supports the capacity to perform reliable simulations, allowing for thorough analysis of how the blast wave interacts with the wall's surfaces and structure. The objective of this comprehensive modelling approach is to design a blast wall capable of absorbing maximum overpressure from an explosion, with consideration for temporary construction scenarios where adaptability and optimization are vital.



(a) **(b)** **(c)**

Fig. 3 *Blast wall geometry views (a) Side view; (b) Front view; (c) Top view*

2.2.2 Mesh Refinement

After completing the geometry construction, a refined meshing process is applied to discretize the model for finite element analysis. The mesh in Fig. 4 is carefully generated to ensure adequate resolution of stress gradients, particularly in areas expected to experience high stress concentrations during blast loading. Solid elements compatible with the material types are used to represent both the particulate composite and polymer matrix composite sections of the wall. The mesh density is optimized to balance simulation accuracy and computational efficiency, ensuring that dynamic response characteristics such as deformation and stress distribution are captured in sufficient detail for meaningful analysis. Table 2 shows parameters of meshing settings in ANSYS. This meshing strategy is critical for producing reliable results in the explicit dynamic simulations conducted using ANSYS.

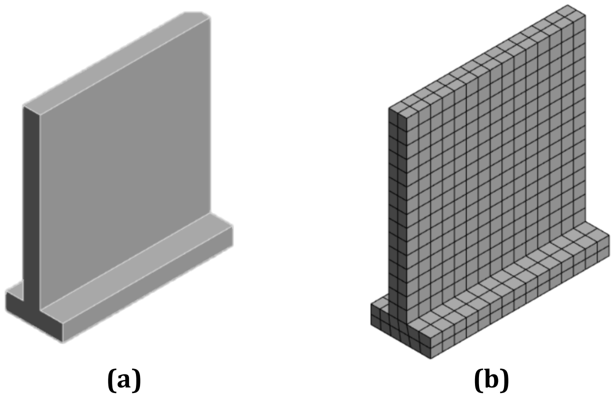


Fig. 4 *Blast wall geometry (a) Solid wall; (b) Mesh structure*

Table 2 *Parameters of meshing setting in ANSYS*

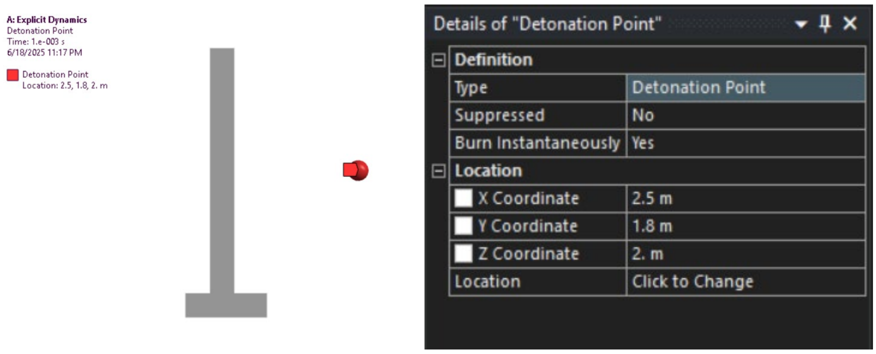
Parameter	Value	Remarks
Element size	0.2m	Base size of mesh elements
Element order	Linear	Linear elements used for faster computation
Capture curvature	Yes	Ensures better geometry representation
Bounding box diagonal	6.9282m	Size reference of the entire model
Average surface area	$7.762m^2$	Affects mesh density on surfaces
Minimum edge length	0.3m	Smallest edge allowed
Smoothing	High	Improves mesh quality
Inflation option	Smooth transition	Ensures gradual layer size change
Inflation element type	Wedges	Used for boundary layer meshing
Nodes	10 317	Total number nodes
Element	8 630	Total number elements
Growth rate	1.2	Mesh refinement
Target aspect ratio	5.0	Element shape quality
Defeature size	2e-002m	Small features are retained

By contrasting coarse, medium, and fine mesh settings, a mesh sensitivity analysis was carried out. A 0.4m element size was chosen in the coarse mesh, 0.2m in the medium mesh, and 0.1m in the fine mesh. For every mesh, important output parameters like directional velocity, peak stress, and maximum deformation were monitored. Results showed that the difference in critical parameters between he medium and fine meshes was less than 2%, indicating convergence. Insufficient accuracy was demonstrated by the coarse mesh, which showed variations of more than 8%. Because it strikes a balance between computational efficiency and precise resolution of stress gradients and transient blast effects within allowable error margins, the 0.2m element size was chosen.

Coarse 0.4m, medium 0.2m, and fine 0.1m mesh sizes were compared where medium and fine meshes showed less than 2% difference in results while the coarse mesh had over 8% variance. Thus, 0.2m was chosen for a robust balance a accuracy and computational efficiency.

2.3 Boundary Conditions

The blast loading on the walls was simulated using ANSYS Explicit Dynamics. The blast load, depicted in Fig. 5, represents a C4 explosive detonation and was applied as a pressure time history at the detonation point on the front face of the wall to realistically simulate the blast wave impact. The simulation utilizes C4 explosive parameters of density 1601kg/ m^3, detonation velocity 8193m/s by matching closely to known literature values where density is around 1.73g/ cm^3, detonation velocity near 8092m/s, and detonation pressure up to 257kbar. These parameters ensure the simulation accurately depicts realistic and pertinent explosion situations as they are in line with field test findings and established C4 characteristics for military and industrial threats.



(a) **(b)**

Fig. 5 *Detonation point in simulation (a) Side view; (b) Details data*

Three materials were selected for this study to comprehensively represent both structural and explosive components involved in blast events, as illustrated in Fig. 6. The primary structural material is CONC-35MPa concrete, chosen for its widespread use as a standard-grade construction material in blast-resistant applications.

This concrete grade, with a compressive strength of 35 MPa, offers a balance of mechanical strength and availability, making it a relevant baseline for comparative analysis. Its mechanical properties, including isotropic elasticity and high compressive capacity, enable it to effectively resist compressive loads generated during explosions.

(a) **(b)**

Fig. 6 *Fixed support in simulation (a) Bottom view; (b) Details data*

Material behavior was modeled to capture relevant physical responses under blast conditions. The concrete was characterized with nonlinear material properties to account for its complex stress-strain relationship under high strain rates, while the epoxy resin polymer matrix composite was modeled using orthotropic elastic properties to reflect its directional stiffness and anisotropic behavior. Together, these boundary conditions and material models enable a comprehensive and realistic simulation of the blast interaction with the wall structure.

2.4 Analysis Parameters

Since displacement, internal force concentration, and dynamic movement are the main markers of blast wall integrity and failure risk, the simulation concentrated on three parameters, total deformation, shear stress distribution and directional velocity. Given the comparison goals of the study, this focused method avoids needless computer complexity from tracking additional outputs like energy absorption or localized damage indices and is in line with engineering practice for evaluating structural response under high loads. In order to evaluate blast wall performance and safety in accordance with engineering standards three parameters were selected due to accurately reflect displacement failure zones, and dynamic movement. This avoids unnecessary complexity and focuses evaluation relevant to comparative goals of the study.

3. Results and Discussion

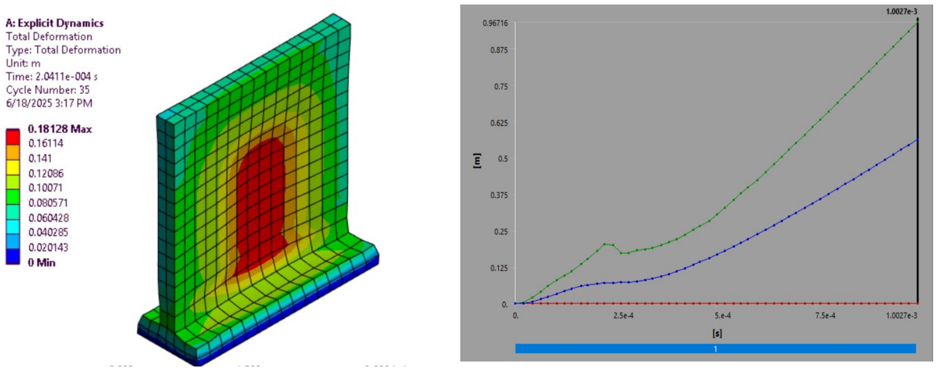
This chapter presents and analyzes the simulation results of the T-shaped blast wall subjected to blast loading using different composite materials. The primary focus is on comparing the responses of particulate composites and polymer matrix composites (PMC) in terms of key performance indicators such as stress distribution, total deformation, and directional velocity.

The discussion explores how the distinct material properties influenced the overall performance of the blast wall. It highlights which material demonstrated superior resistance to blast effects, identifies zones of failure or damage, and quantifies the amount of energy absorbed by each material during the explosive event. These findings provide valuable insights into the relative strengths and limitations of both material types when applied to blast-resistant structural design.

Furthermore, the chapter interprets the implications of the results for the optimization of blast wall designs, emphasizing potential enhancements in material selection and structural configuration. It also outlines directions for future research to address observed challenges and refine predictive modeling approaches. Overall, this section bridges the simulation data with practical engineering considerations, evaluating the suitability of particulate composites and PMCs for effective blast wall applications.

3.1 Total Distribution

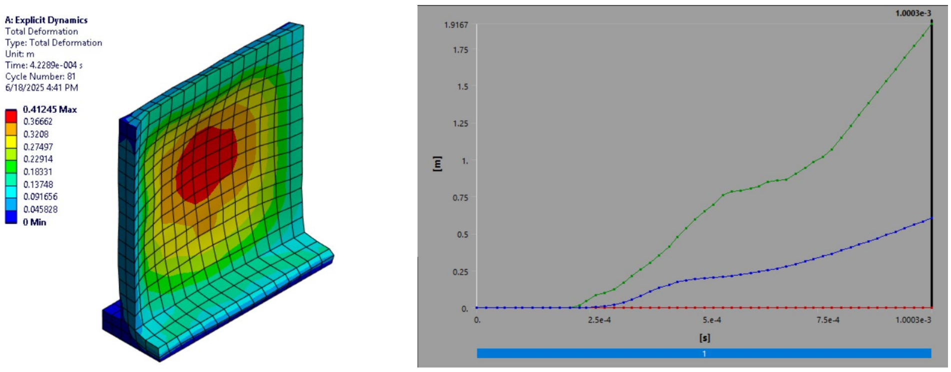
Fig. 7 shows that the concrete blast wall experienced a maximum deformation of 0.9671 m, concentrated in the central region indicated by the red zone, which represents the area of highest displacement. The graph of deformation versus time, where the green line likely corresponds to a node in the central region, shows a rapid increase in displacement reaching approximately 0.85 mm over time. The blue line represents a point near the edge or a less critical location, exhibiting significantly lower displacement values.



(a) (b)

Fig. 7 *Concrete blast wall (a) Geometry; (b) Total deformation vs. time graph*

In contrast, Fig. 8 shows that the maximum deformation for the polymer matrix composite (PMC) wall is higher compared to concrete. The red zone in this case is more spread out and circular, with deformation values around 0.4 m, which suggests a stronger or more direct blast impact on a comparatively weaker structure. Further illustrates that epoxy-based PMC walls experienced peak displacements of 1.9167 m under overpressure. This indicates that the total deformation in concrete walls under blast loading is significantly less than that in PMC walls. The more dispersed and circular deformation zone for PMC reflects its response to a direct blast on a relatively less stiff structure, whereas the concrete wall's resistance to displacement and structural distortion is notably higher.



(a) (b)

Fig. 8 *Epoxy resin blast wall (a) Geometry; (b) Total deformation vs. time graph*

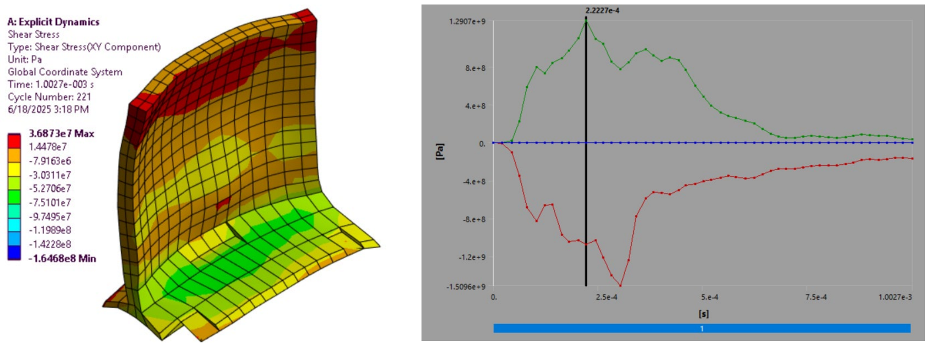
Concrete walls deform approximately 50% less than PMC walls under blast loads due to their higher stiffness and compressive strength, consistent with findings reported by Gebre et al. and Omar et al. PMC materials, such as epoxy-based composites, exhibit greater flexibility and dissipate energy through larger deformations, which can help reduce stress concentrations, as noted by Sahu and Patel.

In conclusion, compared to concrete, PMC walls experience greater deformation, indicating lower stiffness and resistance and suggesting they are subjected to more severe loading effects. Under blast stress, concrete walls distort around half as much as PMC walls, with maximum deformations of 1.9167m and 0.9671m, respectively. When compared to more flexible, energy dissipating PMC materials, concrete's greater rigidity and blast resistance are quantitatively demonstrated by this 1:2 deformation ratio, which also confirms that concrete better limits displacement and preserves structural integrity.

3.2 Shear Stress

Shear stress analysis provides calculating determining the first moment of area and the moment of inertia of the T-shaped cross section, considering the thickness of the wall. The location of the neutral axis was essential for these calculations and significantly influenced the shear stress distribution throughout the structure.

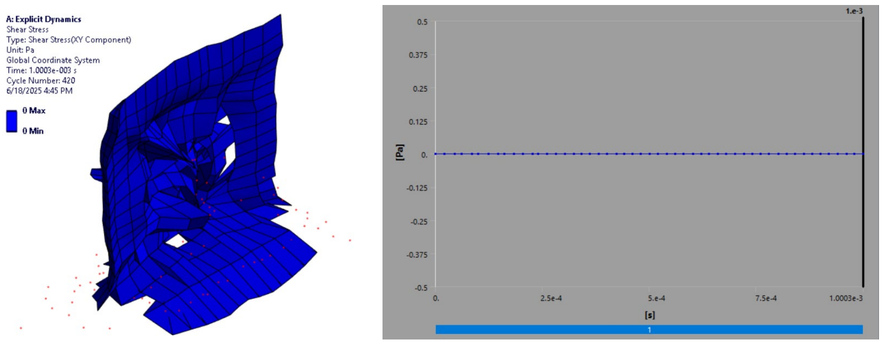
Fig. 9, the highest is concentrated in the upper central region, indicated by the red zone, signaling potential failure or yielding points. This area exhibits severe out-of-plane deformation and curvature, suggesting a major compromise in structural integrity. Further illustrates this deformation, with localized shear stress spikes reaching 1.2GPa at the wall joints. Graph plotting shear stress versus time shows a sharp peak in stress around 2.2×10^{-4} seconds (green curve), followed by fluctuations typical of a dynamic shock event. The blue curve remains near zero, representing a static or fixed reference point, while the red curve enters compression, with negative values reaching approximately -1.5GPa.



(a) **(b)**

Fig. 9 *Concrete blast wall (a) Geometry; (b) Stress vs. time graph*

In contrast, Fig. 10 displays the epoxy-based PMC wall, which appears torn or fractured. The stress distribution remains uniformly close to 0Pa, indicating that the material has exceeded its failure criteria and experienced catastrophic damage beyond elastic limits. The completely flat stress plot confirms that no residual stress remains, signaling structural collapse. To further support this observation, where the stress plot is entirely flat, and the blue curve remains at zero, further confirming absence of stress in the failed structure.



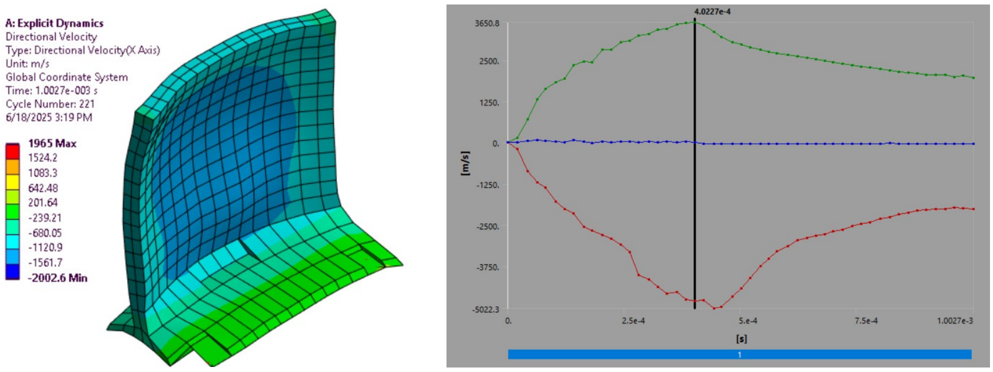
(a) **(b)**

Fig. 10 *Epoxy resin blast wall (a) Geometry; (b) Stress vs. time graph*

Concrete exhibits high, concentrated shear stresses at critical joints, indicating localized stress concentrations that, due to concrete's brittle nature, can lead to crack initiation and failure. Conversely, the epoxy PMC shows a more uniform and lower shear stress distribution, which facilitates better energy dissipation, reducing the risk of sudden failure. These two scenarios represent fundamentally different structural responses to blast loading. The concrete barrier absorbs and redistributes stress through plastic deformation, maintaining structural integrity, while the epoxy PMC shows structural collapse from material failure. These findings are critical for evaluating blast resistance and guiding the design of effective protective structures. As a result, the normalized shear stress ratio is around 120 times more stress concentration in concrete at crucial places prior to crack initiation.

3.3 Directional Velocity

Fig. 11 indicates that concrete blast wall undergoes moderate deformation but remains largely intact. The deformation pattern is curved and spread out, reflecting ductile behavior and strong resistance to blast forces. The maximum directional velocity observed in the concrete structure, reaching 3,650.8 m/s. The graph displays velocity components in the x, y, and z directions. The green line, likely representing the z-direction aligned with the blast-facing side, peaks around 3,650 m/s. The red line corresponds to the y-direction, or horizontal axis, which dips into negative values, indicating backward movement as the wall responds to the pressure wave generated by the C4 explosion. The blue line, associated with the x-direction or depth/constrained edge, remains near zero, showing minimal movement. These observations suggest that while the blast wave imparts significant energy, the inherent stiffness of the concrete effectively limits excessive displacement. Overall, the concrete wall demonstrates a favorable balance between energy absorption and maintaining structural integrity under blast loading.

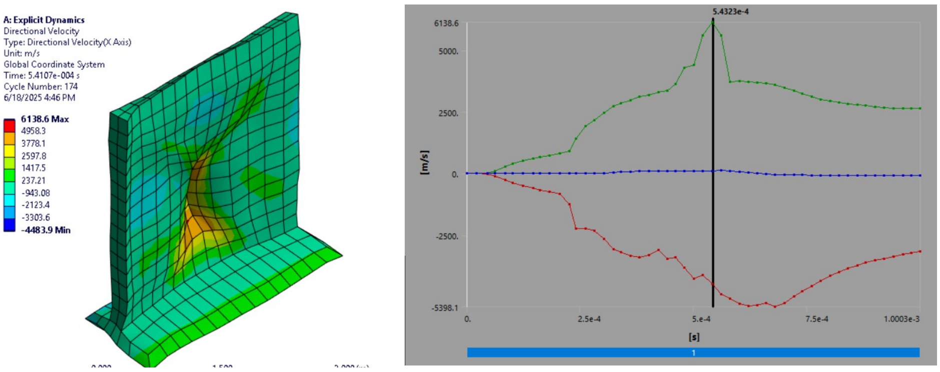


(a) **(b)**

Fig. 11 *Concrete blast wall (a) Geometry; (b) Directional velocity graph*

In contrast, Fig. 12 reveals that the epoxy-based polymer matrix composite (PMC) wall experiences a higher maximum directional velocity of 6,138.6 m/s. This elevated velocity indicates substantial local deformation, a faster dynamic response to impact, and a pronounced rebound effect, particularly evident as a sharp dent at the blast impact point. The blast energy appears to transmit more rapidly through the epoxy compared to concrete, suggesting that PMC walls deform or move more quickly under blast loading. This behavior reflects their lower stiffness and distinct energy absorption characteristics. The green line representing the z-direction peaks higher than that of the concrete wall, indicating a quicker response to blast impact. The red line for the y-direction shows a deeper negative dip, signifying more intense rebound or internal structural movement. The blue line for the x-direction remains largely flat, indicating no significant displacement in that direction. Concrete's lower maximum velocity is attributed to its higher mass and stiffness, which slows down wave propagation and dissipate energy through mechanisms such as cracking and crushing. Conversely, the higher velocity in epoxy signifies less effective attenuation of blast motion.

In conclusion, the directional velocity analysis highlights that concrete walls perform better overall, exhibiting controlled deformation, lower stresses, and effective energy dissipation, making them ideal for resisting blast loads. Polymer matrix composite walls, however, show higher stress and velocities, indicating reduced resistance and increased likelihood of failure, especially in critical zones near the blast. For protective structures like blast walls, concrete remains the more suitable material due to its durability, stiffness, and superior capacity for absorbing and dissipating blast energy.



(a) (b)

Fig. 12 *Epoxy resin blast wall (a) Geometry; (b) Directional velocity graph*

4. Conclusion

This study T-shaped blast barriers composed of polymer matrix composite (epoxy resin) and particle concrete (CONC-35MPa) were evaluated using ANSYS Explicit Dynamics. Consistent with previous studies demonstrating concrete's efficacy for industrial and military blast protection, concrete demonstrated greater resistance to blast induced deformation, shear stress, and directional velocity due to its higher stiffness and strength.

In order to improve blast resistance, the PMC walls showed increased deformation and collapse under stress, indicating the necessity for reinforcing or hybrid designs. The T-shaped geometry enhanced load distribution but created stress concentrations at corners and joints. This underscores the significance of optimizing the design using bracing or fillets to lower these crucial stresses, a tactic backed by current research on blast wall performance enhancement.

Limitations include the simplified material models and specific blast scenarios used. Further work should involve experimental validation, exploration of different composite configurations, and long-term durability assessments. Sensor integration for real-time health monitoring is also recommended to enhance structural reliability during service.

Due to its durability and ability to absorb energy, concrete is still the material of choice for crucial blast barriers, however newer PMC designs may provide lighter, more flexible alternatives. By combining numerical insights with ongoing material science and engineering developments, contributing valuable directions for future blast resistant infrastructure design.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors are responsible for the study conception, research design, data collection, data analysis, result interpretation and manuscript drafting.

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