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Comparative Study on the Analysis of Blast Wall with and without GFRP using ANSYS

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Abstract: ***A bomb explosion within or immediately nearby a building can cause catastrophic damage on the building's external and internal structural frames, collapsing of walls, blowing out of large expanses of windows, and shutting down of critical life-safety systems. In addition, major catastrophes resulting from gas-chemical explosions result in large dynamic loads, greater than the original design loads, of many structures. Studies were conducted on the behavior of structural concrete subjected to blast loads. This analysis investigates the behavior of reinforced concrete blast wall subjected to air blast loading. A total of four different charge weight of TNT, which represents a minimum loading capacity of person or vehicle to carry an explosive was simulated at a stand-off distance of 1.7 m and 2 m from the blast wall. This explosive capacity representative bombs are hand carried bomb by personnel with a loading capacity of 5 kg, Motorcycle 50 kg, car 400kg and also van with the capacity of 1500 kg of TNT explosive. The wall strengthened with GFRP wrapping is again blast analyzed in ANSYS @ 1.7 m and 2 m standoff distances and comparing the results.***

Keywords: Blast wall, GFRP, TNT, Stand-off distance, ANSYS

1. Introduction

Some structures, both military and civilian, might experience explosive loads during their service life. Owing to high uncertainties in blast load predictions and structural parameters, accurate assessment of the performances of structures under explosion loads is a challenging task. Reinforced concrete is the principal material for military engineering and nuclear power plant containment. However, impacts and explosions could completely destroy such structures, causing tremendous casualties and property loss. In recent years due to different accidental or intentional, blast all over the world resulted in studies of the resistance of structures to blast and to develop system to reduce the hazards. The behavior of structures components subjected to blast loading has been the subject of considerable research effort in recent years. Blast wall is known as barrier wall used to isolate buildings or areas from material containing, highly combustible or explosive materials or to protect a building or an area from blast damage when exposed to explosions. Reinforced concrete blast wall is the type used for blast wall protection.

Objectives

- Understand the concept of behavior of structures on blasting and its impact
- Simulate Finite Element Analysis to evaluate behavior of structures on blasting
- Study optimum design, ultimate impact load capacity under blast loads

2. Finite Element Analysis of Blast Wall with and without GFRP

The response of blast wall in the event of accidental explosion is analyzed using the model in ANSYS software. ANSYS is general-purpose finite element software for numerically solving a wide variety of structural engineering problems. The ANSYS element library consists of more than 100 different types of elements. Reinforced concrete blast wall is modeled in CATIA V5 using top down method. The models with and without GFRP Panel are created. Then they are imported to ANSYS for further analysis. The material properties, loads and boundary conditions are given to the model. It was inferred that explicit dynamics analysis enough to find the deflection of the structure under blast loading. Using this type of analysis, stresses, strains, and deformations of structures can be determined. The time-varying displacement, stresses and strains can be easily obtained.

2.1 Parameters

Explosive capacity representative bombs are hand carried bomb by personnel with a loading capacity of 5 kg, Motorcycle 50 kg, car 400kg and also van with the capacity of 1500 kg of TNT explosive. The TNT is located at a specified distance from wall known as the standoff distance.

Table 1: TNT Capacity and standoff distance of Blast wall with and without GFRP

Capacity of TNT (kg)	*Standoff Distance (m)*	
5	1.7	2
50	1.7	2
400	1.7	2
1500	1.7	2

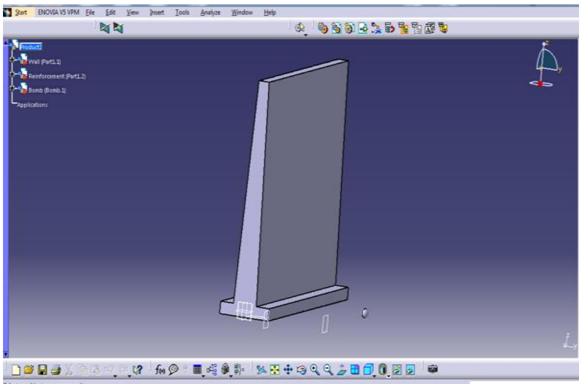

Figure 1: Model of blast wall with TNT explosive in CATIA

2.2 Size of TNT

Density of TNT = 1630 kg/m^3 (from ANSYS)

$$\rho = \frac{m}{V}$$

TNT Mass, m = 5 kg, 50 kg, 500 kg and 1500 kg

$$V = \frac{4}{3}\pi r^3$$

From the above equation radius of TNT explosive according to each mass can be determined and applying to the model.

2.3 Supports

The support condition given to the structure is fixed.

2.4 Finite Element Analysis of Blast Wall without GFRP

The Explicit dynamic analysis of reinforced concrete blast wall is done in ANSYS with various capacities of TNT explosives and standoff distances. The sequence of blast loading is kept as 5 kg, 50 kg, 400 kg and 1500 kg respectively.

Analysis of blast wall without GFRP at 1.7 m

The TNT is located at a specified distance from wall known as the standoff distance. The point at which the explosion occurs in TNT is known as the detonation point. Initially the standoff distance is kept as 1.7 m. The model is created in CATIA and imported to ANSYS is shown below.

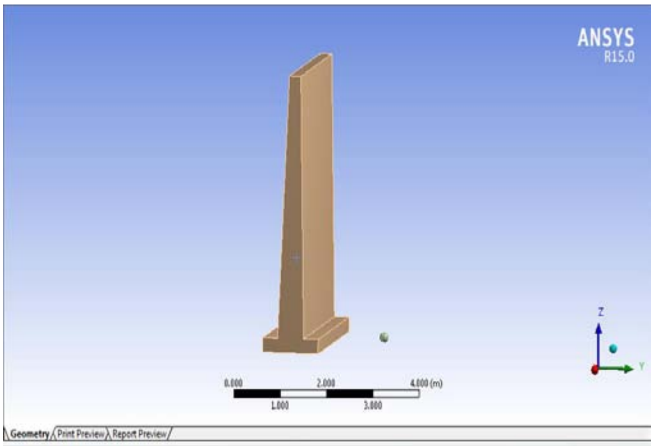

Figure 2: Model of blast wall with 5 kg TNT at distance of 1.7 m without GFRP

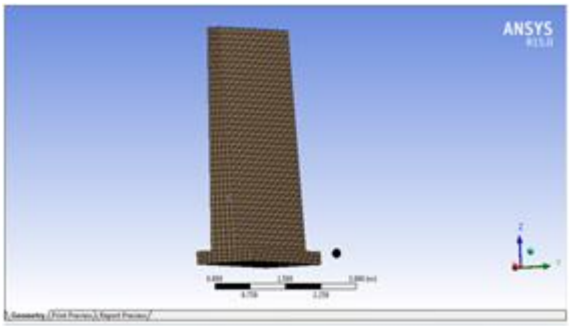

Figure 3: Meshed model of blast wall with 5 kg TNT at distance of 1.7 m without GFRP

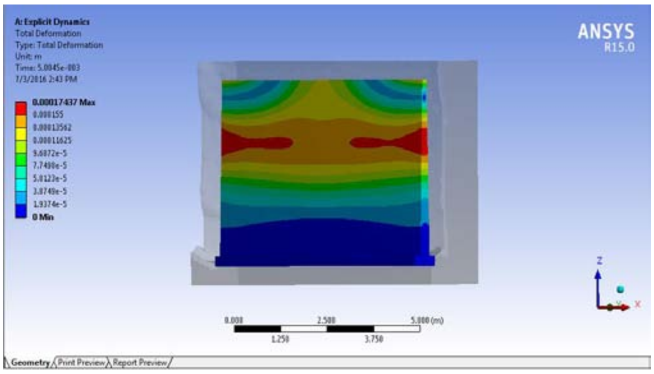

Figure 4: Deflection diagram of Blast wall with 5 kg TNT at a distance of 1.7 m without GFRP

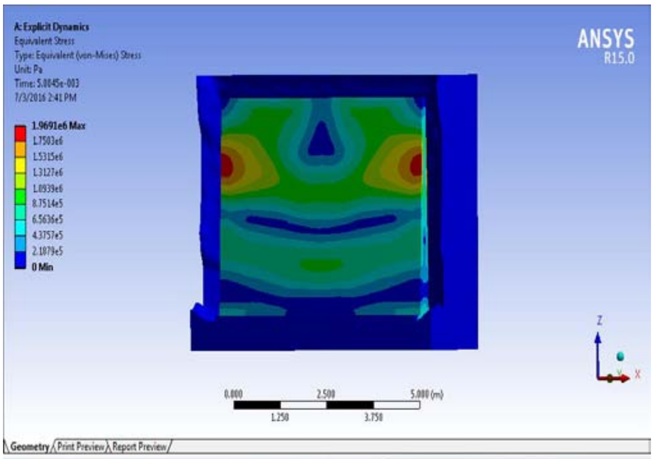

Figure 5: Stress diagram of Blast wall with 5 kg TNT at a distance of 1.7 m without GFRP

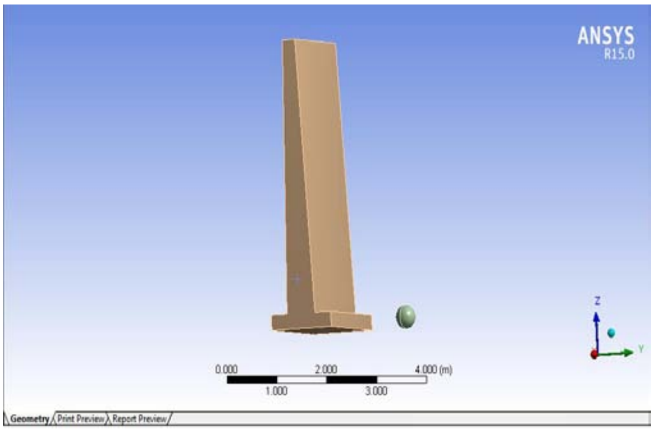

Figure 6: Model of blast wall with 50 kg TNT at distance of 1.7 m without GFRP

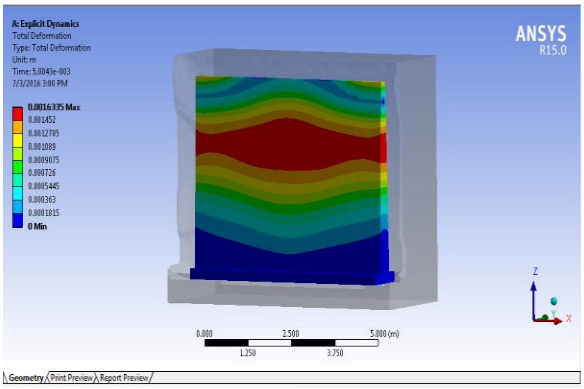

Figure 7: Deflection diagram of Blast wall with 50 kg TNT at a distance of 1.7 m

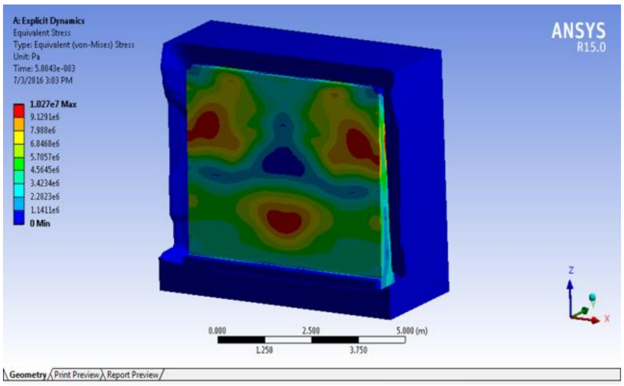

Figure 8: Stress diagram of Blast wall with 50 kg TNT at a distance of 1.7 m

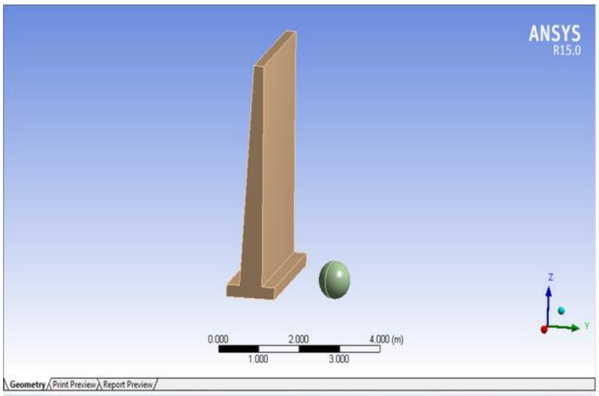

Figure 9: Model of blast wall with 400 kg TNT at distance of 1.7 m without GFRP

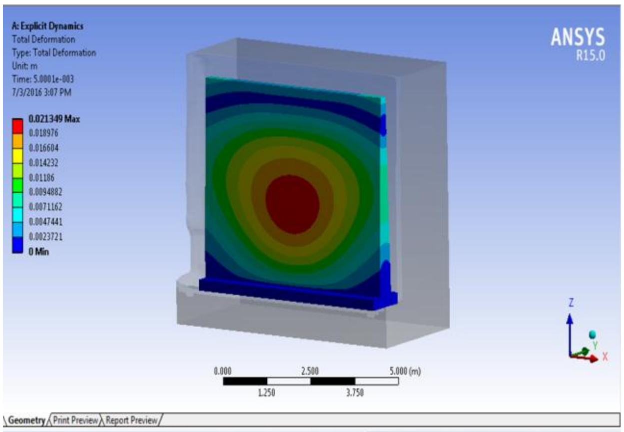

Figure 10: Model of blast wall with 400 kg TNT at distance of 1.7 m without GFRP

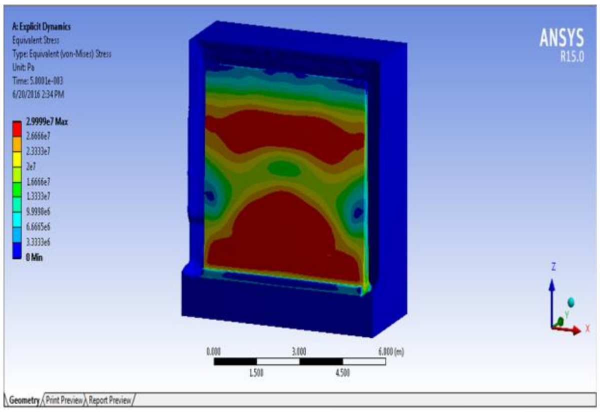

Figure 11: Stress diagram of Blast wall with 400 kg TNT at a distance of 1.7 m

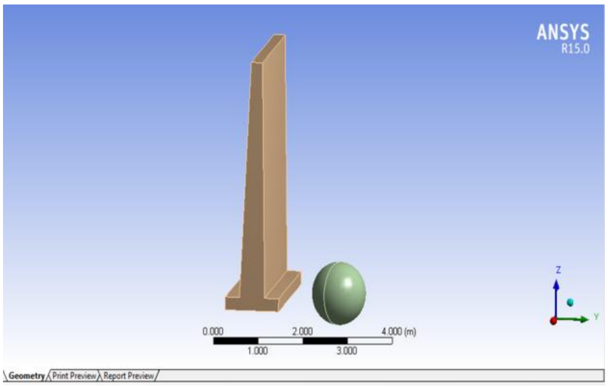

Figure 12: Model of blast wall with 1500 kg TNT at distance of 1.7 m without GFRP

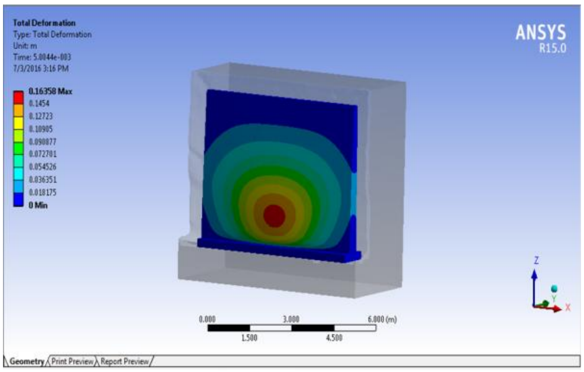

Figure 13: Deflection diagram of Blast wall with 1500 kg TNT at a distance of 1.7 m

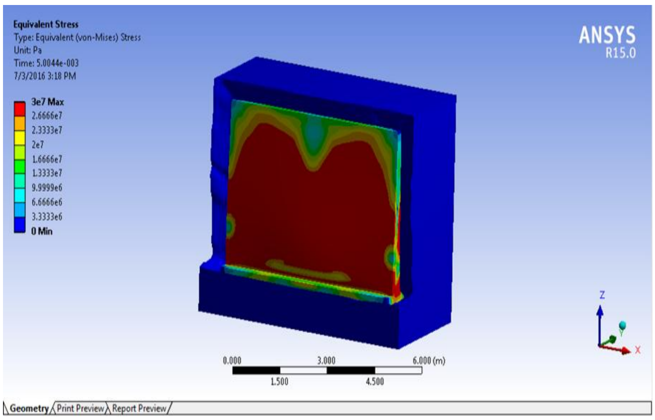

Figure 14: Stress diagram of Blast wall with 1500 kg TNT at a distance of 1.7 m

Analysis of blast wall without GFRP at 2 m

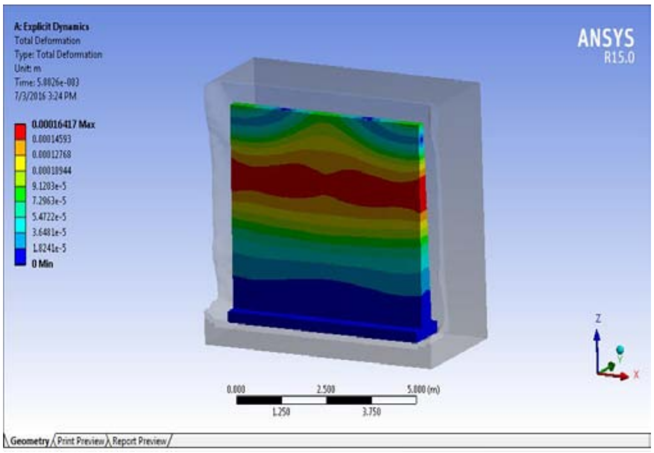

Figure 15: Deflection diagram of Blast wall with 5 kg TNT at a distance of 2 m

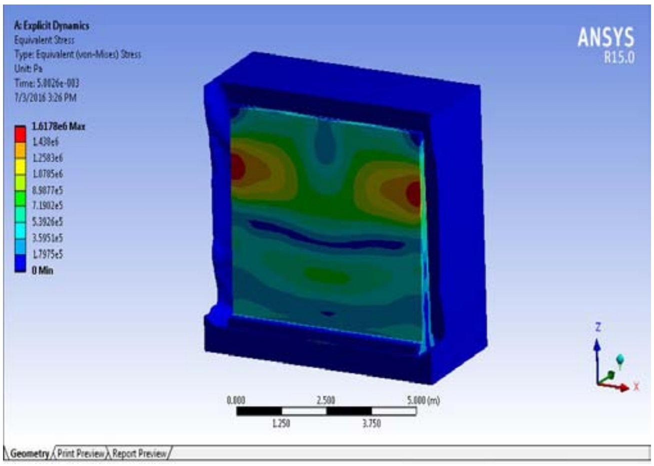

Figure 16: Stress diagram of Blast wall with 5 kg TNT at a distance of 2 m

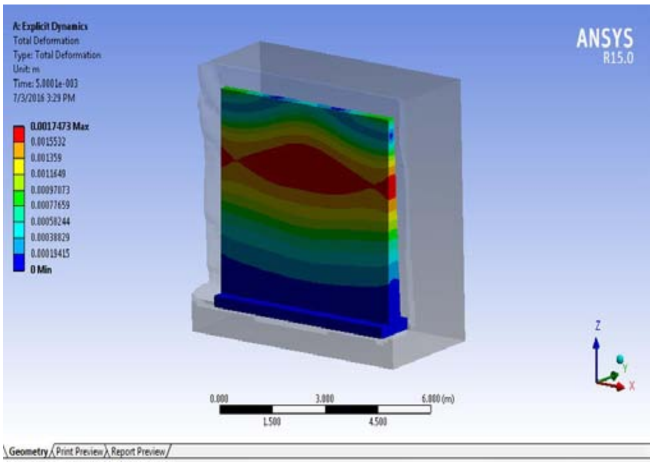

Figure 17: Deflection diagram of Blast wall with 50 kg TNT at a distance of 2 m

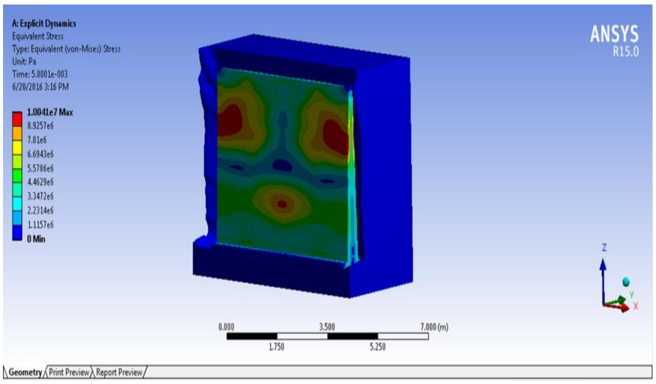

Figure 18: Stress diagram of Blast wall with 50 kg TNT at a distance of 2 m

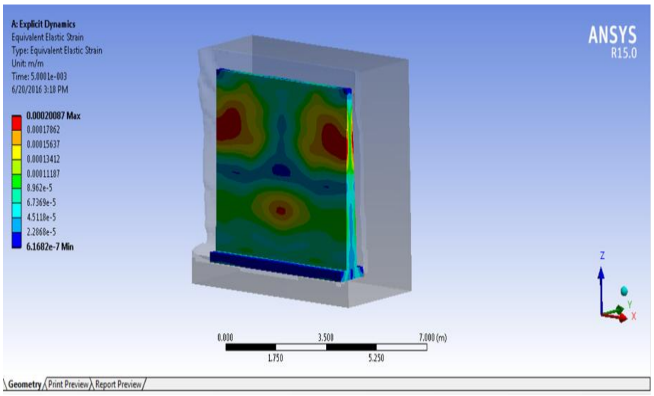

Figure 19: Strain diagram of Blast wall with 50 kg TNT at a distance of 2 m

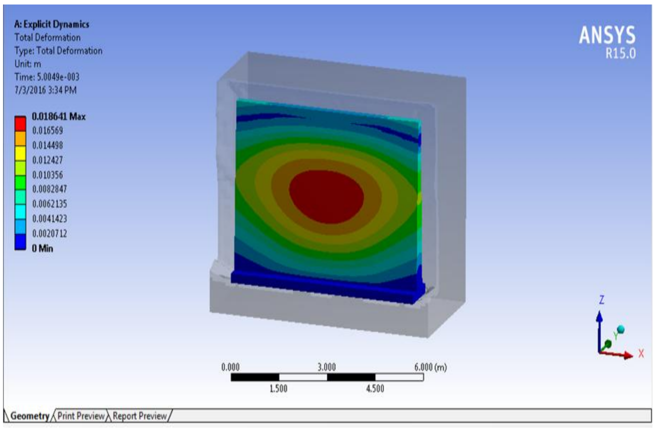

Figure 20: Deflection diagram of Blast wall with 400 kg TNT at a distance of 2 m

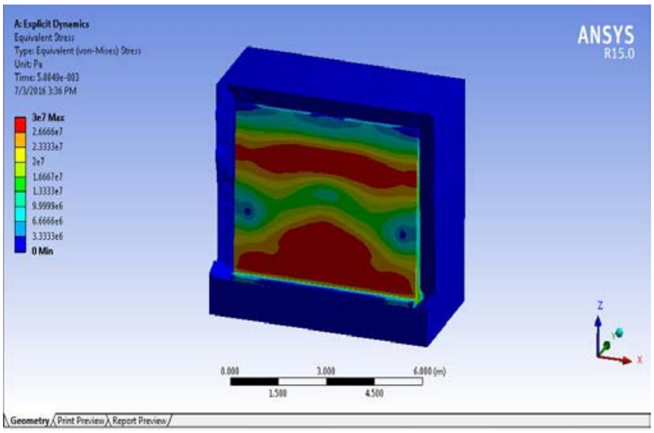

Figure 21: Stress diagram of Blast wall with 400 kg TNT at a distance of 2 m

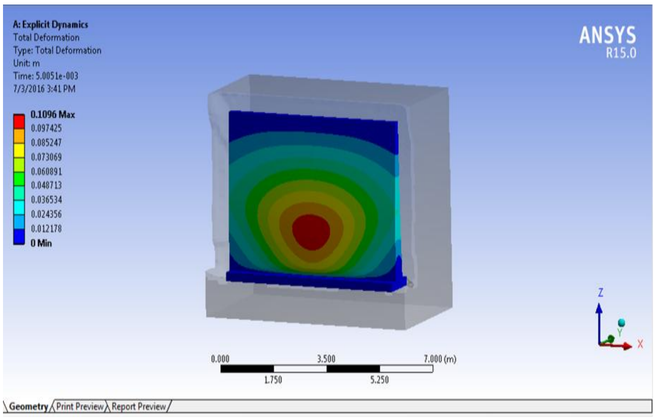

Figure 22: Deflection diagram of Blast wall with 1500 kg TNT at a distance of 2 m

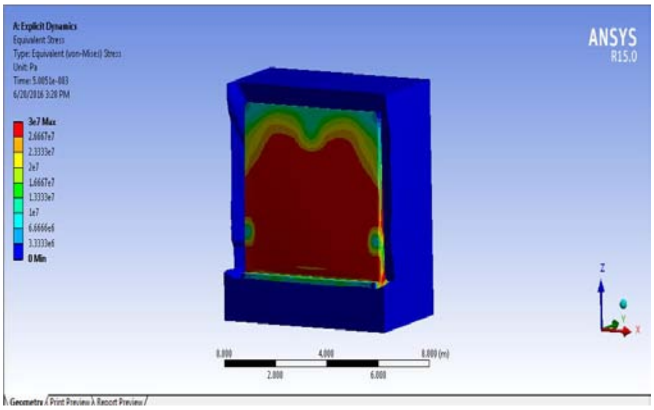

Figure 23: Stress diagram of Blast wall with 1500 kg TNT at a distance of 2 m

Summary of Results

Table 2: Result summary of blast wall without GFRP

TNT (kg)	***1.7 m***		***2 m***	
	Deflection (m)	Stress (Pa)	Deflection (m)	Stress (Pa)
5	0.000174	1.9691e6	0.000164	1.617e6
50	0.00163	1.027e7	0.00175	1.004e7
400	0.02135	2.999e7	0.01864	3e7
1500	0.16358	3e7	0.1096	3e7

2.5 Finite Element Analysis of Blast Wall With GFRP

Consider the analysis of reinforced concrete blast wall with GFRP wrapping. 4 mm thick GFRP panels are fixed around the blast wall to determine the response against blast loads. The sequence of blast loading is kept as 5 kg, 50 kg, 400 kg and 1500 kg respectively. From the analysis, the Displacement, Stress and Strain diagram of Blast wall with GFRP wrapping is obtained. Then comparing and determining the advantage of installing GFRP in reinforced concrete blast wall.

Analysis of blast wall with GFRP at 1.7 m

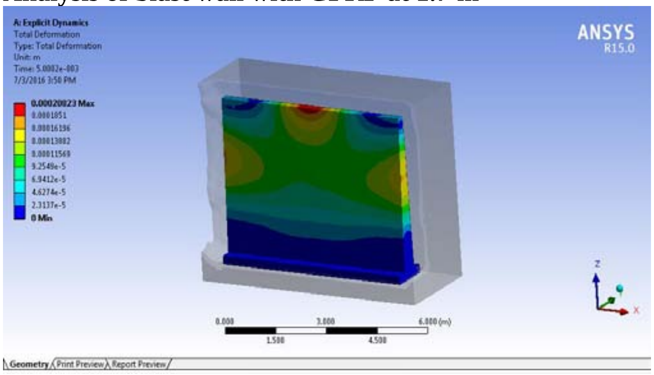

Figure 24: Deflection diagram of Blast wall with 5 kg TNT at a distance of 1.7 m

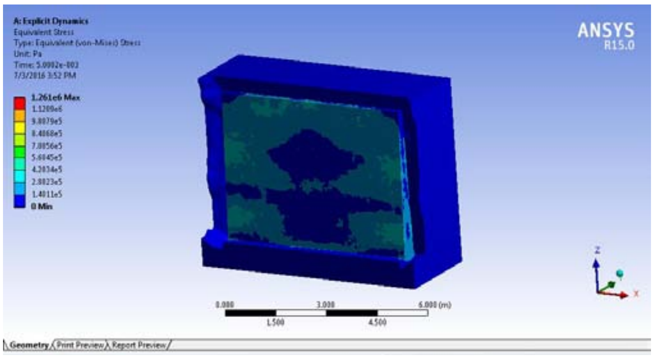

Figure 25: Stress diagram of Blast wall with 5 kg TNT at a distance of 1.7 m

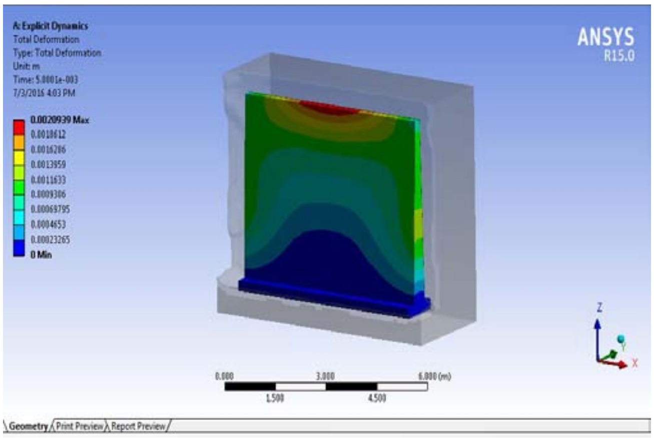

Figure 26: Deflection diagram of Blast wall with 50 kg TNT at a distance of 1.7 m

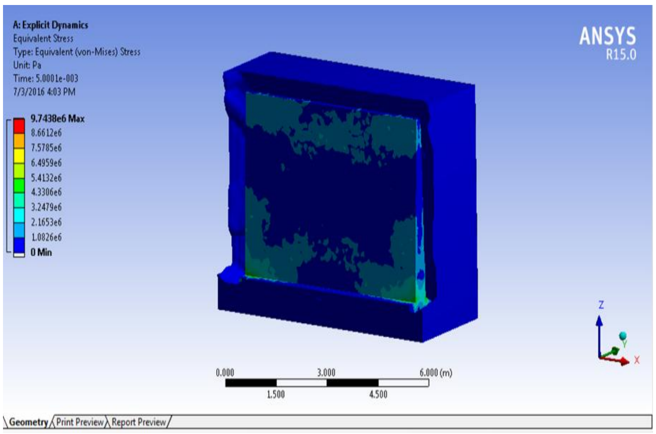

Figure 27: Stress diagram of Blast wall with 50 kg TNT at a distance of 1.7 m

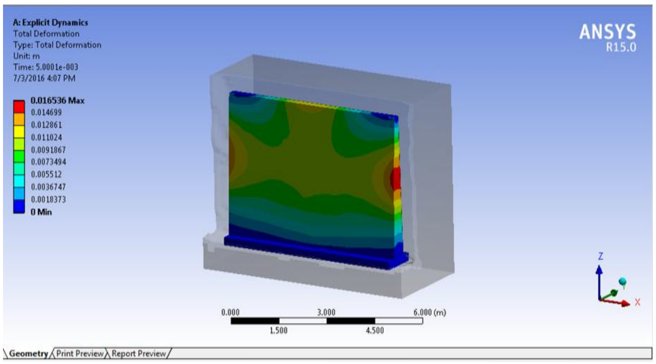

Figure 28: Deflection diagram of Blast wall with 400 kg TNT at a distance of 1.7 m

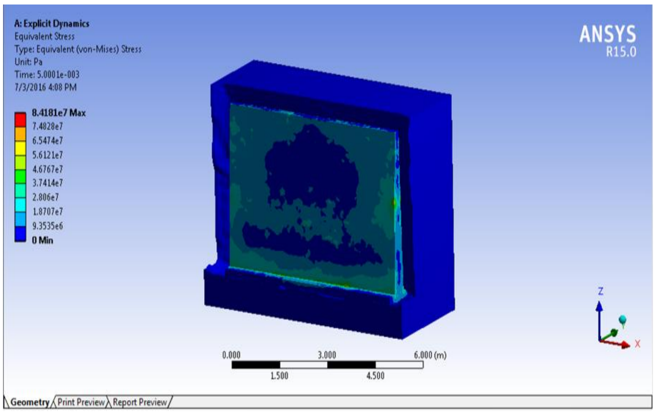

Figure 29: Stress diagram of Blast wall with 400 kg TNT at a distance of 1.7 m

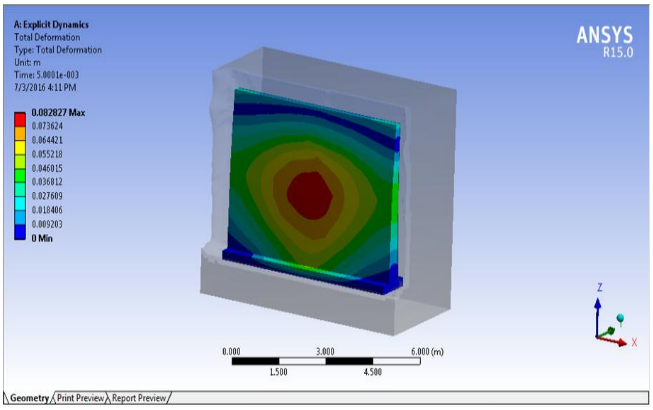

Figure 30: Deflection diagram of Blast wall with 1500 kg TNT at a distance of 1.7 m

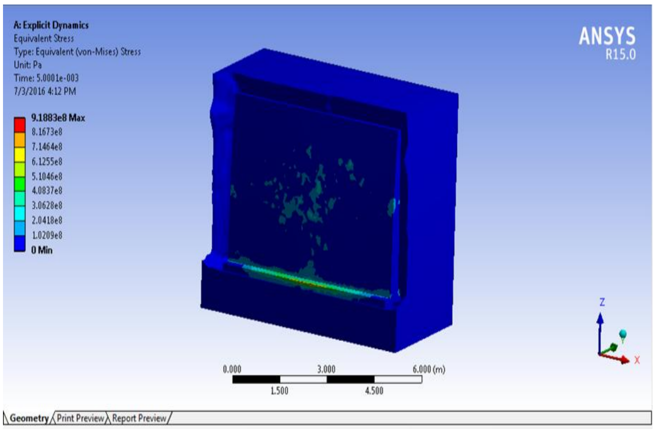

Figure 31: Stress diagram of Blast wall with 1500 kg TNT at a distance of 1.7 m

Analysis of blast wall with GFRP at 2 m

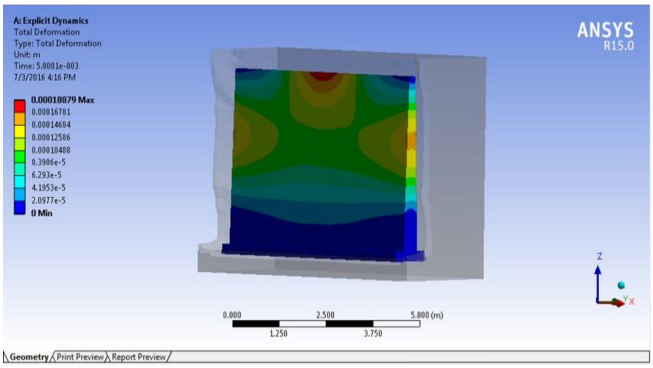

Figure 32: Deflection diagram of Blast wall with 5 kg TNT at a distance of 2 m

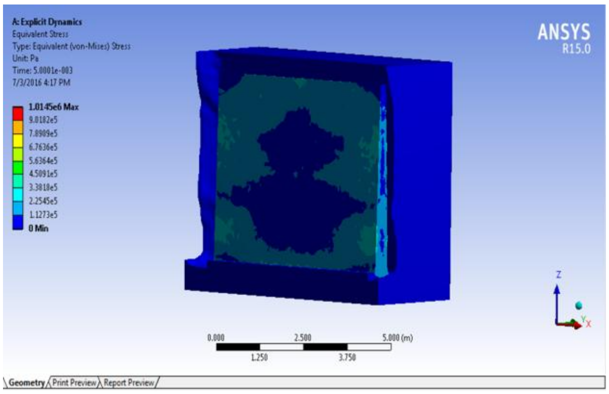

Figure 33: Stress diagram of Blast wall with 5 kg TNT at a distance of 2 m

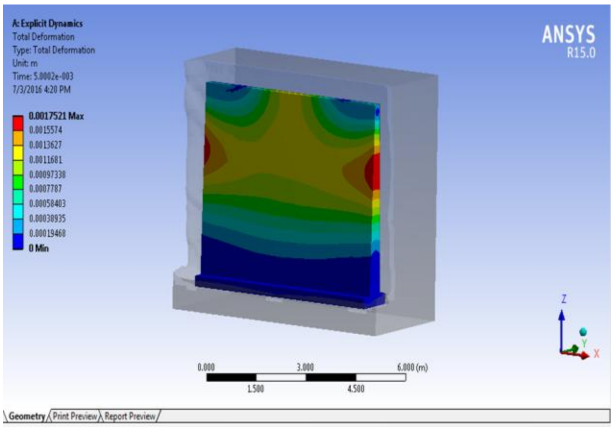

Figure 34: Deflection diagram of Blast wall with 50 kg TNT at a distance of 2 m

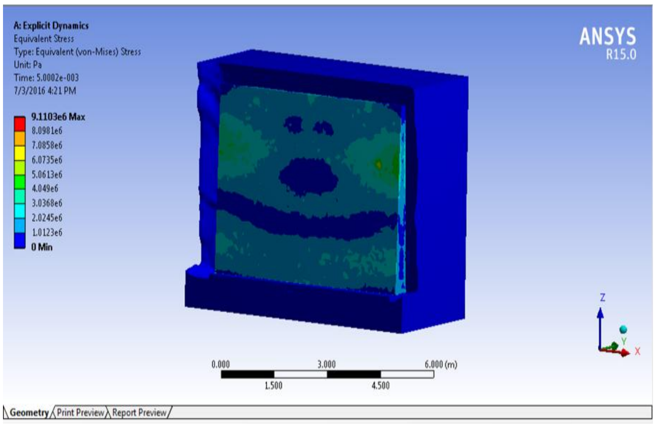

Figure 35: Stress diagram of Blast wall with 50 kg TNT at a distance of 2 m

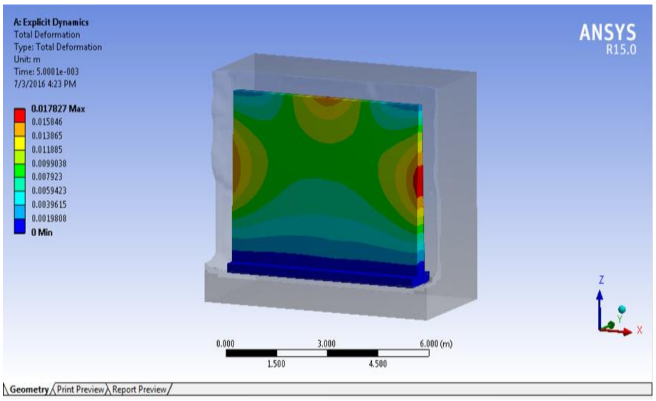

Figure 36: Deflection diagram of Blast wall with 400 kg TNT at a distance of 2 m

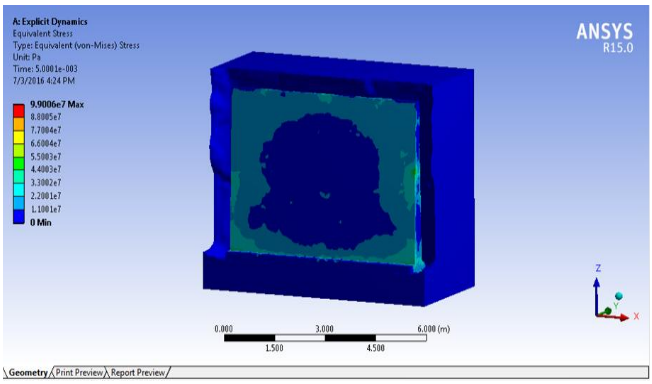

Figure 37: Stress diagram of Blast wall with 400 kg TNT at a distance of 2 m

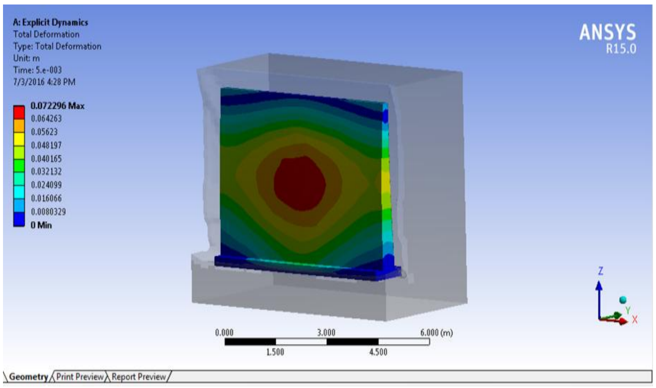

Figure 38: Deflection diagram of Blast wall with 1500 kg TNT at a distance of 2 m

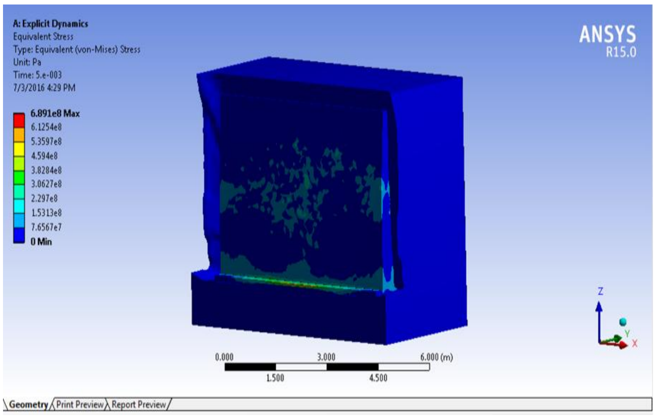

Figure 39: Stress diagram of Blast wall with 1500 kg TNT at a distance of 2 m

3. Summary of Results

Table 3: Result summary of blast wall with GFRP

TNT (kg)	***1.7 m***		***2 m***	
	Deflection (m)	Stress (Pa)	Deflection (m)	Stress (Pa)
5	0.000208	1.261e6	0.0001888	1.015e6
50	0.002094	9.7438e6	0.001752	9.110e6
400	0.01654	8.4181e7	0.01783	9.901e7
1500	0.08283	9.1883e8	0.072296	6.861e8

4. Conclusion

1) From the comparison of analysis results such as deflection and stress, the blast wall wrapped with GFRP showed better performance in preventing damages due to explosion. The degree of resistance to explosion of GFRP wrapped blast wall is greater in higher TNT values. Hence the GFRP panels can be recommended for various blast resistance
2) It is observed that the deflection of blast wall can be safely reduced in the presence of GFRP wrapping around the blast wall. It is clear that for 1500 kg TNT, the deflection is halved in the presence of GFRP when comparing it with the deflection of wall without GFRP. Hence the GFRP panels are recommended for blast resisting structures

References

[1] A. Ghani Razaqpur, Ahmed Tolba and Ettore Contestabile, "Composites Part B" Vol 38, Science Direct (2007) 535-546"R. Caves, Multinational Enterprise and Economic Analysis, Cambridge University Press, Cambridge, 1982. (book style)

[2] Hong Hao, Zhong-Xian Li and Yanchao Shi, "Journal of Performance of Constructed Facilities"ASCE, Volume 30, Issue 2, April 2016H.H. Crokell, "Specialization and International Competitiveness", H. Etemad and L. S, Sulude (eds.), Croom-Helm, London, 1986.

[3] Mohammed Alias Yusof, Rafika Norhidayu Rosdi, Norazman Mohamad Nor, Ariffin Ismail, Muhammad Azani Yahya, Ng Choy Peng "Journal of Asian Scientific Research" Volume 4, Issue 9, 2014, Kanpur, India, 2000. (technical report style)

[4] Osman Shallan, Atef Eraky, Tharwat Sakr and Shimaa Emad "International Journal of Engineering and Innovative Technology" Vol. 4, Issue 2, August 2014)