

Blast Analysis of Concrete Filled FRP Tube Columns

Greeshma P.R¹, Sujith P.S²

P.G. Student, Department of Civil Engineering, Axis College of Engineering and Technology, East kodaly, Kerala, India¹

Assistant Professor, Department of Civil Engineering, Axis College of Engineering and Technology, East kodaly, Kerala, India²

ABSTRACT: The blast is a wave of highly compressed air spreading from an explosion. Explosion and blast can produce in very short time and over load much greater than design loads of a building. Effect of blast-loads on buildings are serious matter because of the increase in the number of terrorist attack. Blast analysis can protect civilian, industrial and military structure from explosion and save lives and property. This research bases over modelling and analysis of the effect of 50kg c4 blast on rectangular concrete filled FRP tubes of different types of fibres using AnsysAutodyn software to predict the response of model to blast. CFFT members is an innovative idea, in which a FRP element acts together with a concrete element, so that both elements resist the axial and flexural loads. For the variety of reasons, infrastructure concerned with concrete filled tubular structure and metallic structures becomes structural unsatisfactory and in many causes, CFFT structures are carrying loads, but are still in service, because of their conservative design by modern standards hence it is necessary to restore or enhance the load carrying capacity and increase the life span of the structure. Many innovative applications have been explored for concrete structures where as they were limited in the case of structures. This project is aimed to investigating the behaviours of concrete filled FRP tubes under blast loading.

KEYWORDS: CFFT, FRP, Fibres, Blast analysis

I. INTRODUCTION

In recent years because of increased fanatic activities, civil structures are exposed to threats from blast-induced impulsive loads. Several such incidents have taken place around the world, causing serious threat to life and property. Generally conventional structures are not designed for blast load due to the reason that magnitude of load caused by blast is huge and cost of design and construction is very high. As a result structure is susceptible to damage from blast load. Designing the structures to be fully blast resistant is not a realistic and economical option, however current engineering and architectural knowledge can enhance the new and existing buildings to mitigate the effects of an explosion. Explosive sources that may be considered in the structural design include military weapons, vehicles bombs, improvised high explosive devices which are increasingly common in attacks around the world. The explosion of bomb in and around the buildings can cause catastrophic impacts on structural integrity of the building such as damage to the internal and external structural frames and collapse of walls. Moreover loss of life can result from collapse of structure. Analysis of structures under blast load requires a good understanding of the blast phenomenon and a dynamic response of structural elements.

1-1 Blast loading: Approximately, 1kg of explosive products produces about 1m³ of gas. This gas expands on the air surrounding the source of the explosion which causes it to move and increase in pressure. The movement of this displaced air from the source may affect nearby objects and cause damages to the structures. Except for a confinement structures, the effects of the dynamic pressure diminish rapidly depends on the distance from source. The ground shock formed during an explosion consists of three principal components. First compression wave which travels radially from

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the source of the wave, second a shear wave which travels radially and also comprises particle movements normal to the radial direction where the ground shock wave intersects with the surface, third is a surface or Raleigh wave. Each wave propagate at different velocities and alternate at different frequencies

1-2 Concrete Filled FRP tubes: Concrete-filled fiber-reinforced polymer tubes (CFFTs), as a type of hybrid compression member, are attractive for their use as composite materials in several special structural applications including piles, columns, bridge piers, poles, and highway overhead sign structures. Owing to the light weight, high strength, and corrosion resistance of fiber-reinforced polymer (FRP) material, this hybrid provides an excellent alternative to conventional concrete-filled steel tubes (CFSTs) in corrosive situations, such as tidal zones of marine piles, which is subjected to deicing salt invasion. A CFFT has two main structural components: a FRP tube and a plain or steel-reinforced concrete infill. When this item is under compression, the concrete core is subjected to axial compression and lateral confinement from the FRP tube, which is in a tensile stress state in the circumferential direction. This lateral confinement from the FRP tube can greatly enhance both the loading strength and the ductility of the concrete. There is a chance for developing weak interface between the FRP tube and the concrete due to concrete shrinkage and inadequate concrete compaction during the concrete casting, which will affect the confinement and will reduce the load bearing capacity of the CFFT. Therefore, effective detection measures based on nondestructive testing (NDT) methods should be taken to assess the concrete infill condition of the CFFT. The concrete infill condition investigated in this paper refers to the completeness of the in filled concrete inside the FRP tube.

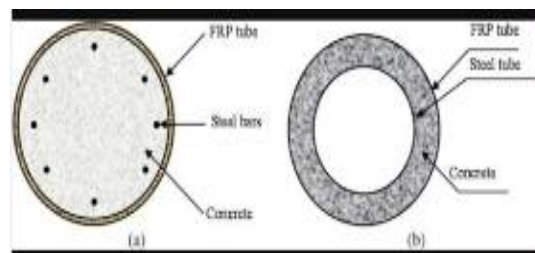


Fig 1. Concrete filled FRP tube

Fiber-reinforced plastic (FRP) is a composite material made of a polymer matrix reinforced with fibres. The fibres are usually glass, carbon, aramid, or basalt. Other fibres such as paper, wood, or asbestos have been rarely used. The polymer is usually an epoxy, vinyl ester, or polyester thermosetting plastic, though phenol formaldehyde resins are still in use

II. GEOMETRY AND MATERIAL PROPERTY

The geometry of the brace was prepared using workbench platform of ANSYS 16.2 Finite element Analysis software. Blast analysis predicts the strength of concrete filled FRP tube columns of different types of fibres. Here six models made with different fibres each having same length and cross section. Models have same size of 200x200 and length of 4m. M30 grade concrete is used for filling CFFT. Analysis is done by using 50kg C4 blast and 50 ms of time interval. The CFFT model is given below:

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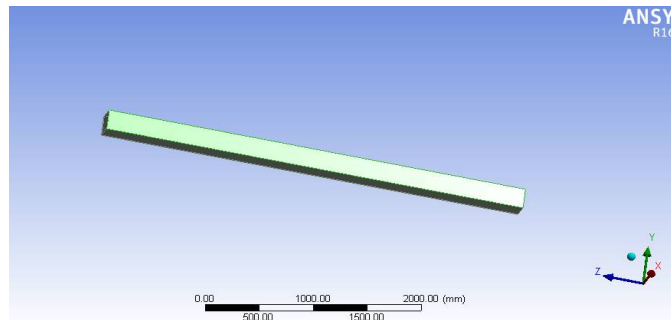


Fig 2. Geometry of CFRT made in ANSYS

Fig1.Geometry of Dual-core self-centering sandwiched buckling restrained brace

Fe 415 grade steel is used for making the model. 6 number of 12 mm diameter bars used as main reinforcement and 21 number of 8mm diameter bar used as lateral ties with a spacing of 190 mm. The length of the bar is of 4m. The percentage of steel is 1.7%

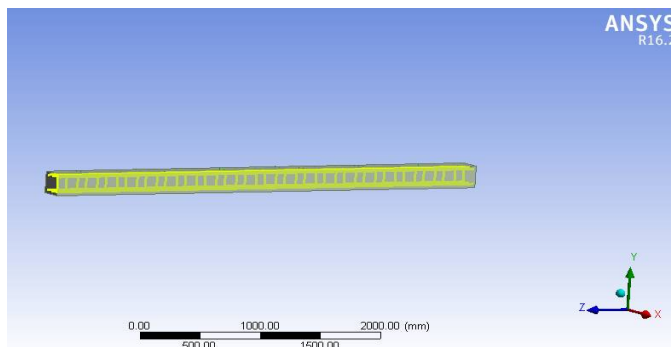


Fig3. Reinforcement details of model

The size of the mesh is a measure of accuracy of the result and the time required for the computation of results. Coarse mesh gives less accuracy and lower time for computation. As the mesh becomes more and finer, the accuracy increases so as the time. At a point mesh convergence occurs, beyond which further reduction of mesh size do not have any effect on the accuracy of results. The special discretization of the simulation domain is represented using a mesh consisting of vertices or nodes, edges and elements. Various meshing tools are available in ANSYS. In this column rectangular meshing is adopted

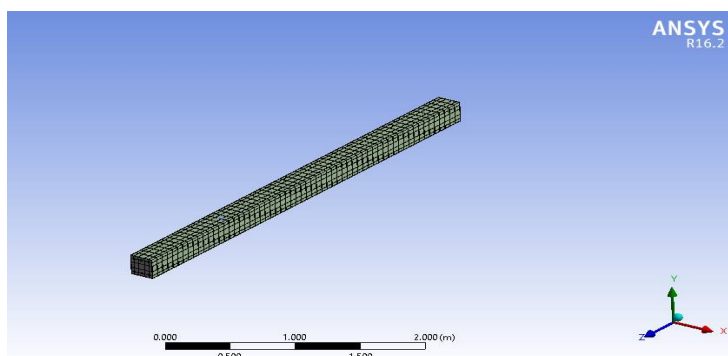


Fig 4.Meshing details of model

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Table 1 Composite Isotropic Parameters

POLYMER	TYPE	TENSILE STRENGTH	YOUNG'S MODULUS	DENSITY	POISSON'S RATIO
GLASS	E Glass	1750Mpa	70Gpa	2.55	0.22
ARAMID	Kevlar	3Gpa	147Gpa	1.44	0.35
CARBON	Polyacrylonitrile	4.8Gpa	300Gpa	1.8	0.26
BORON	Hy-Bor	4Gpa	400Gpa	2.34	0.22

III. BLAST ANALYSIS

Blast analysis is done on concrete filled FRP tube columns by using ANSYS autodyne. Models made with different fibres. Each model has same dimension and length. The fibres used are aramid, boron, carbon and glass. Here the result include the displacement, kinetic energy and axial force on each model

3.1 Displacement

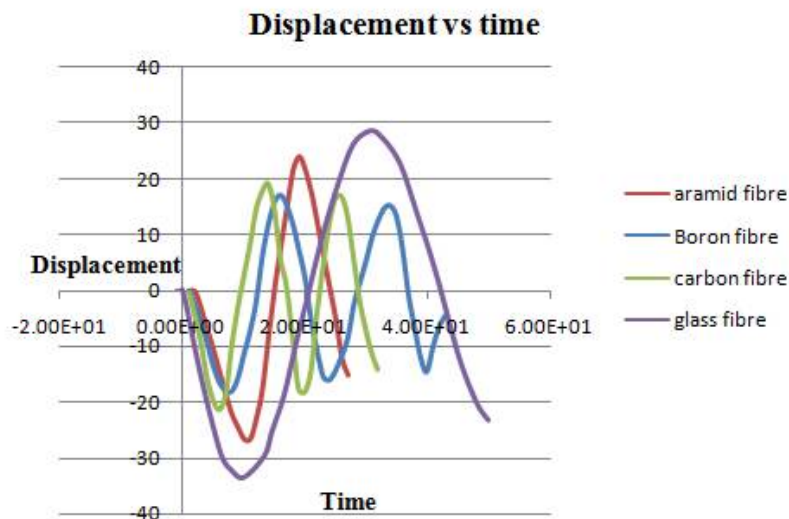


Fig 5 displacement time plot

Displacement is minimum for boron fibre. So boron fibre is better fibre when compared to others. Value of the maximum displacement of boron fibre is 17.06mm and minimum value is -18.36mm.

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3.2 Kinetic energy

Part Summary (Ident 0 - admodel)

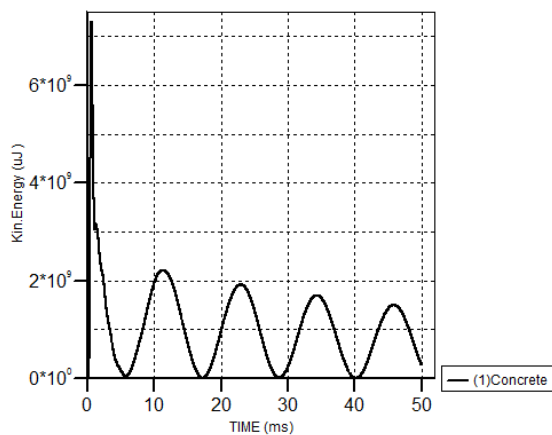


Fig 6.KE of aramid fibre

Part Summary (Ident 0 - admodel)

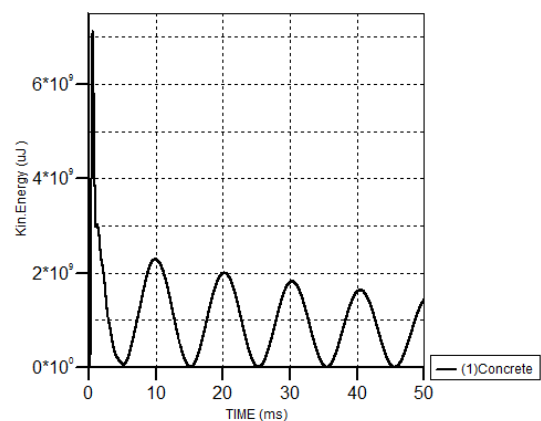


Fig 7. KE of boron fibre

Material Summary (Ident 0 - admodel)

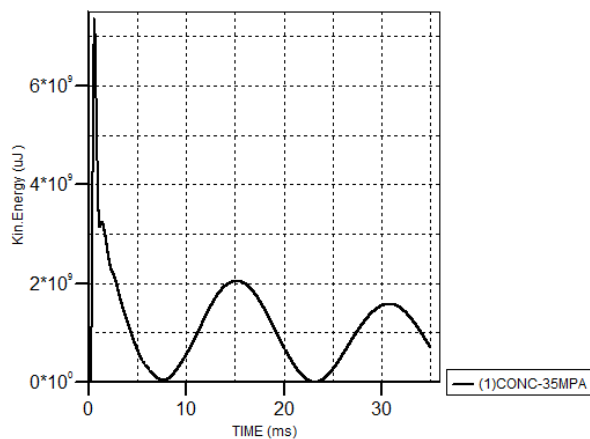


Fig 8.KE of carbon fibre

Part Summary (Ident 0 - admodel)

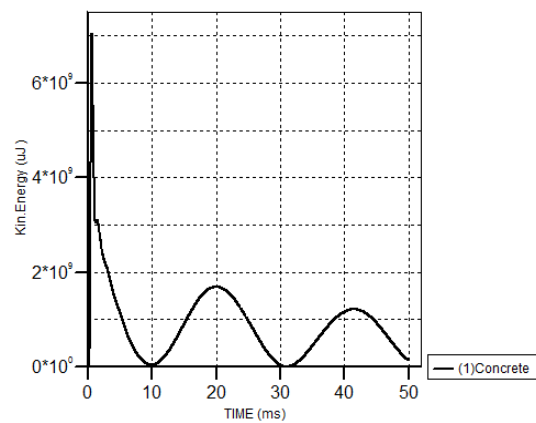


Fig 9. KE of glass fibre

Kinetic energy is minimum for glass fibre and maximum for carbon fibre. Kinetic energy of glass fibre is 7.03×10^9 uJ and energy of carbon fibre is 7.28×10^{10} uJ

3.3 Axial force

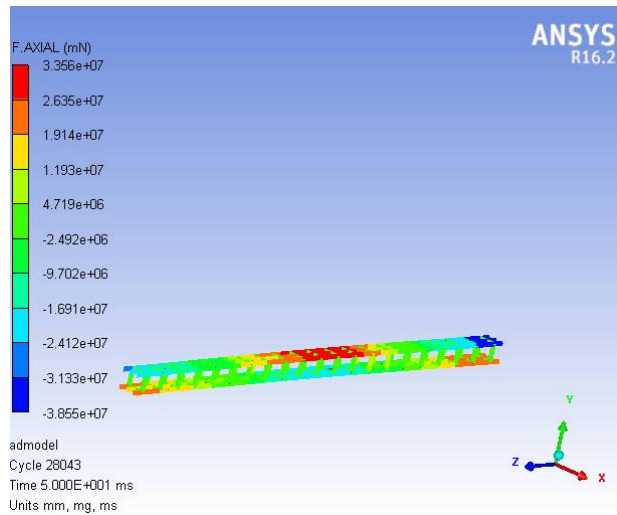


Fig 10. Axial force in aramid fibre

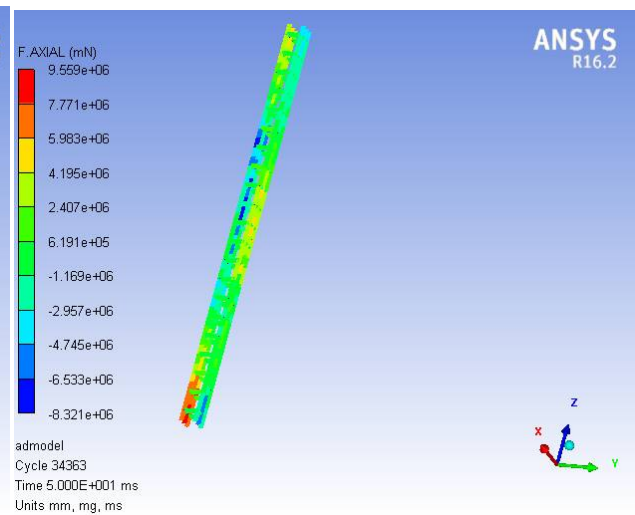


fig 11. Axial force in boron fibre

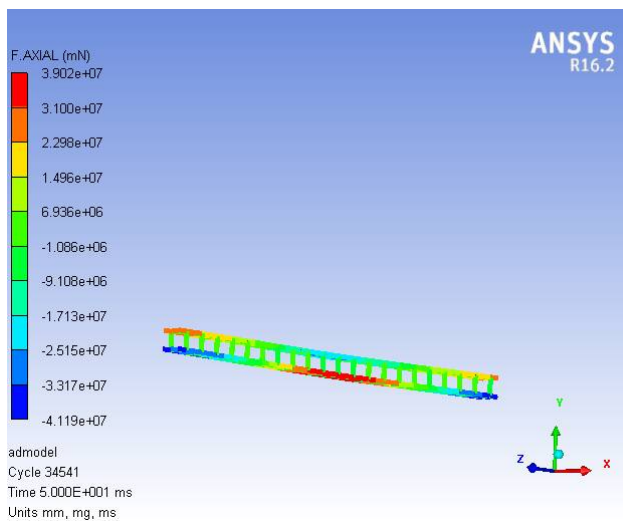


Fig 12. Axial force in carbon fibre

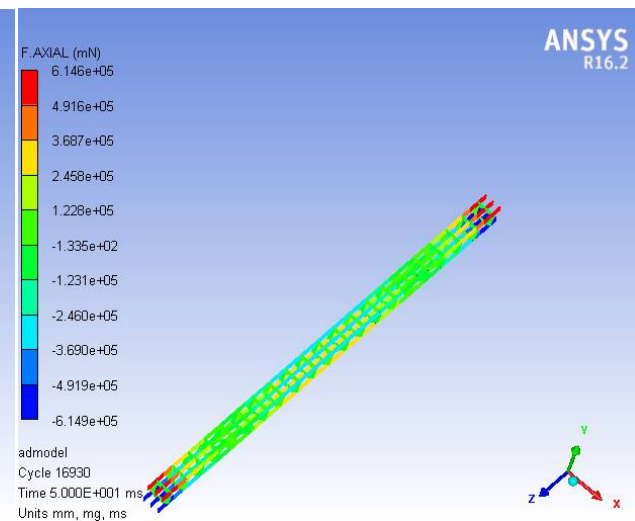


Fig 13. Axial force in glass fibre

Axial force is minimum for glass fibre and maximum for aramid fibre. Obtained axial force of glass fibre is 6.14×10^5 mN and axial force of aramid fibre is 3.35×10^7 mN.

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Table 2. Obtained results from blast analysis of CFFT

FIBRE	DISPLACEMENT (mm)				KINETIC ENERGY (uJ)		F-AXIAL (mN)	
	At gauge 1		At gauge 2		max	min	max	min
	max	min	max	min				
ARAMID	23.65	-27.2	12.65	-	7.367×10^{10}	10^{-10}	3.35×10^7	10^7
BORON	17.06	-	8.778	-	7.03×10^{10}	10^{-10}	9.55×10^6	10^6
CARBON	18.94	-	9.59	-	7.28×10^{10}	10^{-10}	3.90×10^7	10^7
GLASS	28.08	-	14.94	-	7.03×10^9	10^{-10}	6.14×10^5	10^5

IV. CONCLUSIONS

From this work we can say that boron fibres are better when compared to others. Displacement, kinetic energy f axial, all these parameters should be minimum for a good FRP. We can conclude that boron fibre is better one by comparing all the parameters. If we consider displacement, boron and carbon have minimum displacement. In case of carbon fiber all the other parameters except displacement are very large. Glass fibres have minimum axial force and minimum kinetic energy. But displacement of glass fibre is very large. Displacement is the main parameter than others. We can reduce blast effect by using these fibres up to a limit.

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