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FINITE ELEMENT ANALYSIS OF BLAST LOADED ARMOURED VEHICLE

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Abstract

Armoured vehicles are used to carry both soldiers and machinery in the war environment. These are affected from the Blast loads severely in view of the environment of fighting or peace-keeping. In the present work on the "Analysis of An Armoured Vehicle for Blast loading "the effect of blast loading on the vehicle. Both explosions on the underside and on one side of the vehicle are considered in the analysis. Finite Element Analysis has been carried out to perform the analysis for which purpose ANSYS code has been used.

The load is created by a medium sized cracker .The displacement has been measured by a video-based technique. Blast loading on vehicles takes place in few milliseconds, in the experimentation video based methodology used to capture the blast effect on armoured vehicle by the 2.5 mega pixel camera.

By using CATIA V5 and ANSYS 11.0 analysis has been carried out for underside blast loading of the model. The measurement technique has been applied to a 1:16 size scaled model vehicle of HMM WV M1025. The same model is tested experimentally.

Finally deflections of bottom plate of armoured vehicle as obtained by Experimental & FEA results are compared and conclusions drawn.

1. Introduction

Blast loading may result from the detonation of high explosives, chemical ammunitions. The type of extraordinary dynamic load it has to be described by two parameters; peak overpressure and duration.

Explosions create high-pressure, high-temperature that can create permanent deformation of vehicles or structures around it and rupture or tearing of metal takes place and generate flying fragments which can effect the surrounding Environment.

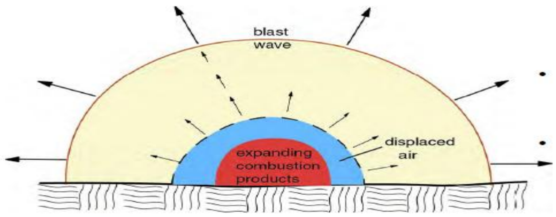

Fig.1. Generation of blast wave from rapid combustion

Expansion of combustion products due to conversion of chemical to thermal energy in combustion and creation of gaseous products in High explosives. Expansion ratio for gaseous Explosions depend on thermodynamics and expansion rate depends on chemical kinetics and fluid mechanics with Flame speeds & Detonation velocity.

2. Scope of Work

Blast loading occurs due to accidents from detonation of chemical plants, gas cylinder explosions, attacks by anti-social elements and other reasons. Therefore, concerted efforts have been underway during the past three to four decades to design structures and vehicles so as to resist large impact loads such as those due to blast.

The difficulty of carrying out experimental tests on blast loaded structures like beams, plates, cylindrical shells, armoured vehicles etc is that the blast takes place in about a few microseconds (1E-7 to 1E-6 seconds). The resultant peak effects have to be recorded in such short durations. Strain gauge techniques, optical sensors, high speed photography are a few techniques available for measuring displacements and stresses in order to assess the structural integrity.

In the Present Project, finite element analysis and videography-based experimental methods are used on model of HMM WV M 1025 model tests are carried out on armoured vehicle. The finite element formulations, the boundary conditions and loading are discussed in detail for the transient analysis of short-term event due to impact. A few test cases are carried out in order to establish the methodology for analyses. The displacements and stresses in the vehicle during the loading event are presented in detail. The displacements are compared as obtained from the FE analysis and the tests. The advantages and limitations of the techniques are highlighted.

3. Experimentation

A special test rig has been designed and fabricated for carrying out experimental work in this project Experimental details are:

Experimental Test rig is experimental equipment designed to measure practically the blast effects on loads on GI (Galvanized Iron) Sheets and MS (Mild Steel) Plate. Test rig is having the different accessories for the attachment of Dial gauges to measure the deflections of sheet, plates during the blast pressure. It is used to apply a small charge of explosives like festival crackers.

The Experimental Test Rig is designed with proper dimensions it looks like 'U' Shaped and having a C-channel in both side of rigs. Experimental Test Rig is a Equipment to find the deflections Under Blast Loading It is Drafted first and given required dimensions and then it is designed in Catia v5 and after designing Test rig is Fabricated as per the design. Material of test rig is Mild steel and having total weight 24 kg together with clamps and nut bolts, and Fabricated with Gas Welding and Black coated.

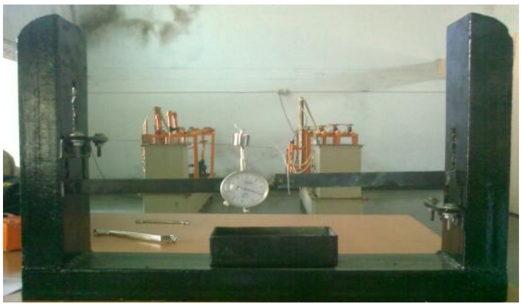

Fig2.ExperimentalTestRigFabricated

Computer Aided Design Model of a "HMM WV M1025" (High Mobility Multipurpose Wheeled Vehicle Model 1025) as given in below figure. Surface Modeling is done in CATIA V5 Design Software. Solid modeling of Vehicle which will takes more time and gives lacks of nodes while meshing in analysis because of having the number of solid parts in the vehicle assembly. Surface modeling will take less time and gives precision results and it is easy to understand the behavior of vehicle under blast load. Vehicle is having overall length 4.8m and a width base of 3.4m and other dimensions are given in below dimensioned figure.

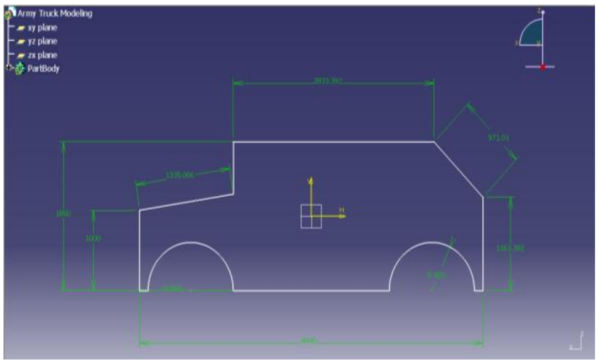

Fig.3 Dimensions of Vehicle

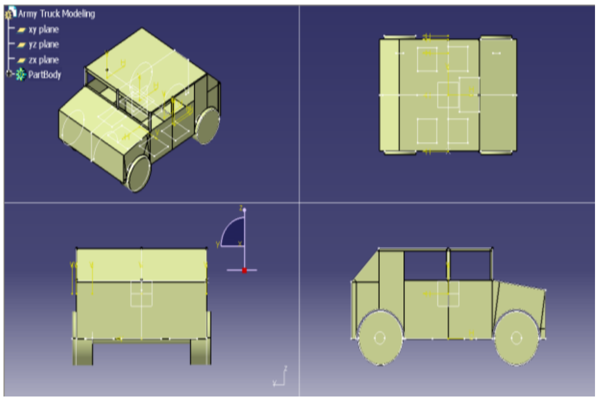

Fig.4 Perspective View of vehicle

3.1 Specifications of Model Vehicle:

Model of HMM WV M1025 Armoured vehicle has been manufactured as per the original model by 1:16 scale ratio. Specifications are given below

- Material : GI Sheet.
- Thickness: 0.21 mm.
- Wheel Radius: 37.5mm
- Dimensions: As per given in Figure
- Thickness of Shaft for Wheels: 2 mm.
- Process: spot welding.

After load scaling to actual vehicle 1:600

- Seats at 1:600 Ratio: 110grm each one (440grm for 4 seats)

Total Weight of Vehicle: 1.26 Kg.

Fig.5 Scaled model vehicle

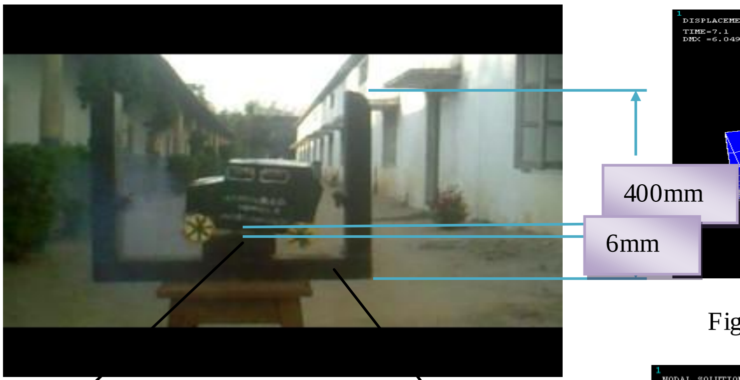

Fig.6 Deformation by Explosive blast

4. FEA on Bottom Plate of Model ArmouredVehicle

Analysis is done on model vehicle by using Ansys Software

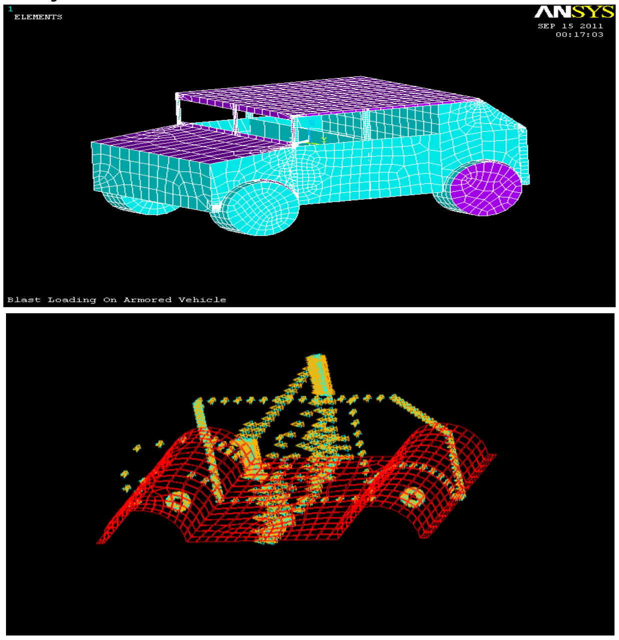

Fig.7 Meshing of Bottom plate 1mm thick

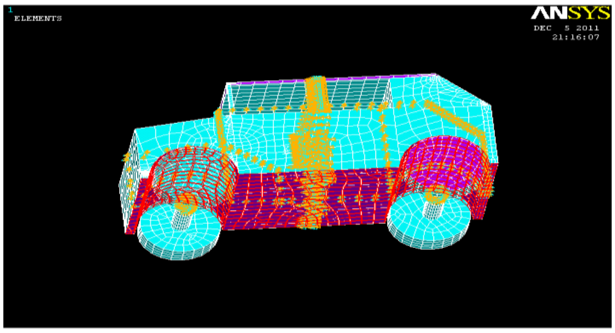

Fig.8 Blast Pressure 100N

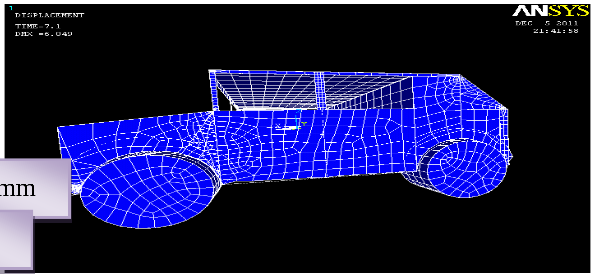

Fig.9 Displacement of Bottom plate 6.049mm

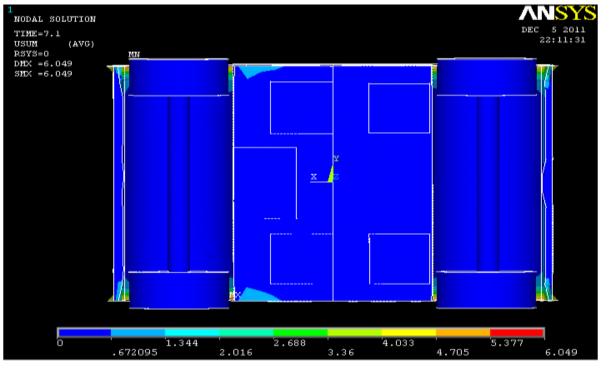

Fig.10 Blast Pressure on Bottom Plate

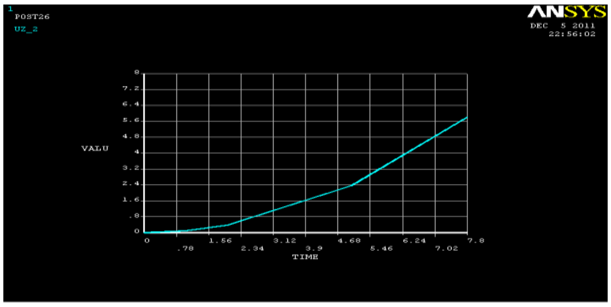

Fig.11 Deformation Vs Time: 6.059mm in UZ – Direction of 7.8 ms

5. RESULTS & DISCUSSION

The fallowing table-3 compares the results obtained from the FEA (Finite Element Analysis) and model vehicle of HMM WV M1025 experimentation.

Experiment Number	Experimental Armoured Vehicle Deflection (mm)	FEA Armoured Vehicle Deflection (mm)	Results Ratio (%)
1	6.0	6.049	99.2

Table-1 Comparison of Experimental & FEA Results of Model Armoured Vehicle.

6. CONCLUSION

A detailed analysis has been carried out on armoured vehicle model of HMM WV M1025 using finite element method and a novel experimental technique. The major conclusions are as follows.

FEA FOR ACTUAL VEHICLE:

THE MAX DEFLECTIONS=30.963mm in 60 milliseconds by 1000N Blast pressure.

VON MISSES STRESS is SMIN= -39364 N/mm^2, SMAX=7600 N/mm^2

ELASTIC STRAIN=3.8 in 60 milliseconds.

FEA FOR MODEL VEHICLE:

THE MAX DEFLECTIONS=6.049mm in 8milliseconds by 100N Blast Pressure.

VON MISSES STRESS is SMIN= -160.67 N/mm^2, SMAX=159.762 N/mm^2

ELASTIC STRAIN=0.007181 in 8 milliseconds.

EXPERIMENT FOR MODEL VEHICLE:

THE MAX DEFLECTIONS=6.0mm

The values in the model as obtained by FEM and Experiment are well allied.

The methodology described in the paper, with some refinements can improve the blast resisting strength in the armoured vehicle and also increase the safety of soldiers. In future, more scaled models can be tested for different loads of blast which vary due to distance and strength of explosive. Better material modelling as available in programs like LS Dyna can be used.

7. References

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