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Technical Report ARAET-TR-08006

**FINITE ELEMENT ANALYSIS OF M15 AND M19 MINES UNDER WHEELED
VEHICLE LOAD**

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**ARMAMENT RESEARCH, DEVELOPMENT AND
ENGINEERING CENTER**

Armaments Engineering & Technology Center

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14. ABSTRACT Unfuzed M15 and M19 mines are present in different proving grounds and test ranges, both as intended and unintended targets for testing of various munitions and weapon systems. There is a concern that these unfuzed mines may be accidentally driven over by various Army vehicles (HMMW, Bobcats, etc.). Composition B is typically the explosive found in these mines and also in many gun launched projectiles (i.e., 155-mm artillery, 30-mm grenades, and 105-mm projectiles). The gun launched projectiles subjects the Composition B explosives to significantly higher shock and stress levels than loading from a vehicle wheel. The purpose of this study is to use Finite Element codes to determine the stress levels in the mine due to simplified vehicle loading scenarios and compare them to the stress seen in gun launched projectiles. This data and analyses together with assessments from other Subject Matter Experts should provide sufficient evidence that accidentally driving a vehicle over either unfuzed M15 or M19 mines would not be a safety hazard.					
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BACKGROUND

In the past, a number of M15 and M19 mines were buried at proving grounds in an unfuzed condition as part of an anti-armor mine detection development program. This study was conducted as part of an effort to develop a safety assessment for wheeled vehicles should any of these unfuzed mines be inadvertently left unrecovered. This study was requested by George Sudol of the Maneuver Support Division and Brian Travers of the Energetics and Warheads Division (EWD), U.S. Army Armament Research, Development, and Engineering Center (ARDEC), Picatinny Arsenal, New Jersey.

TECHNICAL APPROACH

Since the depth of burial and mechanical properties of the soil are not well known and subject to change from the weather, it was decided to make a conservative model of the mine as sitting on top of a rigid boundary. In actual field conditions, the mine would penetrate the ground upon tire contact yielding lower stress, while in the simulation; the rigid support boundary would prevent any mine penetration and produce significantly higher stresses. Another conservative simplification was to simulate the tires as a steel plate. An actual pressurized tire would deform on contact producing lower stresses than loading from a steel plate. The plate size was varied to represent different tire patch sizes for the following vehicles:

- 4 by 4 in. Multifunction Utility/Logistics Equipment Vehicle (MULE)
Unmanned Ground Vehicle (UGV)
- 6 by 6 in. HMMV
- 8 by 8 in. Toolcat (surrogate utility vehicle made by the Bobcat Company)

A total vehicle weight of 8000 lb was given by the requestors and computational runs were made of $\frac{1}{4}$, $\frac{1}{2}$, and total vehicle weight on a single plate applied to the mine to study the effects of weight distribution. The weights were applied on the plate statically.

An implicit finite element option in a code called LSDYNA was used to model the pressure generated in the explosive by the plate/mine interaction. Three plate locations on the mines were run with the plate at the mine center, at the mine edge, and in between the center and the edge. Initial conditions for the plates were on the top surface of the mine with zero initial velocity.

Both the M15 mine (fig. 1) and the M19 mine (fig. 2) contain the explosive fill Composition B. The M15 mine has a 0.091-in. thick steel case and the M19 mine has a 0.125-in. thick polystyrene case. Parameters for the Composition B explosives used in the simulations were obtained from the Explosives Branch of EWD (ARDEC). Parameters for the inert steel and polyurethane were obtained from the Johnson Cook report (ref. 2). Members of the Maneuver Support Division and the Energetics and Warheads Division (ARDEC) met and worked out the technical approach.

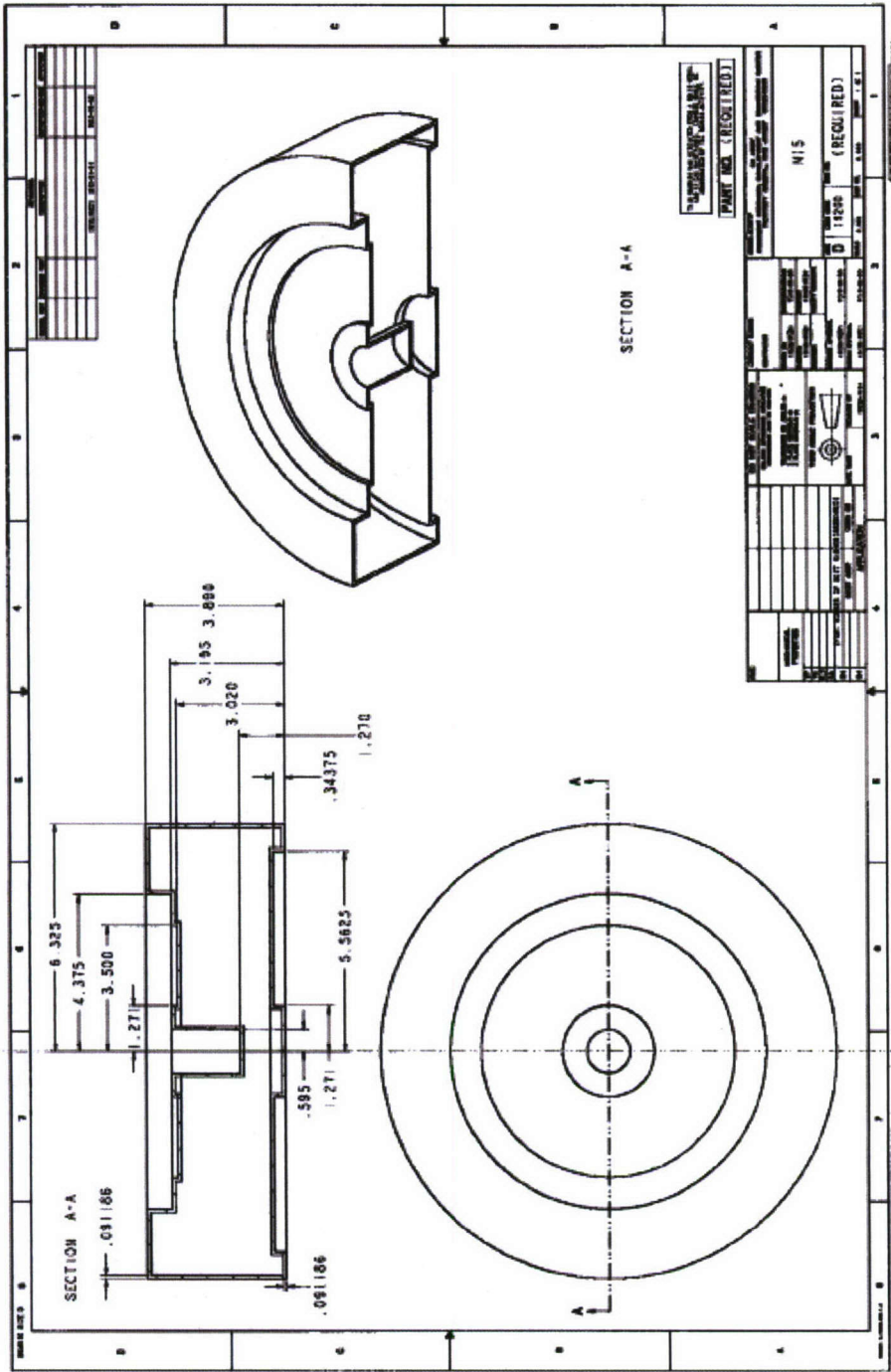


Figure 1
M15 mine

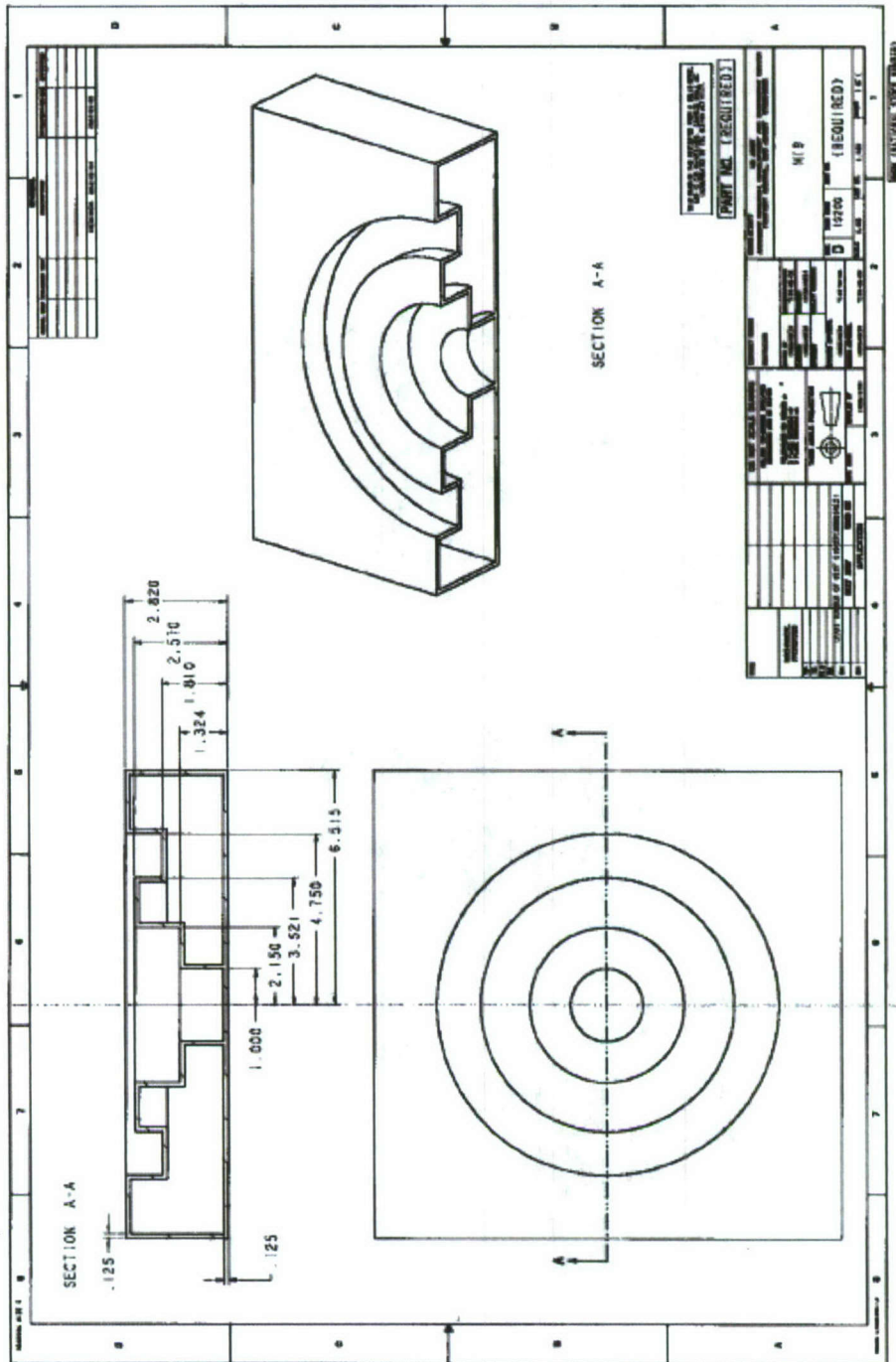


Figure 2
M19 mine

RESULTS

Images from the Finite Element Simulations showing initial loading and final mine geometries are shown in figure 3 for the M15 and figure 4 for the M19 mines. Maximum pressure in the explosive for each mine calculated by LSDYNA code shown for a variety of plate sizes and weights and locations are presented in the table.

Summary of Simulations

Mine	Plate size (in.)	Plate location	Plate weight (lb)	Maximum pressure in explosive (psi)
M19	4 by 4	Center	2000	104
M15	6 by 6	Edge	8000	1788
M15	8 by 8	Midpoint center to edge	4000	1825

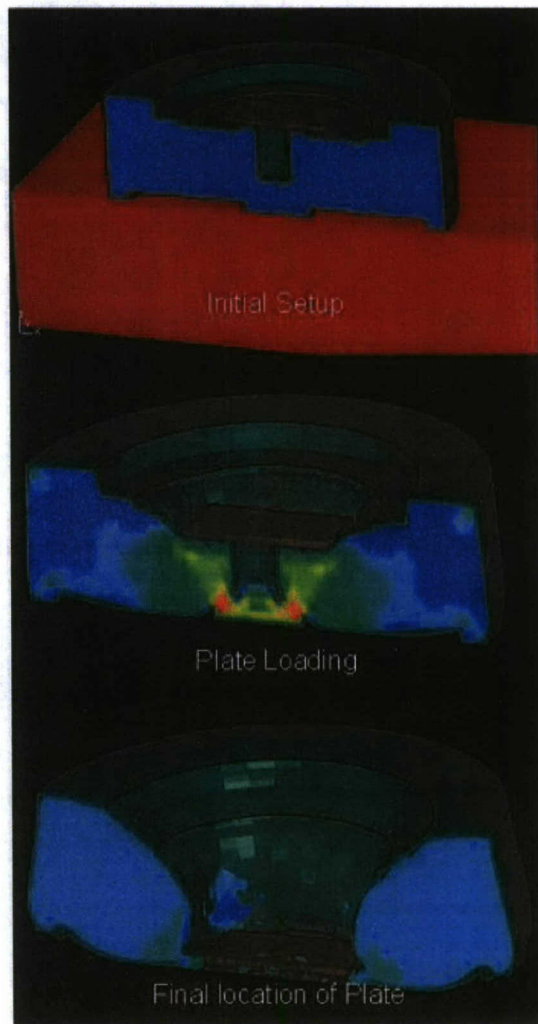


Figure 3
M15 mine simulation with plate in center

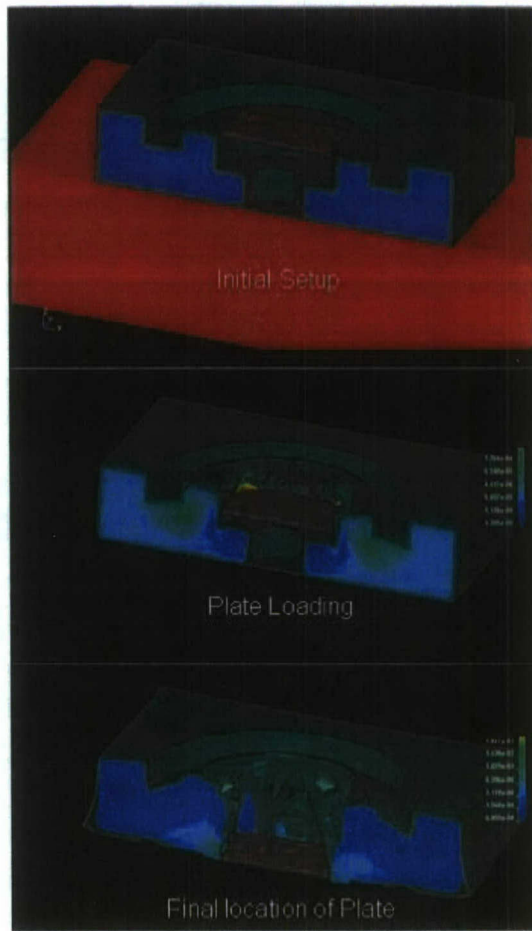


Figure 4
M19 simulation with plate in center

For comparison, the venerable M107 155-mm projectile (fig. 5) at maximum zone is subjected to 15,800 Gs and a maximum chamber pressure of 56,000 psi. While the Composition B explosive in the M107 routinely sees pressures in excess of 18,000 psi, there is a small risk of detonation and is considered safe. There are also other United States munitions, such as 30-mm grenades and 105-mm projectiles that are subjected to more than 15,800 Gs.

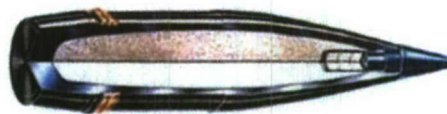


Figure 5
M107 155-mm HE projectile

CONCLUSIONS

Based on the conservative assumptions (no soil burial, mine resting on rigid boundary, plates instead of rubber tires) of our calculations the highest pressure in the mines loaded with Composition B explosive is 1825 psi during vehicle roll over. This is nearly an order of magnitude lower than in the M107 projectile at maximum zone. By analogy, although there is still a risk for detonation from vehicle roll over it is significantly less likely than incurring an in bore detonation of Composition B in the M107 projectile fired at maximum zone.

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