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Exploration of Technologies of Use to Civil Security Forces

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Abstract

This is the final report of a one-year, Laboratory Directed Research and Development (LDRD) project at Los Alamos National Laboratory (LANL). Current civilian security may be enhanced by the use of flexible tile technology. This project explored the use of such materials in three areas: bomb disposal containers, portable armor, and protective vests. In particular, there has been no evaluation of the use of flexible tiles, functional graded ceramics, and ballistic modeling codes in developing improved systems. The state of the art in these three areas was reviewed and potential collaborators were contacted. Civil security forces, both state and Laboratory, were interviewed to determine issues and needs. From a collaboration established with the New Mexico State Police, we now know that the technology has the potential to increase protection without adding undue weight and will be usable by civilian police forces for some applications.

Background and Research Objectives

This project evaluated the use of flexible armor tiles in conjunction with the most advanced equipment available to civilian security forces. A technology developed in a previous Laboratory/industry collaboration, these tiles contain ceramic or kevlar plates and high-strength polymers to minimize weight and for ballistic applications. In addition, we have developed new, functionally-graded ceramic/metal and ceramic/polymer systems that could offer even better protection. Three applications were evaluated -- bomb disposal containers, portable armor, and protective vests.

Present bomb-containment systems consist of large, heavy containers made of concrete or steel. Such a container is mounted on a trailer, which is towed to the site of a suspected explosive device. The explosive device is removed from a building, at high risk to bomb-disposal personnel, and then is placed into this container. This method is time-consuming, inflexible, and does not protect the public or bomb-disposal personnel during the bomb removal phase. Our objective was to determine whether lightweight, portable bomb containers using flexible armor tiles could be used to contain the explosive device during all phases of transportation away from its discovered location.

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Conventional ballistic vests are designed to protect the torso of the wearer against pistol-fired bullets of various degrees of velocity and weight. Typical vests used by civil security forces will withstand most common pistol rounds, but they are vulnerable to penetration by sharp objects such as a "shiv" or ice pick because the object will penetrate woven fabrics. Such objects are common in prison riot situations and are becoming increasingly common in "street" police encounters. We found a commercially available, very light weight aluminum/fiberglass laminate material that in preliminary tests demonstrated a very high penetration resistance to ice picks. We have developed a flexible tile concept to apply these to a normal ballistic vest.

Police vehicles typically have no armor protection. When police encounter a situation in which the criminal has a high-powered rifle, they have to call for special armored vehicles, often available only from the National Guard, to approach the criminal or to rescue police officers who already may be shot and in need of medical help. Our discussions with the New Mexico State Police have uncovered a need for a portable armor blanket that can be temporarily attached to a police vehicle and would provide protection during an assault or rescue operation. Our flexible armor tile technology is ideal for this situation, offering lightweight portability, flexibility, and easy attachment to a police vehicle.

In this project we evaluated the potential for use of tile technology and developed concepts for how tiles would be used for each application. In the next year we hope to demonstrate several systems.

Importance to LANL's Science and Technology Base and National R&D Needs

Advanced materials is a Laboratory core competency. Pursuit of the applications in this project will open up a possibility for applying our knowledge of advanced materials to develop new functionally-graded ceramic-polymer systems. These functionally-graded systems then may be applied to the needs of the Weapons Program. Nationally, functionally-graded ceramics offer a solution to the classic problem of ceramic applications: brittle failure.

Scientific Approach

Substantial progress was made in defining the needs of security forces for the new tile technology. Discussions with the New Mexico State Police, the Laboratory Emergency

Management Office Bomb Team, the Office of Law Enforcement Technology Commercialization, and the Defense Advanced Research Projects Agency (DARPA) provided feedback on initial concepts and led to more advanced designs.

We have designed and purchased materials to build a bomb container capable of stopping the fragments from a 2-lb. pipe bomb and mitigating the blast. This concept is based on laminated Kevlar panels wrapped with Kevlar restraining bands. We also have purchased cermet (SiC/Al composite) tiles and Kevlar cloth to fabricate an armored blanket that will protect a police vehicle from rifle fire. Finally, we have negotiated and acquired several custom fiberglass/aluminum laminated composite panels from Structural Laminates Company that we will cut into tiles and attach to a lightweight ballistic vest to improve ice pick protection. Preliminary tests with commercial ice picks showed that laminate materials performed as anticipated.

We have established relationships with several companies who are interested in our research. Although not part of this LDRD project, we did include the companies as part of an Industrial Partnership Office (IPO) initiative within the Small Business Personnel Exchange Program. This was to evaluate and test two commercial concepts for a bomb box. These tests were conducted in September 1996. The companies' involvement was supported with IPO funds. Although neither of the company's products were completely successful, the experiments did lead to improved fundamental understanding of the phenomena itself and contributed to our final design of a kevlar-panel bomb container.

Technical Results and Conclusions

The investigations and tests conducted this year lead to a number of conclusions.

Light-weight, portable bomb boxes. These can be effective in capturing fragments (shrapnel) and redirecting the blast from common explosive devices. The construction of the bombs was by New Mexico State Police personnel and consisted of ~1 pound of Pyrodex FFF powder in a 2 inch diameter, 8 inch long, schedule 40, galvanized steel pipe which was threaded for steel end caps. The firing mechanism was an electrical squib detonator wired through one end cap. The position of the detonator was estimated to be ~1 inch from the center of the pipe along the long axis. The test setup is shown in Figure 1 below. Blast gages, plywood witness plates and high speed photography were used to diagnose the box effectiveness.

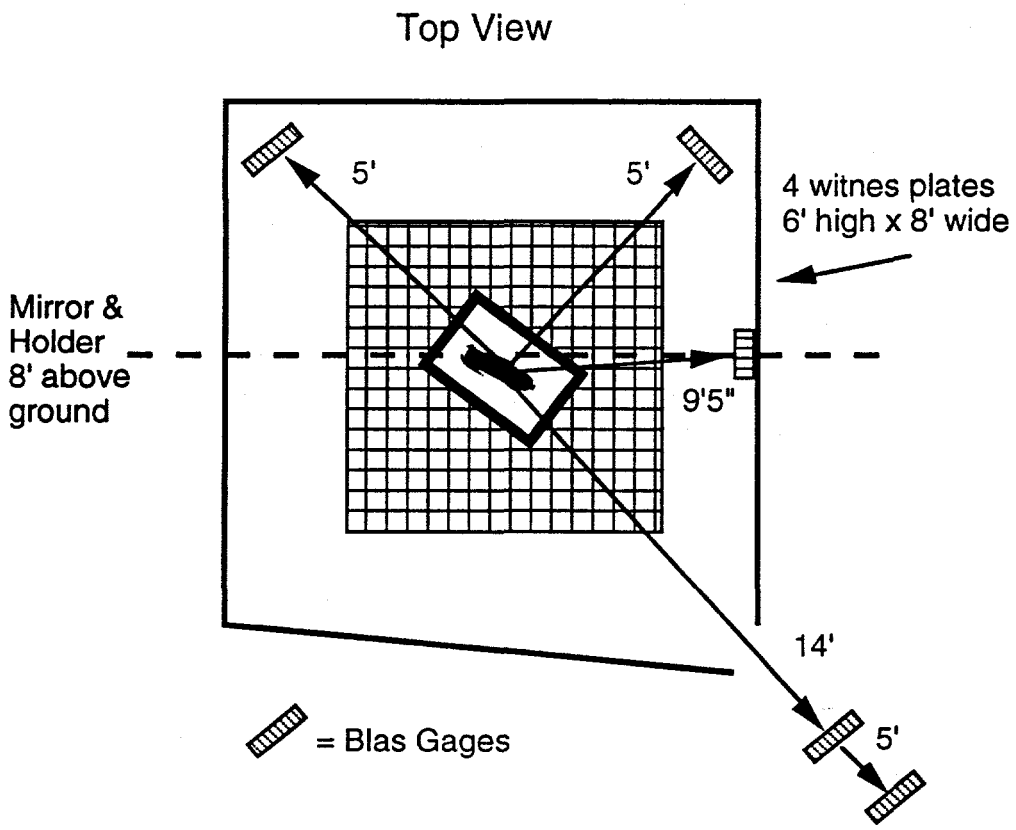

Figure 1. Sketch of setup viewed from above (not to scale)

The first test was of a soft box made of ballistic nylon that was provided by the Last Armor company. At a weight of less than 25 pounds, the Last Armor box contained the majority of the shrapnel from the pipe bomb and yielded significant blast overpressure mitigation. The peak overpressure recorded was between 1.3 and 2.4 psi at a 5 foot standoff. A number of pieces of shrapnel from the pipe bomb escaped the containment system but impacts on the witness plates were small and did not penetrate the 1/2" plywood panel. Final analysis of the failure mechanisms and evaluation of the performance of the containment system will depend upon analysis of the high speed film and real-time video records of the testing, but the success in capturing shrapnel and reducing blast was confirmed.

In the second test using a similar pipe bomb, a 50-pound box made of 7-layer Glare™ aluminum/fiberglass laminate material was provided by the Galaxy Scientific company. One of the faces of this box was completely penetrated by a piece of the end cap from the bomb and blast overpressures reached more than 6.5 pounds per square foot at a 5-foot

standoff. While substantial reduction in shrapnel and redirection of the blast was achieved by this box, we believe that Glare™ will not be a weight-effective material for pipe-bomb boxes. In addition, from the behavior of an internal aluminum positioning system on this box, we learned that ceramic tiles would not be desirable for pipe bomb threats because it is undesirable to include anything in the box that could add to the shrapnel produced by the bomb. This is especially important in scenarios where the box could be used for a larger than anticipated bomb.

The performance of the industrial-supplied boxes, as well as the feedback of the law enforcement participants in these tests, demonstrated a need for continued national laboratory development and contributed to the design of our flexible kevlar box that we hope to test next year. This technology is urgently needed by law-enforcement agencies, government agencies, and corporations; this need was recently illustrated by the Atlanta Centennial Park bombing.

Aluminum/fiberglass laminates. These are effective for ice pick protection. Ice pick tests were conducted against Glare™ material 1.5-mm thick. Hand-held tests, including those by the strongest of NMSP personnel available, showed a maximum penetration of less than 1 mm even with sharpened ice picks against a firm backing. The tests demonstrated that small tiles could be effective if added to the outer layers of light-weight ballistic vests. Further tests were not conducted this year.

Flexible tile technology. This technology does have the potential to be effective for ballistic-resistant blankets for police vehicles. Our investigation and discussions with Police officials led us to conclude that a blanket consisting of armored tiles fastened to a one- or two-layer kevlar blanket could provide effective and usable protection for a police vehicle from high-powered rifle fire with hunting or ball ammunition. Previous experience in developing armor tiles for US Army vehicles showed that the ceramic tiles can defeat these threats without substantial ballistic material backing. No ballistic tests were made of this blanket design during the report period.