

Engineer Support to GWOT

Utilizing COTS Products for AT/FP

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Requirements for Anti-Terrorism and Force Protection (AT/FP) are being extended to more types of new construction, abroad and at home, such as base camps, government buildings, hazardous material facilities, and structures for essential services and utilities. New designs for these buildings are shifting away from massive, brute-strength structures and are using new technologies and materials to meet AT/FP requirements. Materials such as elastomeric membranes, E-glass materials and polycarbonate laminates are being developed, tested and fielded with increasing frequency. Many of the products are specialized materials developed for a specific AT/FP application and require expensive research and development.

However, some of the materials are “commercial-off-the-shelf” (COTS) products already in use in conventional construction and are ready for immediate use in AT/FP applications. In the case of blast resistance, wall construction techniques typically rely on increased mass and strength, using additional concrete and steel reinforcement. However, the blast wave produced by an explosion can cause brittle concrete surfaces to break apart or spall. Large fragments of concrete sent

flying into or away from a building constitute a serious threat to building occupants and those nearby.

In response to this growing concern, the Air Force Research Laboratory (AFRL) Materials and Manufacturing Directorate at Tyndall Air Force Base, Fla., has been addressing fragmentation resistance and blast mitigation for walls and windows since 1994. A significant portion of its research includes the use of ductile materials to resist blast loads and contain fragmentation. The work has revealed that polymer materials applied to a wall surface can withstand large deflections and prevent the spalling or fragmentation of concrete.

In 2003, AFRL became aware of a COTS formwork that encapsulates an entire concrete wall inside a ductile polymer material. The formwork, Conform, is a mature COTS product that has been used for forming concrete walls for conventional industrial and commercial projects and is manufactured by Nuform Building Technologies Inc. The stay-in-place, modular components are rigid, hollow, PVC members designed for forming 4-in-, 6-in-, or 8-in-thick concrete walls. The product provides an interior and exterior surface that is pre-

Commercial-off-the-shelf products already in use in conventional construction can provide proven, readily-available and cost-effective alternatives for Anti-Terrorism and Force Protection applications.

This training center at Fort Leonard Wood, Mo., was constructed in 2004 by the 820th RED HORSE Squadron using the Conform COTS formwork.



Photos courtesy Nuform Building Technologies Inc.

finished, UV stabilized, durable and resistant to mold and mildew.



AFRL conducted blast experiments on 10 different configurations using Conform, and the product performed well in each case.

Fragmentation Resistance and Blast Mitigation

In March 2004, AFRL conducted an initial full-scale experiment, detonating an explosive charge simulating a moderately-sized, vehicle-borne improvised explosive device relatively close to two concrete walls constructed with Conform. The objective of the experiment was to validate predictive response models for each wall and assess fragmentation containment.

To simplify the initial modeling effort, reinforcing steel was not used with the 6-in and 8-in walls. The blast resulted in 42-psi reflected pressure and 226-psi/msec impulse. Both walls performed significantly better than predicted, deflecting a few inches and rebounding to plumb without any evidence of exterior or interior damage.

To understand the polymer behavior, AFRL conducted a full set of laboratory tests. Specimens were used for strain rates ranging from 0.1/sec to 1,000/sec to simulate the difference between static and dynamic loading rates that are seen during a blast response. The tensile strength under dynamic loading increased by a factor of three. The decrease in elongation at rupture reduced overall material toughness by 30 percent, but the effect was not viewed as critical during the short blast response as it would be under static loads.

To push Conform-encased walls to their ultimate limit, AFRL selected thinner walls, 4-in and 6-in, again with no reinforcing steel, and increased the

blast load. The blast resulted in 57-psi reflected pressure and 405-psi/msec impulse. The 4-in walls failed catastrophically, as predicted, and the 6-in walls cracked in half but did not collapse. In both cases, the polymer formwork contained the concrete and fragmentation was minimal.

In total, AFRL conducted blast experiments on 10 different configurations using Conform, including blast barriers with configurations using PVC forms filled with concrete or earth. In each case, the product performed well with little or no secondary fragmentation.

Forced Entry and Ballistics Resistance

AFRL also investigates materials that are ballistic-resistant. To test the ballistic-resistant properties of Conform, AFRL designed a 17-in-thick crib structure using two concrete-filled 4-in polymer forms and 9-in of sand fill. This configuration contained four 50-caliber rounds, all of which entered the same location and did not penetrate the rear face. The manufacturer demonstrated this same configuration at the Force Protection Equipment Demonstration V, held in April 2005 at Marine Corps Base Quantico, Va. In the subsequent demonstration, the configuration resisted six 7.62-mm rounds entering the same point, with penetration reaching less than halfway through the sample.

In addition to blast and ballistic concerns, the U.S. Department of State's Overseas Building Operations (OBO) requires forced entry (FE) resistance for many of their embassy projects. OBO selected Conform for FE testing at the Naval Facilities Engineering Command's Naval Facilities Engineering Service Center at Port Hueneme, Calif. In November 2005, walls were successfully tested for up to 1-hr forced-entry resistance and the State Department issued certifications for seven different 6-in and 8-in wall assemblies using Conform. OBO considers Conform acceptable for use in its embassy construction program and has specified the material for a number of its forced entry-ballistic resistance and blast-rated facilities.

Technology Readiness Level

Other advantages of using COTS products in force protection construction are the established building code approvals and the mature constructability processes. Building codes address such items as structural performance, weather resistance and life safety issues. As a COTS product, extensive documentation is readily available for Conform, including numerous studies and guides related to design, engineering and construction. Affordability is assured because it is already being used in the commercial construction marketplace, which demands low cost and high performance.

For conventional applications, Conform has been readily available for years and has been used by U.S. Air Force RED HORSE Squadrons, U.S. Navy Seabees and the U.S. Army. More than 130 Department of Defense projects have been constructed in the continental U.S. and internationally since 2001.

COTS for AT/FP

AFRL has demonstrated that mature COTS technologies can satisfy AT/FP requirements. Force protection construction materials do not have to be developmental. The advantage of considering commercially-developed COTS materials for AT/FP applications is a readily available supply of cost-effective, certified and code-approved resources. The technology transfer of a COTS product to AT/FP applications provides substantial savings in cost and time before implementation.

The use of a COTS product can eliminate the expense of non-recurring developmental and engineering costs associated with a specialized product. Products suitable for dual-use but manufactured primarily for commercial applications can provide the advantages of affordability, reliability and availability to agencies responsible for force protection construction. **TME**

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