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3.371J Structural Materials
30 November 2017

Structural and Material Properties of HESCO® Defensive Barriers used by the
U.S. Department of Defense for Force Protection

Introduction

In 2010, the military operation in Afghanistan surpassed the Vietnam War as the longest
continuous military conflict in American history, with its onset just shortly after the terrorist
attacks on September 11, 2001. The Iraq War began in 2003, and despite significant reductions
in military support and a draw-down of American forces, ongoing conflicts in the region require
a persistent active U.S. military presence. Though different operations in the tactical or
strategic sense, many commonalities exist between the two campaigns in terms of logistics,
materiel and equipment, or military life and services, among others.

Two such commonalities are the significant network of hub-and-spoke base logistics and
the requisite force protection that permeates each of the military theaters of war. A common
sight across the landscapes of Iraq and Afghanistan, military bases come in many forms: camps,
FOBS (Forward Operating Bases), COPS (Combat Outposts), COBS (Contingency Operating
Bases), etc. Though threats vary across each theater and between regions, almost all the bases
share similar procedures for establishing stand-off, force protection, and perimeter security.

Rapidly-constructible defensive barriers became a mainstay for hasty U.S. military base
construction in both Iraq and Afghanistan. The most common of these barriers are essentially
gabion wire cages with geotextile lining containing local fill material (sand, gravel, or other non-organic soils) to create modular earth walls for base construction as shown in Figure 1 [1]. The concept is ancient, but the modern alterations provide for an effective defensive barrier with significant advantages over alternative methods. Some of the most prevalent defensive barrier products used by the Department of Defense (DoD) are provided through HESCO® Bastion Ltd.

**Figure 1 – Image of HESCO® barriers used in a defensive fortification [2]**

HESCO®, a leader in deployable defensive barrier systems, provides the DoD with an extensive product line of varying barrier geometries for base construction and force protection. This report provides a review of the force protection requirements, the barrier system characteristics, the ballistic and explosive protection capabilities, and the anti-vehicular force protection capacity. With additional insights into HESCO® barriers’ value proposition, installation, and competitive advantage, this report will explore how the company provided millions of service members with a highly effective and efficient force protection solution.
Force Protection Requirements

The DoD’s physical security strategy requires a layered defensive system of both active and passive security measures [3]. The U.S. Army Corps of Engineers (USACE) established Engineer Pamphlet 1105-3-1, Base Camp Development in the Theater of Operations, which outlines how engineer planners work with the supported tactical units to develop a defense strategy that includes survivability and force protection [4]. For all base camp planning, the following protection concerns must be addressed: entry control points, perimeter security, stand-off distance, camp site plans (placement of ammo and fuel holding locations in relation to troop housing for example) and facility hardening [4, pp. 124-126]. While base facilities, logistical access, and troop services are added considerations at the forefront of the base planner’s agenda, the base physical security plan must ensure mitigation against reasonable threats in accordance with the supported unit’s defensive plan. The following sections review the base planning measures in the context of defensive barriers:

Entry control points (ECPs) are the designated access points where defensive posture is heightened and increased barrier measures account for the transit flux of personnel and vehicles. While the entire defensive perimeter of a base should be impregnable, the ECP includes a tiered system of anti-vehicle barriers to interdict potential attacks and VBIEDs (Vehicle-Borne Improvised Explosive Devices).

Perimeter security addresses any attempt of breaching the base walls by personnel or vehicle and likely requires a tiered system of active and passive defenses. Potential passive layers include concertina fencing to prohibit dismounted personnel, temporary concrete walls to create standoff from vehicles, and HESCO® containers to provide protection and
concealment against ballistic rounds or VBIED fragmentation. Active measures could include over-watch from guard towers, rotating security, or ground movement sensors.

Stand-off distance is achieved through the application of multiple perimeter defensive lines and space (wire, concrete barriers, and earthen HESCO® walls, for example).

Hardening structures refers to the application of HESCO® barriers, concrete walls, or sandbags throughout the base to further protect areas of troop concentrations or high-value assets. Within the perimeter, key installation buildings are enhanced with force protection, ammunition and fuel points are isolated and protected, and housing areas are often supplemented with bunker protection.

Camp site planning incorporates the required physical security elements and necessary facilities into the site plan according to the natural layout and evaluated enemy threats. With an understanding of force protection requirements, the engineer planners must apply available equipment, labor assets, and materials to execute the physical security defensive plan.

**HESCO® Bastion History, Products, and Materials**

Developed by HESCO® Bastion Ltd. out of Leeds, England in the late 1980’s, the original designed use for the product included flood control and soil erosion prevention. The British armed-forces recognized the defensive benefits of the barrier system, and they were first implemented in the 1991 Gulf War [5]. HESCO® Bastion gained prominence in the mid-1990s during the NATO operations in Bosnia, as American soldiers filling sandbags quickly identified the superior method for reinforcing their defensive perimeters. HESCO® Bastion earthen walls were used to fortify NATO-led IFOR (Implementation Force) bases in Bosnia, and U.S. Army
engineer soldiers using M9 Armored Combat Earth Movers (ACEs) and Small Emplacement Excavators (SEE Trucks) became familiar with the new barrier materials [6].

The modernized HESCO® Bastion products used in Iraq and Afghanistan resemble their predecessors from the 1990’s, but with several features to improve transportability and constructability. HESCO® Bastion provides an array of products based on differing unit geometries, but the material components and purpose are generally similar. After speaking with HESCO®’s Emergency Response Manager, the most commonly used military product and configuration is the MIL™ 1 Unit stacked in a pyramid formation (a two-unit base with one unit centered atop) [7]. A MIL™ 1 Unit is composed of 9 HESCO® cells: a row of 5 connected cells and row of 4 connected cells with additional spiral hinges for linking as shown in Figure 2. A linked MIL™ 1 Unit in a row formation is 4.5 ft high, 3.5 ft wide, and 32.75 ft long [8]. HESCO® MIL™ 1 Units are palletized and containerized for shipping, with 7 units to a pallet at 2,387 lbs, and 8 pallets per 20-foot container [8]. Thus, given available fill material, labor, and military construction equipment, one 20-foot container filled with MIL™ 1 Units can be used to construct approximately 610 ft of HESCO® wall in pyramid formation.

Figure 2 – Image of HESCO® MIL™ 1 Unit dimensions and view of side panel materials [8, 14]
From the company’s available technical specifications, the HESCO® MIL™ series products are designed for “general use as an earth-filled barrier” and are “suitable for filling with earth, sand, gravel, crushed rock, and other granular materials” [8]. The HESCO® side panels are composed of AISI 1010 carbon steel at a mesh spacing of 3 in by 3 in [8]. The MIL™ 1 Unit, and all sizes less than 7 ft in height, use a 4 mm gage welded wire mesh frame, whereas the 7-foot tall MIL™ 7 and larger units use a 5 mm gage wire [8]. The welded mesh cage is coated to meet ASTM A856, which regulates the standards specifications for Zinc-5% Aluminum-Mischmetal Alloy-Coated Carbon Steel Wire [8]. Considering its UK-based origins and markets, the steel wires and zinc-aluminum coatings also adhere to the British Standards, BSI EN 10218-2:2012 and BSI EN 10244-2:2009, respectively [8]. The geotextile lining fabric is made of a “heavy-duty, non-woven, permeable, polypropylene” which contains the granular fill material while allowing for the requisite seepage [8]. The polypropylene liner is 1.37 mm thick with a wide-width tensile strength of 85 lbs/in [9, pp. 4-5]. Finally, the vertical edges of the side panels are connected using spiral hinges of AISI 1010 steel with “an inside diameter of 0.857 in and a pitch of 1 in” [9, pp. 4-5]. All steel wires are “fabricated to have a minimum yield strength of 92,800 psi and an ultimate strength of 99,350 psi” [9, pp. 5].

**Ballistic and Explosive Testing**

In developing the physical security base plan, the tactical situation necessitates that the perimeter, guard towers, and ECP defenses be capable of withstanding direct fire attacks from small arms weapons (.50 caliber and below), hand-held grenade attacks, rocket-propelled grenades (RPGs), and placed munitions (homemade, improvised, etc.). Other enemy
considerations are indirect fire attacks from mortars, rockets, and artillery, which should be mitigated against with internal protective bunkers and facility hardening. And finally, perimeter exposure, and ECPs specifically, are susceptible to VBIEDs, which are managed with a series of passive and active response systems. The material qualities of HESCO® provide a stable and suitable defensive barrier, but they must also perform against a variety of threats.

In July 2005, at Kandahar Air Force Base, Afghanistan, a group of paratroopers from the 173rd Airborne Brigade field tested the ballistic capacity of a row of HESCO® units [10]. Given their location-specific requirement for a slimmer barrier, the MIL™ 1 cell depth was reduced in half to 50 cm. The squad initiated against the experimental HESCO® wall with a 107 mm High Explosive (HE) Rocket, placed two meters from the wall base [10]. They proceeded to expend two RPGs, two 40 mm M203 grenade launcher HE rounds, and 400 rounds of 5.56 mm ball ammunition from M4 automatic rifles and M249 light machine guns, resulting in zero penetration through the HESCO® wall and minimal surface damage [10]. The experiment indicated the resiliency of the barrier material against mortars and small arms fire. A representative from HESCO® confirmed the typicality of these results, and advised that a barrier material width of two feet is suitable to stop .50 caliber rounds and smaller, while a MIL™ 7 or two MIL™ 1 barriers providing seven feet of barrier depth can stop an RPG round [7].

In the early 2000’s, HESCO® barriers were tested by a number of military agencies to determine their suitability as barricades for ammunition storage. If a single storage site of ammunition is detonated through enemy action or accidental initiation, propagation of that explosion can detonate subsequent ammunition stacks. To limit this propagation, DoD regulations require at least 43 ft of separation between ammo stores of Net Explosive Weight
up to 4,000 kg [11]. HESCO® barriers were tested and proven to prevent propagation with only 28 ft between stacks, thus, reducing the footprint required to store ammunition on contingency military installations [11]. In an experiment led by the Army Research Laboratory, a sand HESCO® barricade with an 8-foot thick base (two barriers wide) topped with a 5-foot thick barrier was submitted to propagation detonation testing [12]. At a mere 10 ft from the HESCO® barricade, a donor stack of 576 unserviceable 155 mm projectiles was detonated to replicate a massive enemy-inflicted or accidental detonation [12]. At 10 ft from the opposing side of the HESCO® barricade, a mixed-composition of explosive charges and munitions was staged as the acceptor stack to bear the brunt of the explosive force as shown in Figure 3 [12].

![Figure 3 – Image of HESCO® (concertainer barricade) explosive testing configuration [12]](image)

The HESCO® barricade was completely demolished and extensive sand spray and a rising fireball ensued, while the acceptor projectiles were flung from their staged position [12]. However, as previously researched by J.R. Johnson in 1966, fragments of 106 mm howitzer rounds penetrate no further than 4 ft into a sand barrier [12]. So, although the acceptor stack
was dislocated by the pushing explosive force, it was not hit by shrapnel fragments and did not sympathetically detonate [12]. While the testing does not precisely replicate indirect fire HE rounds or VBIEDs, the underlying results of the barricade detonation test prove that HESCO® barriers can be used to dissipate a blast force and excel at stopping explosive fragmentation.

**Anti-Ramming Capability**

Mitigating against indirect and direct fires onto the camp or against perimeter defenses is critical for the protection of base security forces. But the evolving enemy threats in both Iraq and Afghanistan proved that ECPs were consistently targeted by the enemy, often with VBIEDs. And thus, base defense plans incorporated stand-off and an echelon of active and passive barrier systems to recognize and defeat potential car-bomb threats prior to reaching the entry point. To slow-down and serpentine approaching vehicles, and to resist enemy vehicle-ramming or VBIEDs, the fortifications surrounding ECPs require a level of anti-ramming capacity.

The U.S. Army Corps of Engineers’ Protective Design Center along with the Department of State (DoS) regularly updates a list of active and passive ‘vehicle-impact rated barriers’ that meet the specifications of ASTM F2656-07, Standard Test Method for Vehicle Crash Testing of Perimeter Barriers [3]. The ASTM provides the testing apparatus specifications and testing procedures, as well as the generated reports required [13]. The ASTM identifies four categories of vehicle size (sedans, pickups, medium-duty pickups, and heavy goods vehicles) with three test speeds (40 mph, 50 mph, and 60 mph) [13]. To establish an effective barrier against vehicle ramming requires that the structure stops the designated sized vehicle at the given speed with no more than one meter of penetration beyond the interior line [13]. The requisite
perpendicular impact rating for a DoD and DoS structure in the physical security plan is generally K-12, corresponding to the 15,000 lbs medium-duty pickup traveling at 50 mph [13]. The HESCO® MIL™ 1 pyramid formation provides a K-12 vehicle anti-ramming rating as shown in Figure 4, and the largest MIL™ unit qualifies for the H-50 ASTM rating, corresponding to the 65,000 lbs heavy goods vehicle traveling at 50 mph [14]. While a variety of anti-ramming barriers may be used to complement an existing ECP system, the benefit of HESCO® barriers are that they provide ballistic and explosive protection, as well as anti-ramming effectiveness.

Figure 4 – Image of HESCO® K-12 anti-ramming vehicle barrier testing [14]

Value Proposition, Alternatives, and Conclusions

The HESCO® Bastion products are not the only defensive material used in theater, but they’re certainly one of the most prevalent. The competitive interests of cost, time, and scope can stagnate acquisition and materiel decisions, but the time savings and material benefits of HESCO® barriers give them an obvious edge and make them a critical component of rapid base construction and force protection. Given the structural characteristics, and the ballistic,
explosive, and vehicle ramming defense capabilities, the concluding paragraphs address the value proposition of HESCO® in comparison to alternative defense materials considering: the time to construct, worker skill level required, and permanence factors.

Other common material options for creating hardened defensive structures or barriers in the theater of operations include, but are not limited to: prefabricated concrete wall segments (often called ‘T-Walls’), sandbag structures, concrete block structures, structures made with local building materials, wooden facilities, pre-engineered metal structures, or prefabricated concrete structures. On some of the larger base camps, wooden or metal buildings are constructed to provide semi-permanent facilities for camp services. While not especially protective, the buildings are assembled quickly, with a minimal level of skilled labor and through the aid of heavy-lifting equipment. Alternatively, concrete or masonry structures could provide valuable force protection but require more labor and time. But an additional drawback of building concrete block structures or facilities with local building materials, is that most of the bases in Iraq and Afghanistan are constructed on borrowed land with an eventual hand-over plan to local forces. For that reason, very few permanent structures are constructed on military camps to preserve funds and avoid eventual demolition. Lastly, the T-Walls and concrete prefabricated structures (generally bunkers or towers) are the next most common defensive material encountered in the theater of operations. The greatest benefits of these materials are that they can be reconfigured or relocated with simple construction equipment, and can supplement existing defensive plans with an additional layer of fortification. The disadvantages to these concrete structures are high cost and inconsistent quality. The quality assurance of local manufacturing processes with unreliable material supply chains often lead to
degraded products with questionable structural integrity. Finally, the benefits of sandbags are that they are plentiful, and easy to fill with unskilled labor and minimal tools. However, the equivalent sandbag wall to one MIL™ 1 Unit HESCO® wall described earlier requires roughly 1,500 sandbags as shown in Figure 5 [15]. At an average pace of 3 min per sandbag, the operation would take a squad of 10 nearly 7.5 hours to complete. The planning factor for one MIL™ 1 Unit assembly is 20 min with a team of 3 including one piece of construction equipment (often a loader) [15].

![Image of a wall of 1,500 sandbags compared to one HESCO® MIL™ 1 Unit [15]](image)

Construction equipment is readily available in the Engineer Companies organic to each Army Brigade, so equipment and labor are generally not a concern for HESCO® erection. The competitive advantage for time savings is crucial for rapid base construction, and while a combination of defensive barrier systems is beneficial for a tiered physical security plan, the clear advantages for HESCO® barriers are apparent. HESCO® Bastion products have been, and remain a critical component of DoD force protection and defense design.
References


