An Exploratory Comparison of Water-Tamped and -Untamped Explosive Breaches

Practical Applications for the Tactical Community via a Pilot Study

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ABSTRACT

Background: Tamping explosive charges used by breachers is an increasingly common technique. The ability to increase the directional effectiveness of the charge used, combined with the potential to reduce experienced overpressure on breachers, makes tamping a desirable tool not only from an efficacy standpoint for breachers but also from a safety standpoint for operational personnel. The long-term consequences of blast exposure are an open question and may be associated with temporary performance deficits and negative health symptomatology. **Purpose:** This work evaluates breaches of varying charge weight, material breached, and tamping device used to determine the value of tamping during various scenarios by measuring actual breaches conducted during military and law enforcement training for efficacy and blast overpressure on Operators. **Methods**: Three data collections across 18 charges of various construction were evaluated with blast overpressure sensors at various distances and locations where breachers would be located, to assess explosive forces on human personnel engaged in breaching activities. **Results and Conclusions**: Findings indicate that water tamping in general is a benefit on moderate and heavy charges but offers less benefit at a low charge with regard to mitigating blast overpressure on breachers. Reduced overpressure allows Operators to stage closer to explosives and lowers the potential for compromised reaction time. It also reduces the likelihood of negative consequences that can result from excessive overpressure exposure and allow Operators to "do more with less" in complex environments, where resource access may be limited by logistic or other limitations. However, tamping in all instances improved blast efficacy in creating successful breaches. Future studies are planned to investigate tamping mediums beyond water and environment changes, whether tamping can be used to mitigate acoustic insult, and other explosive types.

KEYWORDS: *breachers; blast; overpressure; tamping; water tamp*

Introduction

Charge construction is the bedrock of a successful breaching program. Variations on charge construction, and specifically the application of properly executed tamping, can greatly enhance breaching success and safety.

Tamping is a technique that adds a dense medium to the charge "backside" (i.e., the side not facing the target), thereby allowing for the redirection of what would otherwise be wasted energy when the explosives are detonated. Throughout explosive breaching history, a variety of tamping materials have been used, such as wood, rubber, plastic, and water. However, the obvious downside to the use of a rigid tamping material is the potential for fragmentation, which could lead to critical injuries. The high risk of rigid tamping materials makes non-rigid alternatives such as water a preferable alternative.

A growing body of literature has noted short-term performance deficits after exposure to mild/moderate blasts, and subjects with repeated blast exposure report symptomatology often referred to as breachers' brain.[1,2] Breachers' brain is characterized by irritability, trouble sleeping, and cognitive task issues such as slow-think.[3] We investigated tamping not only to better understand the mechanisms of making charges more effective and efficient, but also for a secondary benefit of lowering blast overpressure, which may affect breacher efficacy and long-term health by means of an exploratory pilot study.

The breaching community has been using water as a tamping medium for years because water can increase breaching charge efficiency by redirecting toward the target the potentially lost energy on the backside. By enhancing the blast effect in this way, breachers can lower the net explosive weight of a charge and still gain the same results in breaching. Another notable point of interest is that water tamping may mitigate blast overpressure experienced by Operators. Understanding whether water tamping can mitigate blast overpressure during breaching events is critical because breachers with repeated overpressure exposure have tentative links to negative health outcomes[3,4] that may not only have long-term negative consequence but also short-term performance concerns. Additionally, individuals with chronic low-level blast exposure, such as instructors, seem to be more at risk for possible detriments in neurologic function on high-memory-demand tasks, such as those assessed by the Defense Automated Neurobehavioral Assessment rapid procedural reaction time assessment tool and the Go/No-Go test.[5] Individuals with chronic low-level blast exposure also seem to be more at risk for reporting symptoms of memory issues, sleep disturbance, and irritability.[6] Collectively, these symptoms present a profile similar to that of post-concussive symptoms,[7] with a complex profile of injury from the various facets of blast (i.e., pressure, heat, shrapnel, environmental).[8] Moreover, blast exposure was positively correlated to increased symptom profiles.[7]

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For this study, a breach is considered successful when no additional tools, explosions, or work (e.g., kicking a partially destroyed door) were needed after detonation for the breaching team to access the entry. Thus, we propose the following:

Hypothesis 1: water tamping will increase the breaching success rate from blasts of the same construction on the same target type.

Hypothesis 2: water tamping will lower the observed overpressure from blasts during breaching in locations where breaching personnel are located.

Methods and Data

Ten blasts using water-tamped (n = 5) and -untamped (n = 5) breaches were evaluated across two different data collection sites from 2017 to 2018. Eight additional charges from a third site collected in 2016 were considered for comparing overpressure from tamped and untamped charges.

During training, explosive charges of various shapes and sizes were detonated repeatedly to measure overpressure. Generally, explosives were a combination of pentaerythritol tetranitrate (PETN)-based 25-grain detonation cord (det cord; velocity of detonation, 6,400 m/s), sometimes combined with either C1 or C2 detasheet (PETN-based flexible explosive; velocity of detonation, 7,100m/s). Regardless of the explosive construction (det cord only or det cord + detasheet), explosives were detonated with M81-style Igniters and shock tubes in conjunction with J-1 or equivalent RDX (i.e., Research Department eXplosive [cyclotrimethylenetrinitramine]) or PETN-based blasting caps. When breaches were done with det cord only, strands varied in length but were generally 80-in long (i.e., door length) and consisted of 1-strand (light breaching), 2-strand (moderate/solid core exterior door), or 3-strand (heavy exterior door) charges. Rubber sheeting was placed against the door in all charges to function as a push, and when applied, water tamps were same-length water bags made of flexible plastic. Overpressure was measured using laboratory-standard static and dynamic-pressure transducers (PCB Piezotronics) and blast sensors (BlackBox Biometrics). Most importantly, when charges were compared between tamped and untamped, the charge construction, weight, and position were identical across conditions for that evaluation. B3 gauges are static calibrated at the factory across low, medium, and high ranges with at least five data points and have been verified by the factory to hold calibration over approximately 1 year or 1000 detonations. The B3 also adapts to the environment by reading atmospheric data as an additional calibration mechanism. Though imperfect, it is notable that the B3 gauge has a transparent self-calibration system. Measurement issues assessing pressure waves are a known difficulty,[9] so having this documentation, even if imperfect, provides increased transparency in science.

Data Collection 1: Spring 2017, Military Facility

We evaluated a 21-day training course for military personnel with a substantially heavy concrete wall- or fence-breaching component. The charges evaluated (tamped = 2, untamped = 1) were conducted in a single afternoon but do not represent the entirety of charges detonated at the course. Charge weights were 11-lb C-4/det cord combination charges; the C-4 with det cord (totaling approximately 11 lb) was placed in a roughly oval shape to provide an entry port through concrete. When tamped with water, intravenous (IV) bags were placed behind the entire shape of the charge, with two 1000mL bags per charge section, for a total of six charge sections, thus totaling 12L of tamping. Bags were laid parallel to the C-4 charge, forming a triangle over the charge block. To account for the limited number of measured detonations (one per condition), three rows of sensors were used to measure the blast. This portion of the course occurred in an open area environment with no notable topography or man-made structures nearby to contain or reflect the blast aside from the structure being breached. Sensor stands were placed at the shielded and unshielded minimum safe distance (MSD) for each individual charge. At the unshielded MSD, two sensor stands were placed at 45° off the wall at 40 ft from the charge on the left and right sides. At the shielded MSD, one sensor stand was placed directly in front of the charge 90° off the wall at 26 ft from the charge. The breaching stacks were positioned at 40 ft from the charge 45° off of the wall on the left and right sides. Sensors were positioned at the height of the center of the charge.

Data Collection 2:
Spring 2018, Military/Law Enforcement Training Facility

Similar to collection 1, charges evaluated were conducted as part of a larger course (tamped = 4, untamped = 4). Charges were placed on the hinge side of a door against the door and the frame using a 78-in × 2-in piece of 330B rubber. Two different weights of det cord were used: 25 grain and 50 grain. When water was added as a tamp, a plastic sleeve containing 3000mL of water was added to the back side of the linear charge. The charges used in data collection 2 are considered light breaching charges. Three sensor stands were placed at 11 ft from the location of the charge for each door. Each stand was spaced 45° apart in a semicircle with the charge as the epicenter. Each stand had two sensors in incident orientation to the charge. The distances reported here, as was the case with data collection 1, represent MSD for the construction of the explosives used. The environment was open, with no reflective surfaces to bounce pressure waves, and was fairly flat.

Data Collection 3:
2016, Law Enforcement Training Facility Site

Charges were three hockey puck–style (HP) charges composed of a 350-grain net explosive weight (NEW). The HP charge was 7 ft of 50-grain det cord, spiraled up and placed on one side of a 6-in × 6-in piece of 330B rubber. The rubber was then placed against the target as a push. When water was added as a tamp, 2 × 1000mL IV bags were placed on the back side of the HP. Eight blasts (tamped = 4, untamped = 4) were evaluated. Charges were placed on the lock side of the door against a door frame in a semi-enclosed environment (i.e., three walls, no ceiling), similar to an open-top shoot house/Hogan's alley. Sensor stands were placed at 5 ft from the location of the charge because of environmental constraints. This distance was under MSD. All other aspects paralleled those of collections 1 and 2. Buildings were Conex shipping container style (i.e., like freight cars) with doorways. Spacing was similar to that of US suburban environments, with reflective surfaces approximately 22 ft opposite the charge.

Data Preparation

Where possible, sensor readings are the reported average of multiple sensors with the same orientation and nearly identical location in terms of distance. Data were reviewed for abnormalities or sensor failures and compared with ancillary collected data to ensure accuracy.

Results

Hypothesis 1 was evaluated by recording breach success per charge. The success rate of untamped and tamped charges for heavy breaching was 100%, whereas that of the untamped charges for light breaching applications was 50% and that of the tamped was 100%. There were two unsuccessful breaches: one untamped 25-grain charge (door hung improperly) and one untamped 50-grain charge. As previously mentioned, all charges in this phase used a rubber push, with the explosive secured to the push for best effect.

Hypothesis 2 considered to what extent, if any, water tamping reduces measured blast overpressure. Water tamping effectively reduced overpressure for all charge levels. On average, water tamping produced an 18.4% overpressure reduction (Table 1).

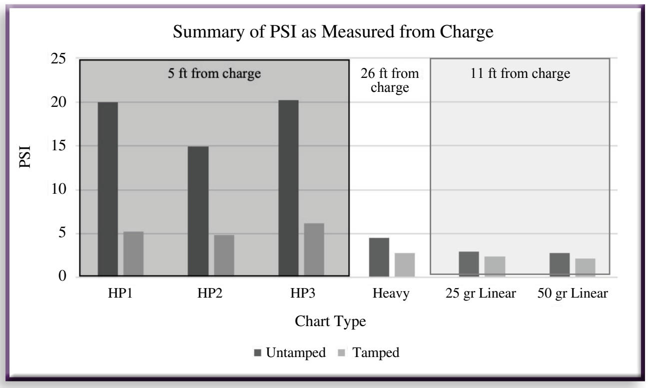
Data from site 3 further illustrates that tamping reduces overpressure compared with untamped charges (Figure 1). Tamping conducted in a quasi-enclosed environment consistently yielded lower overpressure readings compared with untamped charges in study scenarios involving a direct comparison between untamped and tamped charges with equal NEWs and compared with two different NEWs.

Conclusions, Implications, Limitations, and Future Directions

Notably, evaluating all data collections together, the trend indicates a reduction of measured overpressure regardless of distance to charge, charge construction type, environment, or NEW; tamping had a measurable impact in lowering overpressure. What is clear is that there does not appear to be a downside to tamping with water when conditions allow for it. A positive outcome is reducing Operator exposure to overpressure, especially in such areas as interior breaching and other conditions that expose the Operators to reflective pressures and increased durations. Reduced overpressure allows Operators to stage closer to explosives and lowers the potential for compromised reaction time. It also reduces the likelihood of negative consequences that can result from excessive overpressure exposure and allows Operators to "do more with less" in complex environments where resource access may be limited by logistic or other limitations.

Water tamping helps mitigate risk to breachers in terms of experienced overpressure. Tamping usefully increased breaching effectiveness in defeating barriers. Water appears to be a cost-effective, blast-overpressure mitigation strategy as well as a strategy for improving the chances of successfully breaching obstacles to be used by breachers as operational demands dictate. It does, however, seem best to use tamping on all charges because of the increased effectiveness, with the decrease in pressure being an additional benefit. It cannot be ignored that water is heavy, and austere environments may limit the ability of personnel to use water-tamped charges. Water alone cannot replace an effective skill set in breaching without using tamping materials.

FIGURE 1 *Comparison of data collections 1 (heavy), 2 (25-grain, 50-grain charges), and 3 hockey puck–style (HP).*



Note: Because of charge setup, training environment, and other factors, sensor distance is marked between charges. The most important factor is that tamping consistently lowered overpressure across setups. PSI, pounds per square inch.

This study is limited by its sample size and environment. By attaching to training events, our ability to collect extremely controlled data was limited. Individual breachers are known to have minor variations in charge construction to facilitate adaptation to local materials or regional building codes or to suit personal preferences in blast outcomes (i.e., tying in a longer tail to kick a door in a specific direction). We feel this is accounted for by evaluating charges from multiple sites across multiple charge builders, demonstrating that the effect of tamping is actually consistent at lowering overpressure on Operators while increasing charge efficacy, despite those variations in personal charge building.

Future studies are planned to investigate tamping mediums beyond water (to include gels and fluids with various viscosities), environment changes (e.g., breaching in fully enclosed/subterranean spaces), and whether tamping can be used to mitigate acoustic insult. Additionally, and finally, more explosive types will also be investigated to determine how explosive velocity interacts with tamping mediums.

Disclaimer

The opinions and assertions contained herein are the private views of the authors and are not to be construed as official. This work has been assessed and approved for public release.

TABLE 1 *Charge Weight, Type, and Overpressure*

					95% CI		
Charge Weight	Tamped/Untamped	n*	Mean	SD	Lower Bound	Upper Bound	% Change from Untamped
Heavy	Untamped	3	3.47	0.35	2.61	4.34	—
	Tamped	3	2.83	0.19	2.34	3.31	–18.4
25gr	Untamped	2	2.75	0.28	2.31	3.19	—
	Tamped	1	2.39	—	1.53	4.10	–13.1
50gr	Untamped	2	2.81	0.73	0.99	4.63	—
	Tamped	3	2.14	0.65	0.53	3.76	–23.8

*For 25-grain (25gr) and 50-grain (50gr) charges, n represents the number of charges detonated. For the heavy charges, n represents the rows of sensors in the field.

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Author Contributions

GHK conceived, oversaw, and gained funding for the research. WM oversaw and managed data collection and assisted in writing. AMR, AM, and JS collected data. CRL and MJE prepared, analyzed, and wrote the manuscript.

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