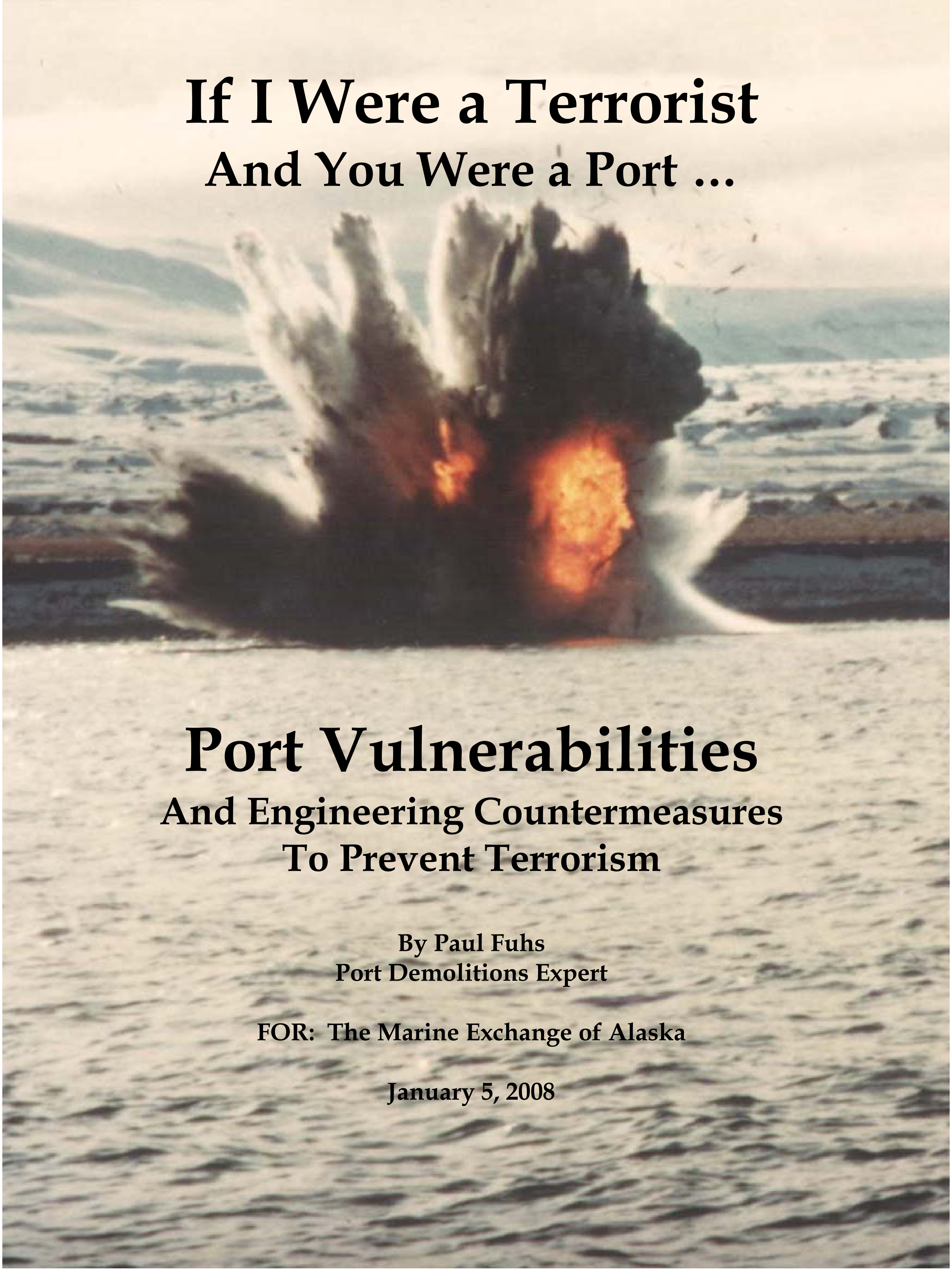

If I Were a Terrorist

And You Were a Port …

Port Vulnerabilities

And Engineering Countermeasures To Prevent Terrorism

By Paul Fuhs
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FOR: The Marine Exchange of Alaska

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About the Author:

Paul Fuhs is currently the President of the Marine Exchange of Alaska, a trade association for the Alaska maritime industry. He does consulting work for a variety of clients including shippers, ports, marine pilots and marine engineering design firms.

For 12 years, Mr. Fuhs worked as a commercial diver and underwater explosives expert in the Bering Sea, headquartered in Dutch Harbor, home port for "The Deadliest Catch." He demolished a variety of civilian and former military port facilities and other structures to make way for new port construction in the rapidly developing fisheries brought about by the 200 mile Exclusive Economic Zone.

He also led emergency response work for the U.S. Coast Guard, blasting and burning fuel on vessels that had run aground, to prevent environmental damage to the rich Aleutian Islands ecosystem.

During the Vietnam War, Mr. Fuhs was trained as a military intelligence agent and a North Vietnamese linguist. During the 1990's he served as the State of Alaska's Commissioner of Commerce and International Trade.

As mayor of Unalaska/Dutch Harbor he implemented use of Open Cell bulkheads for port improvements and has been a proponent of the Open Cell™ system since that time.

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Introduction:

It goes without saying that marine ports are critical strategic assets to any country, both militarily and economically, thus making them prime targets of terrorism. Bringing down major container crane or fuel facilities would cause serious damage to a nation's or region's economy and would score a major symbolic victory for the terrorists. The 2002 West Coast longshoremen's strike demonstrated the financial damage caused by disruption of port activities. A 10-day shutdown was estimated to cost up to $20 billion in financial damages. Because of this, serious attention has rightfully been given to port security across America and other countries.

Most port security programs focus on controlling access by terrorist agents into port facilities through screening identification, fencing, security cameras, etc. While these methods are effective in reducing the risk of attack on port facilities, ports are too dynamic in their operations and there are too many land and water based avenues of ingress to always guarantee physically stopping a determined terrorist.

The fact is that due to the design of many of our port structures, even a small cadre of operatives, carrying small amounts of high explosives, can inflict major damage to our ports.

This paper describes the techniques used to demolish port facilities and identifies their weakest design elements which should receive additional security attention such as increased surveillance or physical barriers. For new facilities, or for facilities that are being replaced, designs should be used that would thwart or eliminate destruction by terrorism. Those designs are also described here.

Port Design Vulnerabilities and Vectors of Attack

The most vulnerable elements of any port structure are those constructed of concrete. Concrete is a tremendous building material, strong when reinforced and kept in place. It is even stronger when compressed through prestressing techniques.

However, concrete is a form of ceramic, with weak lateral strength. Subjected to high velocity explosive shock, it shatters like glass. Once broken, the sheer weight of the broken member tends to pull the rest of the structure down with it.

We have all seen videos of buildings imploding. Such a small amount of explosives is used and yet the whole building comes down. How does that happen? Primarily by attacking the first two or three floors of elevator shafts. Once those levels fail and began to fall, they pull the rest of the building, tied together through reinforcing rebar, down with them until the whole building collapses. The heavier the building, the easier it is to bring down.

In ports, those sections with the heaviest loads are the most subject to successful attack. Those would be the sections holding container cranes which exert tremendous forces on the tangent points of their traveling wheels. Of course, this would also cause the most damage to the operating capability of the port.

I will describe here some of the simple methods which can be used to quickly demolish concrete pillars, piles, I-beam steel members and prestressed deck members. This is not secret classified information. It is readily available through the internet and specialty book stores.

Concrete supports can be brought down by very small amounts of explosives. The key to this easily deployable device is detonating the opposing charges at exactly the same time through electric detonators or equal length detonating primacord. When the shockwaves meet in the center of the pillar and attempt to reflect off each other, massive structural damage is created through internal pulverization of the concrete.

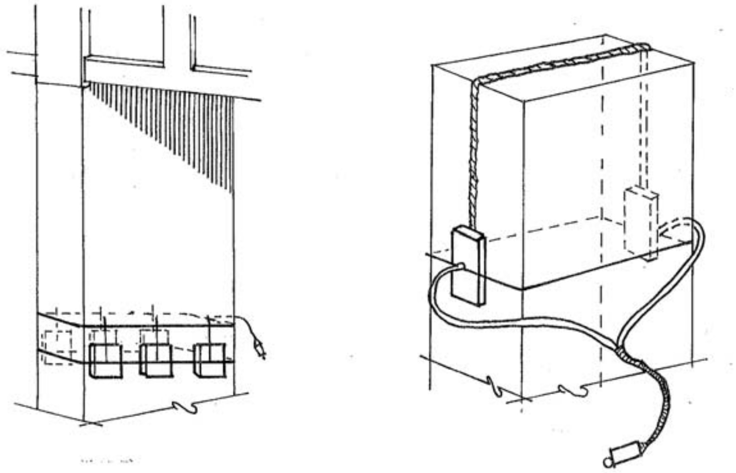

Figure 1. Opposable Charges

Here is the formula for calculating the explosive charge:
Source: Special Forces Demolition Techniques, Army Field Manual FM 31-20

“Multiply the diameter or thickness of the target to be breached by the constant, 5, which gives the number of pounds of plastic explosive required for reinforced concrete. For example, if a concrete target pier measures 1.06 meters in thickness (about 3.5 feet) the total amount of plastic explosive required is 6 pounds (2.72 kilograms). Divide the required amount of explosives in half and place the halves diametrically opposite one another on the target, using ropes or a simple wood frame. Simultaneous detonation of both charges is mandatory.”

Only six pounds of explosives are needed to take out a 3.5 foot thick concrete support!

Concrete piles which are often prestressed to provide compressive strength for piledriving, have little lateral strength and can be easily attacked with small amounts of explosives using the method previously described, deployed from a skiff or from divers operating below the surface. (See Figure 2 below.)

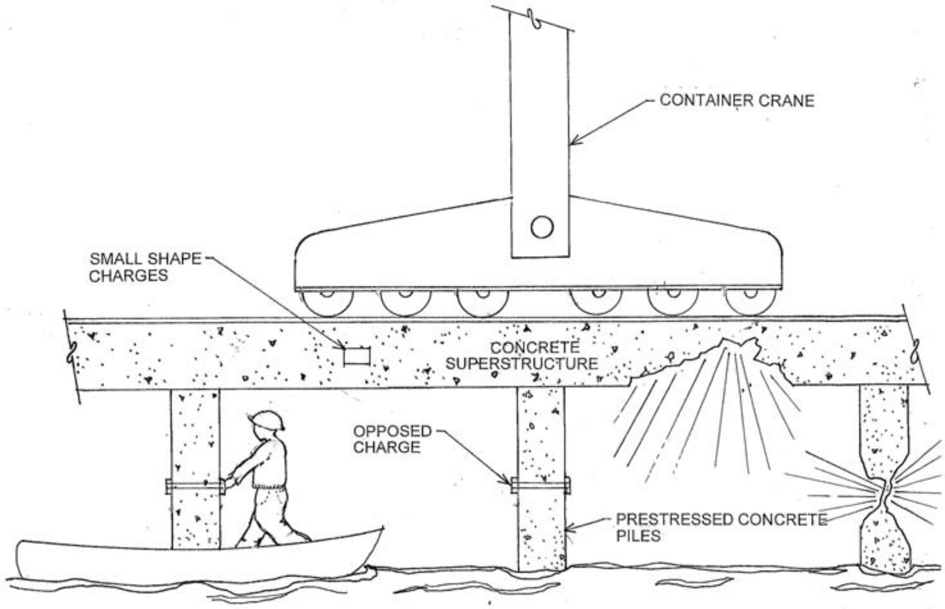

Figure 2. Opposed Charge Elevation

Round steel piling is the most difficult to attack. You can place charges around it but it will only crimp the pipe. There are shaped charges available but they are difficult to procure or manufacture and time consuming to deploy. If deployed underwater, a chamber must be purged of water to create the airspace for the shaped charge jet to develop. This provides positive buoyancy to the charge which must be counterweighted, etc.

Even then the charge only cuts out about a ½ inch ring of the piling so the upper section tends to settle down on the lower section and not provide the movement needed to bring the superstructure down. Round steel piles should always be used in port applications due to their superior resistance to attack.

I-beam steel sections (Figure 3) and tied-back steel bulkheads (Figure 4) are more easily breeched through the direct application of plastic explosives. When these charges are placed in strategic locations, they can cause massive failure of structures. The charge of plastic explosives (RDX) need only be as thick as the steel, but never less than ½ inch to maintain detonating wave strength. These charges are also deployable in a short time period. (See Figure 3 on next page.)

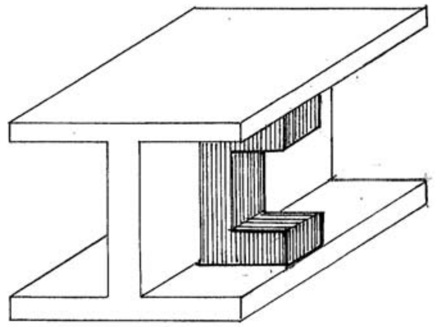

Figure 3. RDX, Plastic Charge
Source: U.S. Navy Seal Combat Manual 0502-LP-190-0650

Traditional steel bulkheads with exposed tie rods and walers are also subject to attack due to their exposed structural elements.. Although they may not experience immediate catastrophic failure such as concrete, they would be rendered essentially unusable since they would no longer support a bearing load at the face of the dock.

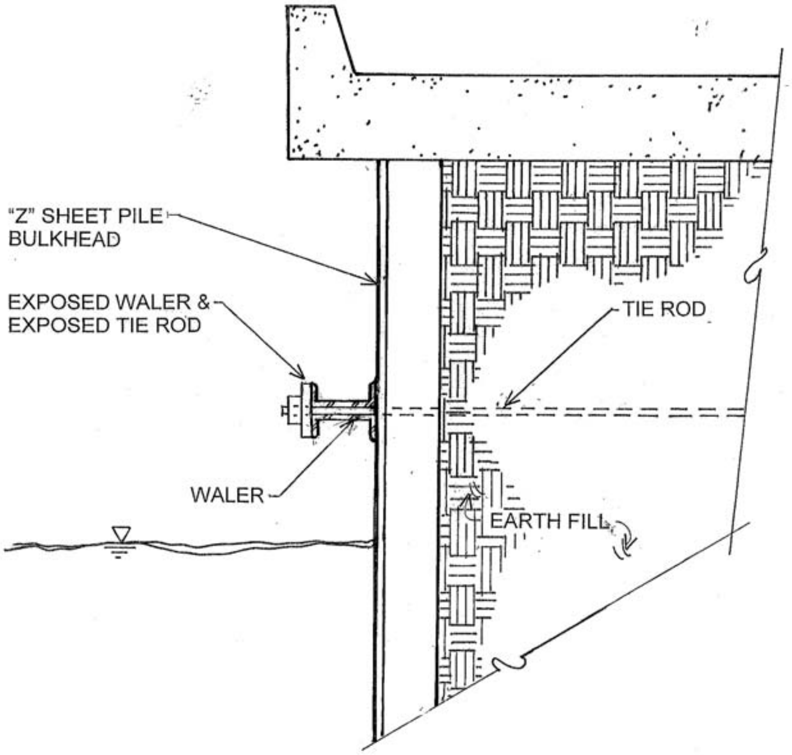

Figure 4. Typical "Z" Sheet Pile Bulkhead

Concrete caisson structures consist of huge prefabricated concrete structures, resembling an open box, that are then sunk onto a prepared seabed foundation. The box is then filled in with dredged or other soil material to create a monolithic dock structure. These facilities are highly resistant to attempts to damage them through use of explosives due to the mass of concrete involved, inability to place opposing explosive charges, the sheer mass of the soil and the soil's absorption and fracturing of the detonation wave.

However, they are subject to damage from large scale seismic events as occurred in Kobe Japan in 1995, which caused major structural failures and shifting of foundations. They are also extremely expensive to build. (See Figure 12.)

Wooden pile structures are very susceptible to attack using 400 grain detonating cord. Only two wraps around the piling are necessary to cut clean through the piling since the water pressure tends to concentrate the force of the charge into the piling. The detonating cord is continued from piling to piling so only one detonation point is necessary to bring down a large section of dock. (See Figure 5.) One or two divers can wrap many piling in a short period of time.

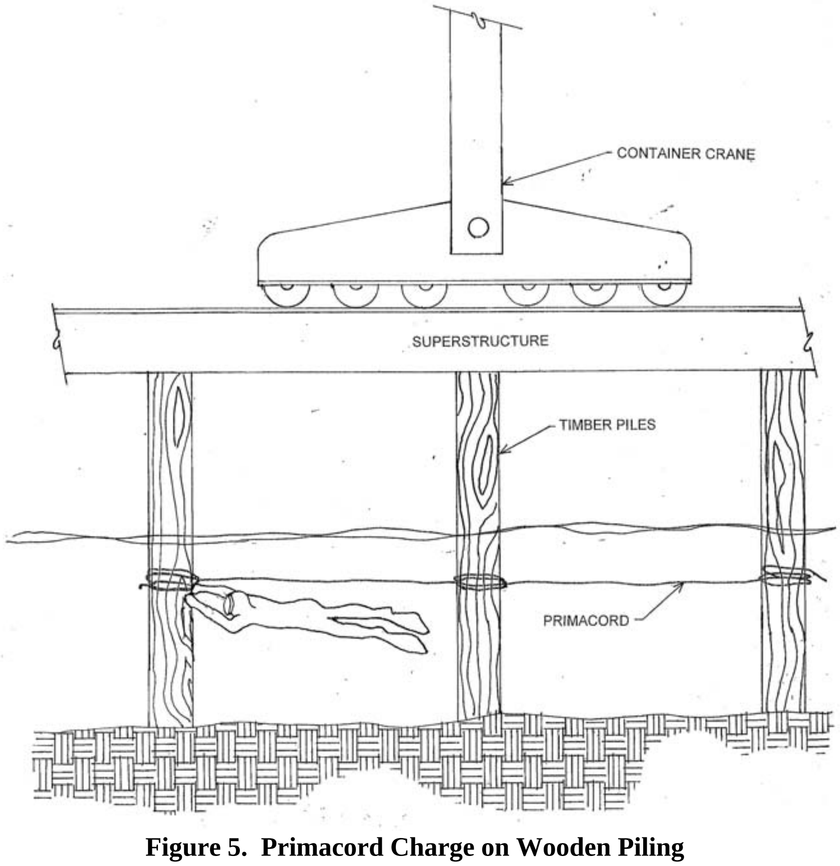

Figure 5. Primacord Charge on Wooden Piling

If a leading corner of a dock is attacked, as that corner falls down, the weight of the deck and superstructure starts to pull the rest of the dock down with it, snapping off section after section of wood piling as it goes down, particularly if cross bracing has not been meticulously maintained. I have taken down an entire 1,000-foot wooden dock by shooting only 16 wooden piling at the leading corner.

Prestressed concrete deck members are also highly susceptible to attack. Even if a dock is built on round steel piling, it is often covered by prestressed concrete deck members. Since concrete has little lateral strength on its own, long concrete sections are "prestressed." Steel strand is stretched within a concrete form and then concrete poured over them. After the concrete has set, strand is released and the concrete member will camber due to eccentric compression. When dead load is placed on it, the member will return to a level position rather than sagging.

This genius technology allows for huge spans and even whole buildings resting on a single concrete pier. However, that strength is only realized within the plane of the stressing. Any lateral movement whatsoever or damage to the concrete covering the stressed strand will result in the prestressed member exploding on its own as the tremendous pressure inside is released. This often occurs when construction crews incorrectly lift members into place and subject them to any lateral movement. Concrete is literally blown everywhere.

The illustration below (Figure 6) shows how prestressed deck members can be attacked resulting in massive structural failure of docks.

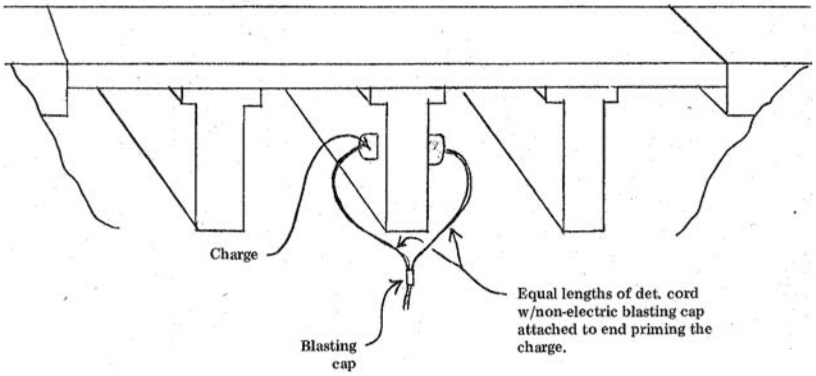

Figure 6. Prestressed Dock Attack Source: CIA Sabotage Manual

Admittedly, all these methods of attack would require penetration of security measures by land or water. But they don't require many people or much in the way of explosives or equipment to deploy. The results would be devastating to any port.

A simpler way to create the same destruction would be to use an incoming vessel to ram the dock. An infiltrated vessel crew could take charge of the helm and use the vessel to create major damage to concrete and wooden dock structures.

Those of us who work around docks know how carefully marine pilots bring vessels to the face of a dock, precisely because they know how fragile these facilities are.

A ship, or container loaded with explosives could also be detonated at the dock causing massive structural damage.

What is the most cost-effective engineering design that could thwart all of these potential attacks to port structures and make them virtually indestructible?

THE OPEN CELL SHEET PILE SOLUTION:

Open Cell sheet pile design and construction involve a special and patented application of sheet pile technology. On the front face of the dock the interlocking sheets are driven in a rounded, scalloped pattern. Upon reaching the end of the scallop, a three sided transition pile is driven (Figure 7). One leg of the Y starts the next front face scallop. The bottom leg of the Y starts a row of tie back sheet piles that extends back from the face of the dock.

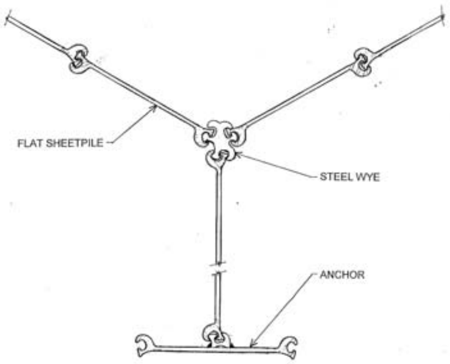

Figure 7. Open Cell Components

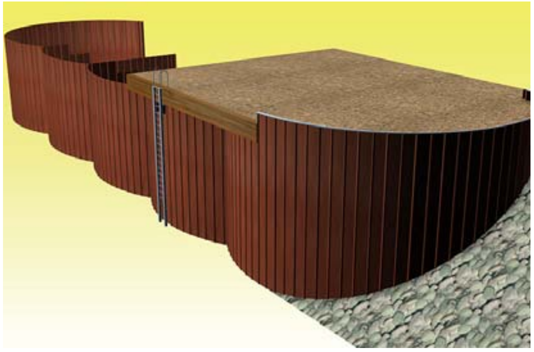

Figure 8. Open Cell Elevation

The resulting cells which are open at the end (hence the name Open Cell) are then filled with soils which are compacted in layers during placement (Figure 8). The force of the compacted soils on the tie back walls provides the horizontal strength at the face of the dock. The additional weight of crane rails and concrete slab or asphalt surfacing adds additional stability to the structure. This also provides the unusual characteristic of Open Cells being able to be used in weak soil environments (Figure 9).

There are currently more than 150 installations of open sheet pile structures worldwide and not one has ever suffered a structural failure. The rounded nature of the dock face piles and the soil mass behind them provides protection from damage to the dock from ramming by vessels. In fact they are so strong that it is necessary to place a fendering system as part of the dock to provide a cushioned landing for berthing vessels. You can test this concept yourself by placing an egg lengthwise in your palm. No matter how hard you squeeze it, because of the rounded surfaces, you can’t break it. (See Figures 9, 10 and 11 on the next page to see actual deployments)

Figure 9. Open Cell Being Backfilled

Figure 10. Open Cell Bulkhead Dock with Fenders

Figure 11. Man Standing on Open Cell Dock Overtopped with Wind-Driven Sea Ice, Nome, Alaska

These Open Cell sheet pile structures have been used in the most extreme environments in the Alaska Arctic where they are subjected to incredible forces of ice driven by powerful ocean currents and regular gale force storms in the Aleutian Islands and Arctic. Open Cells have withstood severe impacts from ice and vessels without significant damage (Figure 11).

Vulnerabilities to Terrorist Attack

There are no vulnerabilities to terrorist attack with these structures. The integrated nature of the sheet piles, the rounded front face and the sheer mass of the soil fill makes them virtually indestructible. It would take something on the order of a huge concussion or atom bomb to destroy one of them. You could punch a hole in the face of the pile wall with a shaped charge but it would not affect the structure and could be easily repaired with a welded patch.

In fact, one of the features of these structures is that they are virtually free of maintenance (with the exception of the cushioning fender system, which must be periodically replaced like any fendering system and cathodic protection) and they have a useful life of 75 to 100 years. To dismantle an Open Cell would require excavation of backfill and removal of pile sections one by one with a crane.

The costs of Open Cell sheet pile structures are typically 60% the cost of pile-supported port structures. (See Figure 12 on next page.)

For ports using Open Cell sheet pile installations, the threat profile of the port should be reduced to reflect the lowered risk of terrorist attack. This can potentially allow ports to reduce their security costs and premiums for insurance policies to insure against unintentional and intentional damage.

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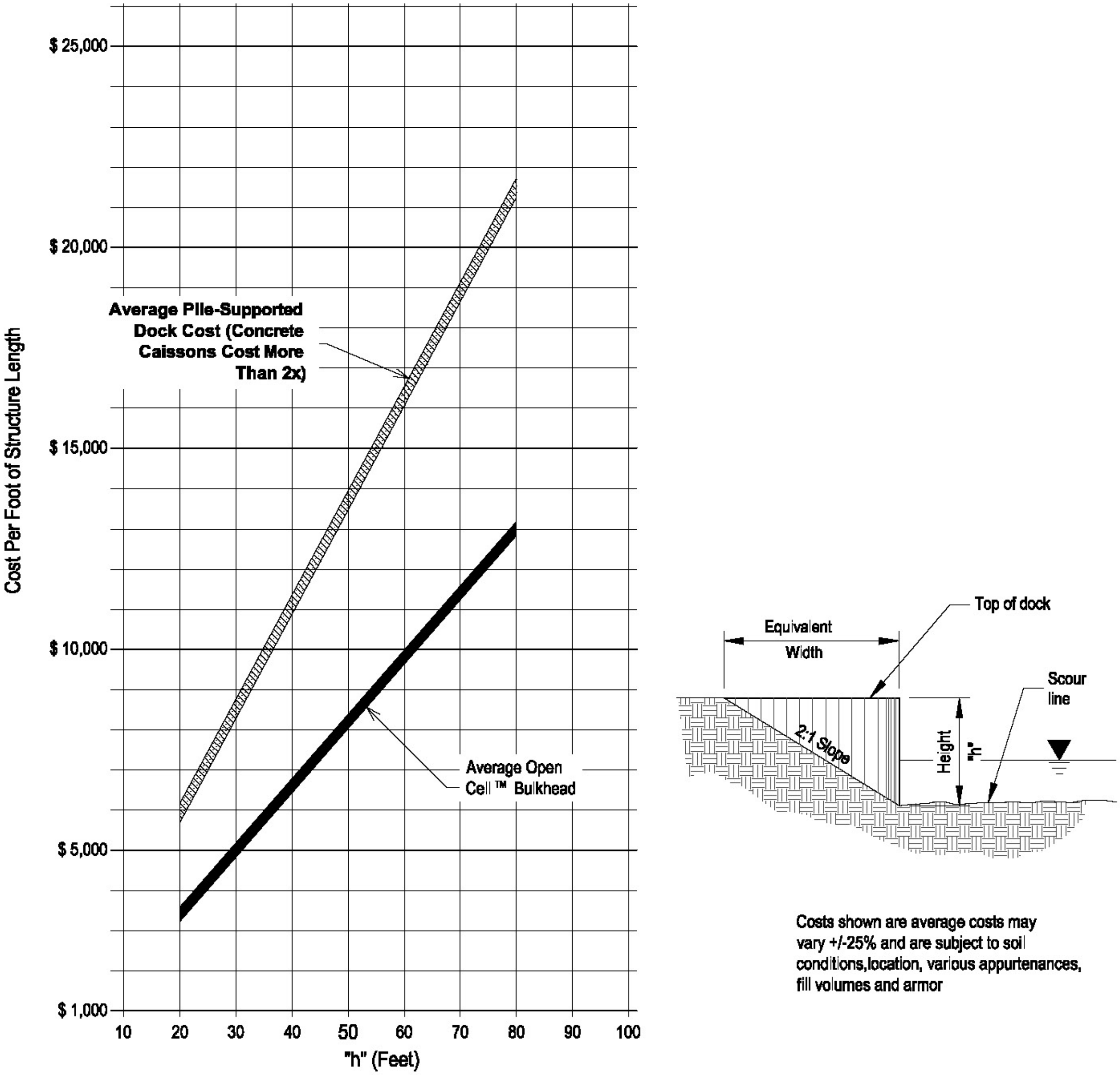
Cost Comparison of Open Cell Docks



Costs shown are average costs may vary +/-25% and are subject to soil conditions,location, various appurtenances, fill volumes and armor

Figure 12. Cost Comparison of Heavy Duty Docks