REMR TECHNICAL NOTE CO-RR-1.2

FRACTURING OF RUBBLE STONE BY EXPLOSIVE CHARGES

PURPOSE: To describe a unique method of reducing voids in some coastal structures through the use of explosive demolition agents.

BACKGROUND: An explosive is defined as any substance or device that can be made to produce a volume of rapidly expanding gas in an extremely brief period. Types of high explosives include dynamites, gelatins, and blasting agents.

When explosives are used for sand sealing, an extremely permeable core made of large core stone is subjected to impact blasts from an explosive charge. The blast fragments the inner core stone, causing settling and thus reducing the structure's permeability.

Blast damage (rock fragmentation) results from the impacting blast wave. The damage potential depends on structure composition and the explosive's parameters. The project engineer should be able to correlate peak blast pressure developed (shock) and corresponding charge weight required for adequate results.

CONSIDERATIONS: Some explosives may be identified by weight strength, cartridge strength, or product name. Detonation pressure, a function of density and detonation velocity, is a better indicator of an explosive's ability to perform work.

The velocity of detonation (VOD) is the speed in which a one-dimensional detonation wave or shock front travels through a column of explosives in a borehole or other confined space. It is dependent on factors such as density of the explosive, ingredients in the explosive, particle size of the ingredients, charge diameter, and degree of confinement. The confined detonation velocity of commercial explosives varies from 5,000 to 25,000 ft/sec. Some manufacturers test under unconfined conditions. In that case, the unconfined value is approximately 75 percent of the confined VOD. It is important to know the conditions under which the manufacturer makes his velocity measurements.

Density can be expressed in terms of specific gravity or cartridge count. Cartridge count equals 140 divided by the specific gravity. For some explosives, the density is often specified as the pounds of explosive per foot of charge length in a given borehole. The density of an explosive is important when working in water, because if the specific gravity of the charge is less than I or the cartridge count is greater than 140, the explosive will not sink.

Detonation pressure is a measure of the pressure in the detonation wave front. It is a function of the VOD and the density of the explosive. Therefore, it

is a very important property to consider. Detonation pressure can be approximated by several methods.

Conditions that can have an effect on a blasting operation include:

a. Rock specifications.

1. Presence or extent of one or more free faces.
2. Tenacity or cohesive strength.
3. Structure.
4. Degree of fragmentation required.

b. Explosive specifications.

1. Type, strength, and nature.
2. Method of initiation.
3. Type of detonation.

(a) Instantaneous or sequential.
(b) Regular or short delay.

c. Shothole or chamber specifications.

1. Size, type, and depth.
2. Depth to which hole is loaded.
3. Loading density and degree of confinement.

d. Method for removal of resultant debris.

Poor fragmentation will result in inadequate sealing and high secondary blasting costs. Therefore, everything possible should be done to maximize the primary blasting effort. Fragmentation can be improved through the following techniques:

a. Drilling shallower holes or better distributing the explosive charge over the length of the hole.

b. Shorter spacing between holes.

c. Shorter burden distance. (The burden is defined as the volume of rock within the zone of influence of the charge or the volume of rock to be broken by any one hole or charge.) The burden distance is the distance between the main body of a charge and the nearest free face.

d. Use of an explosive that gives less brisance (ability to shatter rock by shock or impact) and greater gas production.

e. Use of short-delay detonation.

Additional provisions are necessary when explosives are used for hydraulics applications. The following should be points of consideration:

a. Effects of shock waves transmitted through water to nearby installations must be taken into account.

b. Effects of hydrostatic pressure should be noted. Because of water pressure, burden distances must be reduced.

c. The explosive components should be able to withstand prolonged exposure to water without deteriorating or losing sensitivity.

d. Effective placement may be difficult.

METHODOLOGY OVERVIEW: Since jetties are composed of dense rock, an explosive with a high detonation velocity and density, and resulting high detonation pressure, is desirable. The contracting officer should compute the permissible pounds of explosive charge per loaded foot of hole. This may vary as the work progresses based on effects of the blasting.

A pattern for drilling shot hole groups must be developed, and each hole logged. Shot holes should be drilled vertically from the jetty crown area into the jetty core zone using a drill suitable for penetrating dense rock. The size of the hole should reflect the degree of charge confinement required. Lining the bore holes with plastic casings is recommended in hydraulic applications.

The explosive should be placed in the holes at proper depths to obtain optimum charge potential. Detonating cord downlines should have a fiber strength suitable for the work and, like the explosives, be water resistant.

The charges should be variably detonated to enhance shattering effects.

After blasting, localized settling is usually experienced, and additional stone to rebuild structure height is needed. The jetty crown may require regrading to smooth out rough surfaces, dislodge loose material, and clear away trash and shot debris.

Although the operator will want to use the lowest priced explosive that will adequately accomplish the job, the cost of explosives should not be kept down at the expense of the operation. The cost of the explosive is minor compared with the cost of drilling and mobilizing.

FUNCTIONAL EXAMPLE: The Yaquina North Jetty Rehabilitation and Test Blasting Section is taken as an example. This project is located at Yaquina Bay, Oregon (Figure 1). Rubble-mound jetties were constructed to maintain the entrance channel stability. The jetties were 305 m (1,000 ft) apart, with the north jetty 2.1 km (7,000 ft) long and the south jetty 2.6 km (8,600 ft) long. Crest elevation of the jetties was approximately 6.7 m (22.5 ft) mllw. The structures were composed mostly of sandstone, with some hard igneous rock and basalt (Figure 2). Water levels in the area ranged from 3.5 m (11.5 ft) to -0.9 m (-3.0 ft) mllw.

In 1977, helicopter surveys of the seaward end of the jetties were conducted. Several uranin dye tests were performed on the north jetty to examine the rate of water passage through the structure. Traces of dye passed through the

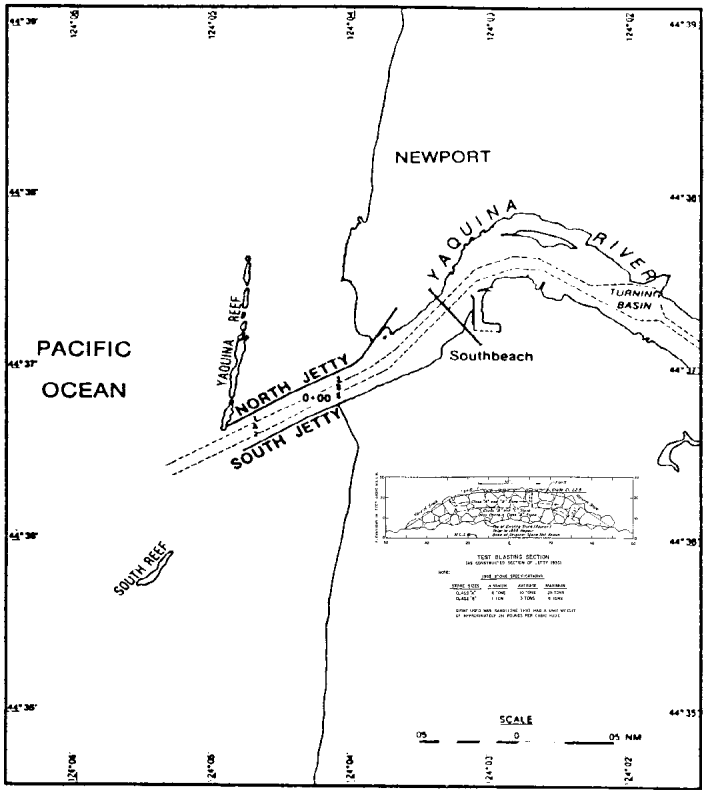

Figure 1. Location of jettied entrance to Yaquina Bay

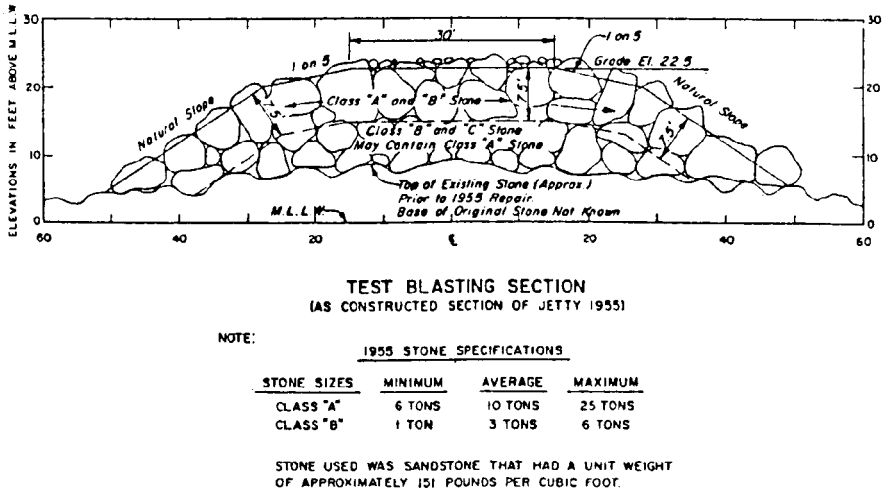

Figure 2. Cross section of north jetty

structure and could be seen in the channel within 45 sec, and high dye concentrations occurred within 3 min, indicating high water and sediment volumes passing through the structure.

It was decided to sand seal a portion of the north jetty. A 91.4-m (300-ft) test blasting section was planned to reduce the size of core stone. The sealing procedure called for 7.6-cm- (3-in.-) diam holes, up to 10.6 m (35 ft) deep, to be drilled on a 0.9-m (3-ft) grid. A total of 24 holes were drilled with 4 to each transverse line. After plastic liners were fitted into each hole, explosives having a charge of 7.3 N/m (0.50 lb/ft) and a minimum unconfined detonation velocity exceeding 10,000 ft/sec were placed in the lower portion of each hole and variably detonated to enhance shattering effects (Figure 3).

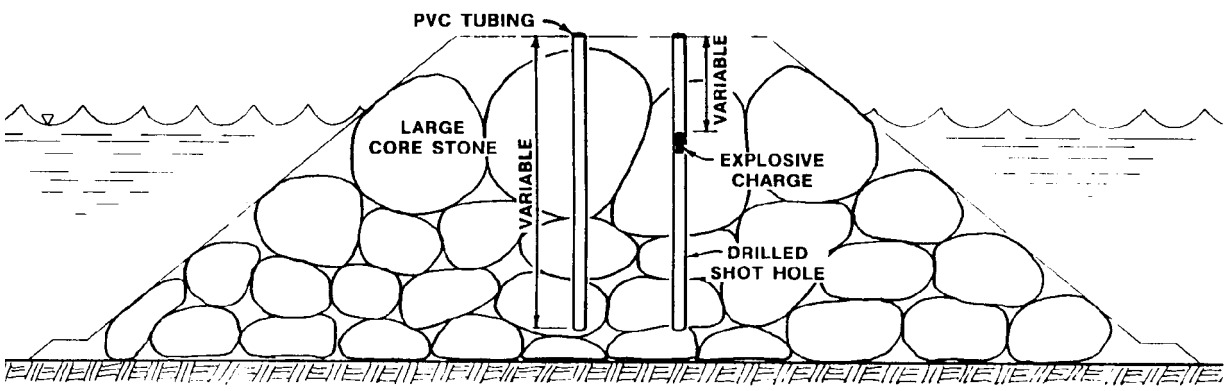

Figure 3. Explosive charge deployment

Some difficulty was experienced in placing the closed plastic tubing as deep as the hole was drilled, since sand caved into the hole with the removal of the drill steel. The tubing was generally placed to about 5 ft from the end of the hole.

After sealing efforts were completed, additional dye tests indicated the structure's core permeability had been substantially reduced, and subsequent surveys revealed an accretion of the adjacent north beach.

This method was considered a low-cost alternative requiring no major reconstruction of the existing structure. Quality control was difficult. Each additional test area was dye tested to determine sealing results before

proceeding. Some localized settlement of the structure was reported after blasting. Total cost for the project was $553,664.

SUMMARY: This method of sealing may be a viable alternative for some unique structures. It is an experimental method, and quality assurance control may be difficult. The following measures should also be considered:

a. Blasting should be restricted to the low tide period during daylight hours so that shot holes can be loaded and fired safely.

b. Blasting should not be permitted when visibility is less than 1,000 ft.

c. For quality control and reference purposes, a blasting report and drilling and loading notebook should be maintained and should contain complete entries after each group of holes is blasted.

d. Appropriate safety concerns should be addressed, such as vibration control, airblast monitoring, and lightning detection.

e. Seismographs and other instrumentation should be used to measure shock waves and underwater dynamic pressure response to the blasting.

f. Coordination with agencies such as the Environmental Protection Agency, Fish and Wildlife Service, and US Coast Guard should be emphasized.

Deployment personnel should be competent in the use of explosives. Recommended safety practices for transporting, storing, loading, and firing explosives can be obtained from the Institute of Makers of Explosives (IME) or an explosives manufacturer.

REFERENCES:

a. Trans Tech Publications. 1973. “Explosives for North American Engineers,” Clausthal, Germany.

b. US Department of the Interior, Bureau of Mines. 1968. “Factors in Selecting and Applying Commercial Explosives and Blasting Agents,” Information Circular 8405, Washington, DC.