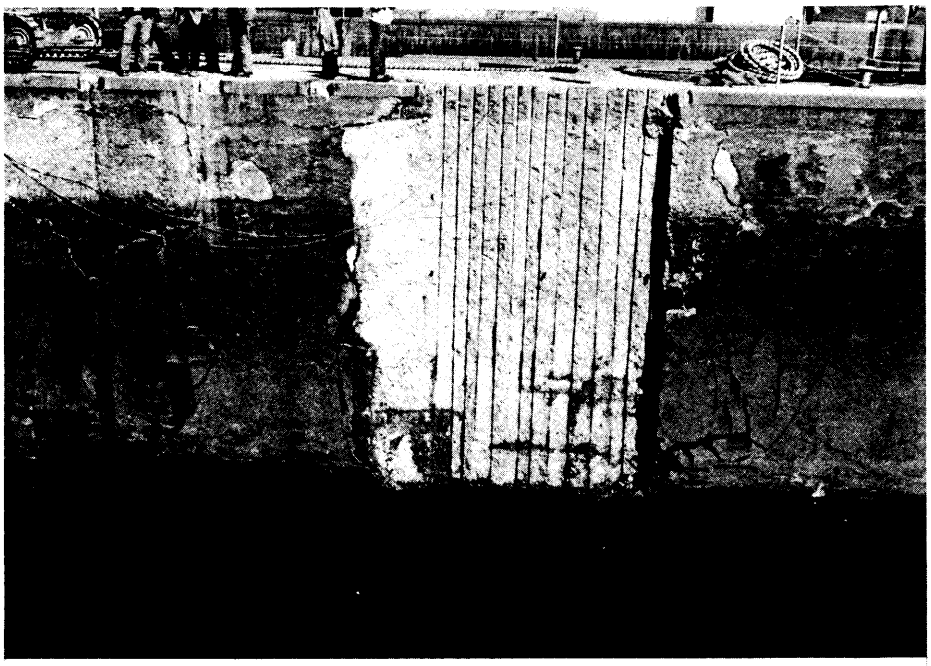
REMR TECHNICAL NOTE CS-MR-1.2

CONCRETE REMOVAL TECHNIQUE: EXPLOSIVE BLASTING



Explosive blasting as depicted above was used at Emsworth Lock in the Pittsburgh District to remove deteriorated concrete

PURPOSE: To describe use of explosive blasting as a technique for concrete removal.

APPLICATION: Explosive blasting has successfully been used numerous times at Corps of Engineers' projects for removal of large volumes of distressed and deteriorated concrete. The blast removal work generally involves drilling of a single row of boreholes along the removal line, loading each hole with light charges of explosives (usually detonating cord) along the length of the hole, and detonating the explosive with electric blasting cap(s).

ADVANTAGES: Explosive blasting is the most cost-effective and expedient means of removing large volumes of distressed and deteriorated concrete from Corps locks and dams. Explosive blasting produces good fragmentation of concrete debris for ease in handling for disposal.

LIMITATIONS: Stringent safety regulations are imposed by local, state, and federal agencies due to the inherent dangers in handling and using explosives. The blast effects experienced by surrounding property are limited to maximum peak particle velocity of 2 in./sec and airblast pressure of 0.1 psi.

Monitoring for ground vibrations due to blasting is required when it is estimated that damage may occur or when scaled distance is less than 50 $ft/lb^{1/2}$. Scale distance is defined in Engineer Manual 385-1-1 (Ref a) as:

$$S = \frac{D}{\sqrt{W}}$$

where

S = scaled distance, $ft/lb^{1/2}$
D = distance between blast and structure, ft
W = maximum mass of explosives per delay, lb

Monitoring for ground vibrations can be performed with a three-component seismograph and should be accomplished, along with recording and interpreting of ground vibrations, by qualified personnel. These and other safety criteria are set forth in EM 385-1-1.

PERSONNEL REQUIREMENTS: Highly skilled personnel of proven ability and experience should be selected to perform and execute the blast design.

EQUIPMENT: The following equipment and tools are required:

a. Drill rig capable of drilling holes (usually 1-1/2 to 2 in. in diameter) to the required depth without significant loss of alignment along the depth of the hole.

b. Electrical firing system for detonating explosive.

c. Tools and equipment for removal of fragmented and weak concrete from freshly blasted surfaces.

d. Equipment for handling and disposing of debris.

STEP-BY-STEP PROCEDURE:

a. Locate and drill a single row of boreholes along the removal line according to blast design.

b. Load each hole with detonating cord to the strength specified by the blast design.

c. Electrically detonate explosive.

d. Remove debris.

(NOTE: Selection of the proper charge weight and borehole diameter and spacing for successful concrete removal depends on the location of the structure, acceptable degree of vibration and damage, and quantity and quality of concrete to be removed. Therefore, whenever possible, a pilot test program should be conducted to determine optimum parameters.)

ENVIRONMENTAL CONSIDERATIONS: Precautions should be taken to protect wildlife habitat from damage by debris during blasting and to ensure proper disposal of the material. Blasting should be avoided during a salmon migration or during nesting seasons of endangered species if there is a chance that blasting might prevent the species from reproducing. Underwater detonation should also be avoided to prevent fish kills. Fractured concrete, larger than gravel size, can be used for aquatic habitat enhancement (e.g., artificial reef construction) by increasing the diversity of underwater surfaces. The State Fish Commission or the Corps Resource Manager at the project site should be consulted if the debris is used in this manner.

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BACKGROUND: At Corps projects, all explosive detonations are initiated using electric blasting caps. Recently, a new type of blasting cap called a Magnadet (Ref b) has been developed that is reported to be safer than the conventional electric blasting cap. It is designed to detonate only when the current frequency is greater than 15 kHz. This would reduce the chance of premature detonation due to standard electric current (110 and 220 v), lightning, static electricity, or currents generated by radio transmissions to almost zero.

Controlled blasting techniques for explosives have been developed to minimize damage to the material that remains after blasting. One such technique, known as cushion blasting (Ref c), involves drilling 3-in.-diameter or smaller holes, loading each hole with light charges distributed along its depth, and cushioning the charges by completely stemming each hole. Distributing and cushioning of the light charges produce a relatively sound surface with very little overbreak. Another technique, called smooth blasting (Ref c), is the same as cushion blasting except that the cushion is not included. Also used for controlled blasting are electrical blasting-cap delay series that employ proper timing sequences to provide greater control in reducing ground vibration, noise,

and fly rock. Note that the delay caps of different manufacturers should not be mixed in the same series. An incompatibility may exist between systems that could cause misfires and result in serious injury.

Recently, controlled blasting has been used successfully at Corps projects to remove distressed and deteriorated concrete. For one such project, Emsworth Lock in the Pittsburgh District, a pilot test program was implemented to evaluate removal techniques for future work on the lock. For the explosive blasting portion of this program, boreholes were located 1 ft behind the lock face and vertically drilled to a depth of approximately 26 ft. The removal area was divided into sections and the hole spacing varied among sections. Satisfactory results were obtained for both 9- and 12-in. spacings using a detonating cord strength of around 100 grains/ft in each hole.

For anyone who needs more background for monitoring and evaluating blasting projects, the Waterways Experiment Station offers a course on blasting called "Systematic Drilling and Blasting." Although this course is oriented toward quarry blasting, much of the information presented can be applied toward blast removal of concrete. Another source of information regarding the use of an explosive is the manufacturer, especially when a new product is to be used.

REFERENCES: a. Safety and health requirements manual. US Army Corps of Engineers, Washington, DC, 1981. Engineer Manual 385-1-1.

b. Defusing the risk with explosives. In: New Civil Engineer, Jan 1981, p 28.

c. Blasters' handbook. E. I. Du Pont de Nemours and Company, Inc., 175th Anniversary Edition, Wilmington, DE, 1977.