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Experiment

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If the Primer Is Orange, It Is Probably Red Lead!

by

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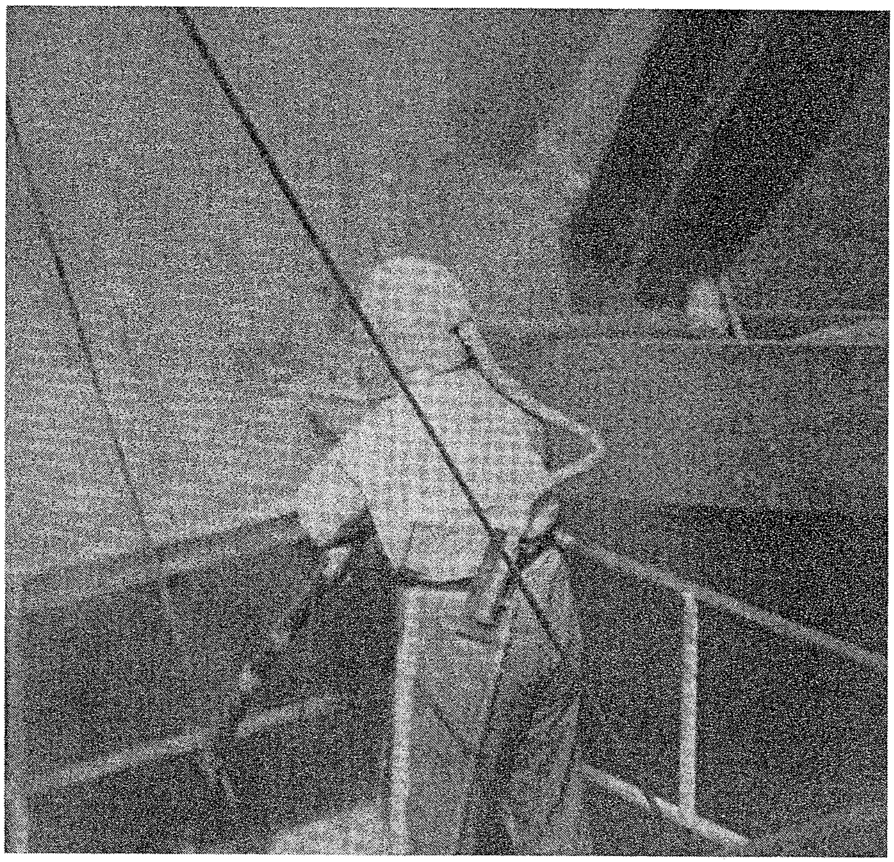
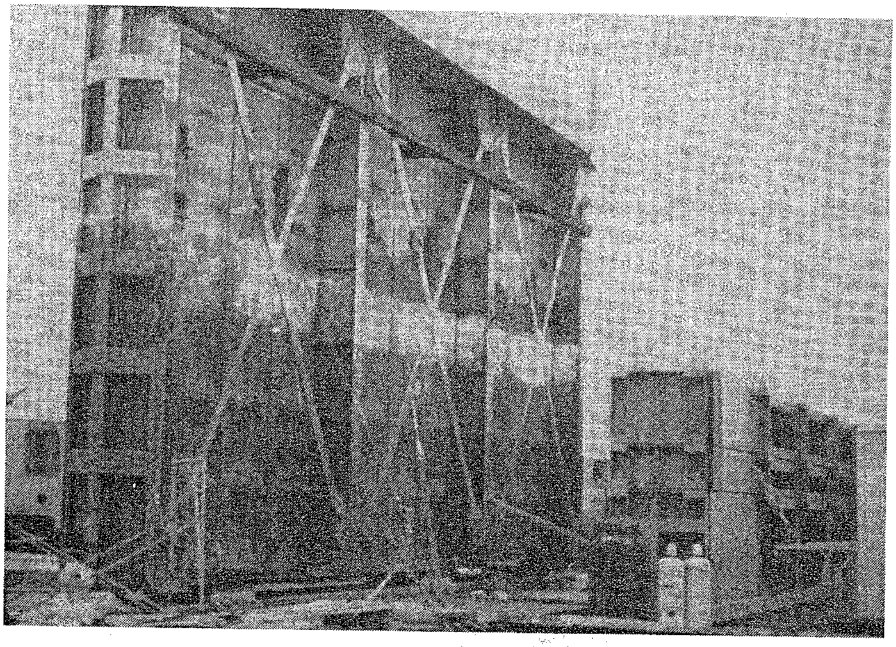


Blaster removing red lead vinyl paint system from tainter gate.

The toxicity of lead has been well-known perhaps as long as lead has been used as a pigment and must be considered whenever lead-based paints are used. Regulations have been enacted to address various aspects of the use of lead-based paints. It is important to understand what these regulations do, and do not, address.

Lead enters the human body primarily through the mouth and lungs. Once inside the body, it is absorbed into the blood stream and carried throughout the body. In the short term, high concentrations of lead can reduce the ability of the blood to carry oxygen, thus causing anemia. In the long term, repeated exposures – even to low concentrations – can result in a buildup of lead in the vital organs. Lead toxicity can cause permanent damage, especially to the kidneys, reproductive organs, and nervous system, and it may even cause death. Perhaps because these hazards are so widely known, painters routinely take appropriate precautions to reduce the potential for overexposure.

For more than 100 years, lead has been used as an inhibitive pigment in paints. The use of lead for this purpose has offered two important advantages: effectiveness and cost. Lead-based paint has been applied to some Corps of Engineers structures and has provided excellent corrosion protection for both atmospheric and immersed steel. The Steel Structures Painting Council (SSPC) estimates that 38 percent of all steel in US industrial facilities is coated with lead-based paint.



Miter gate set onto barge in preparation for repainting.

In the 1970s, the Federal Lead Based Paint Poisoning Prevention Act was passed. This regulation restricts lead content to less than 0.06 percent in paints to be used on family housing, children's toys, and other surfaces where it might pose a hazard to children. This regulation, which is binding on the manufacturers of such coatings, does not directly impact the industrial painting normally conducted by the Corps on hydraulic structures. Industry can still manufacture and use lead-based paints for such purposes.

A minor indirect impact of the regulation is that some manufacturers avoid using any lead pigments in their plants for fear that they might contaminate batches of trade sales paints. Manufacturing plants dedicated solely to the production of industrial coatings are not affected. At the present, there are no Federal regulations that fully prohibit the application of coatings containing lead. However, Occupational Safety and Health Administration (OSHA) regulations do limit the exposure of workers to airborne concentrations of lead. These regulations suggest industrial practices to reduce the amount of lead released into the air. If such practices do not eliminate the problem, workers must be suitably protected through the use of respirators. These regulations have little impact on Corps painting activities since respirators are already required for the application of all solvent-borne coatings. Some regulations (state, installation, painters' union, etc.) may govern local sites, but have no widespread impact.

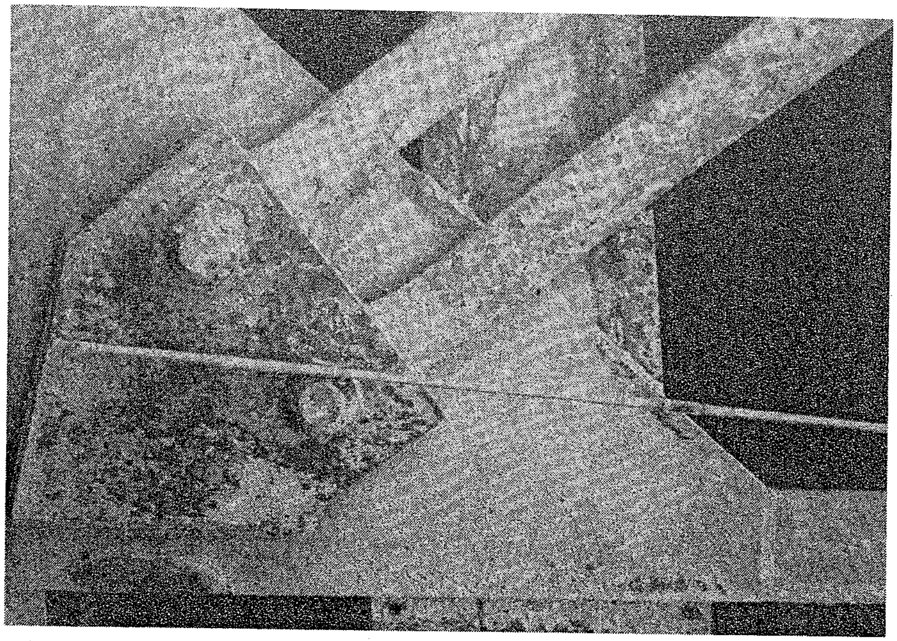
The only regulation requiring abatement or removal of existing lead-based coatings was developed by the US Department of Housing and Urban Development (HUD). This regulation is binding only on HUD-financed and Native American housing, so it has no impact on Corps projects.

Regulations such as the Clean Water Act and the Safe Drinking Water Act regulate the concentration of lead dissolved in water. Lead pigment in paint is relatively insoluble in normal water. Since Corps painting projects are generally associated with large volumes of water, the amount of lead pollution has never approached the levels of these regulations.

One regulation has had a monumental effect on the maintenance painting industry over the past several years: the Resource Conservation and Recovery Act (RCRA). The RCRA addresses hazardous wastes. It requires that waste materials, such as the spent abrasives used in abrasive blasting, be subjected to an acid extraction test. If the test reveals a lead level in excess of five parts per million, the waste is considered hazardous and accordingly must meet strict handling and disposal requirements. Although the full force of this regulation has been in effect for only one painting season, some generalizations can be made:

- If the paint system being removed by abrasive blasting used a red lead primer, it will probably fail the extraction test and thus must be considered to be hazardous.
- When a hazardous material is being removed, the resulting debris must be properly contained, stored, transported, and treated to make it nonhazardous.
- A major problem related to containing the debris is the need to meet the OSHA requirement for protecting workers from toxic dust.

The "newness" of this RCRA regulation has created numerous problems for the painting industry. Contract writers do not have adequate guidance to clearly specify the level of effort desired to protect the interests of the owner. Similarly, contractors do not have the background knowledge necessary to properly comply with the regulation. It is not uncommon to receive



Close-up of corrosion on miter gate. Repainting will probably be done by contractor.

bids varying by a factor of 10 or more for a painting contract that includes the removal of an existing lead-based paint. An evaluation of such bids usually finds that the low bidders do not understand the regulation and the high bidders are unequipped or afraid to take a lead removal contract. Bids from knowledgeable contractors are often found to be about three times higher than they would be for a similar job not involving the removal of lead-based paint.

The US Army Construction Engineering Research Laboratory (USACERL) Paint Technology Center has recently begun research on a REMR Research Program work unit to address the lead paint problem. Over the next several years, the program will develop field guidance for both the maintenance and removal of lead-based paint systems. Districts planning such work before the publication of this guidance should consider the following points:

- Although current regulations do not forbid the continued use of lead-based paints, it does not seem prudent to continue to apply major quantities. As stated in the current Painting Guide Specification CW-09940, "(lead-based paint) shall only be used for maintenance of areas previously painted with (lead-based paint)." The next revision of this specification will probably prohibit even this limited use.
- Since regulations do not require the removal of existing lead-based coatings, maintenance-in-place of reasonably sound coatings would appear to be a cost-effective practice.

When a contract is being written for the removal of an existing coating, the Corps is responsible for informing the contractor if lead is present. Historically, lead primers for atmospheric steel commonly used by the Corps included TT-P-86 (all types) and TT-P-615 (all types). Corps formula P-6 (also called CE-512) has been used for both atmospheric and immersed steel. The lead-based vinyl paints known as V-101 and MIL-P-15929 were specified for immersion service during the early and middle 1950s. If records do not exist, the coating to be removed should be tested. An initial determination might be conducted with a pocket knife. If the primer on the steel is orange, one can virtually be assured that it contains red lead. Unfortunately, some lead-based primers such as P-6 and TT-P-86 Type II also contain a dark red iron oxide pigment that hides the characteristic orange of the red lead. Only laboratory testing can conclusively identify the presence or absence of lead in these coatings.

The USACERL Paint Technology Center has purchased copies of the SSPC publication *Industrial Lead Paint Removal Handbook*. This reference contains basic information on lead paint removal, contract specification guidance, and excerpts from applicable Code of Federal Regulations. Districts currently preparing contracts that include the removal of lead-based coatings may obtain a copy of the handbook by writing to the Commander, US Army Construction Engineering Research Center, P.O. Box 9005, ATTN: CECER-FM/Mr. Alfred D. Beitelman, Champaign, IL 61826-9005, or by calling (217) 373-7237, or FTS (217) 958-7237.

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Chemical Grouting of a Concrete Dam

by

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Chemical grouting has been used to seal leakage, arrest deterioration, and improve stability in aging concrete dams. It is a viable alternative to removing and replacing deteriorated sections of concrete. Chemical grouting requires less equipment and time than does concrete removal and replacement and, therefore, can provide a less costly repair.

Background

Soda Dam, owned and operated by Pacific Power-Utah Power, is located in Soda Springs, Idaho, on the Bear River. The dam, which was constructed in 1925, is founded on basalt bedrock. It consists of a nonoverflow gravity section, an integral intake powerhouse section, a gated-spillway section, and a short earth-embankment section. The nonoverflow gravity section of the dam is 210 ft long and 72 ft high (Figure 1). This section of the dam was constructed in monoliths 65 to 80 ft wide and in lifts 5 to 6.5 ft thick. Minor leakage along lift joints has occurred during the life of the project.

Concrete deterioration occurred on the downstream face of the dam during the first 25 years after construction. In an attempt to arrest the deterioration, a thin shotcrete layer was placed on the downstream face in the 1950s. Initially, this layer may have served to protect the surface from further deterioration, but ultimately, it probably contributed to increasing the rate of deterioration. Minor leakage resulted in water being trapped behind the shotcrete. During inspections in 1990, the existing shotcrete layer was found to be delaminating from the underlying surface. This discovery prompted an investigation program to determine the extent of deterioration.

Inspection

A backhoe and jackhammers were used to remove much of the shotcrete layer covering the downstream face to permit inspection of the surface of the structure. Six core holes were drilled 4.5 to 11.5 ft deep on the downstream face of the structure, and two vertical core holes were drilled through the entire height of the structure into the foundation. Samples were retrieved for compressive testing and petrographic analyses. The visual inspection and drilling and testing revealed the following:

- Advanced deterioration existed in the outer 1 to 2 ft of the downstream face and in the upper 10 ft of the structure.

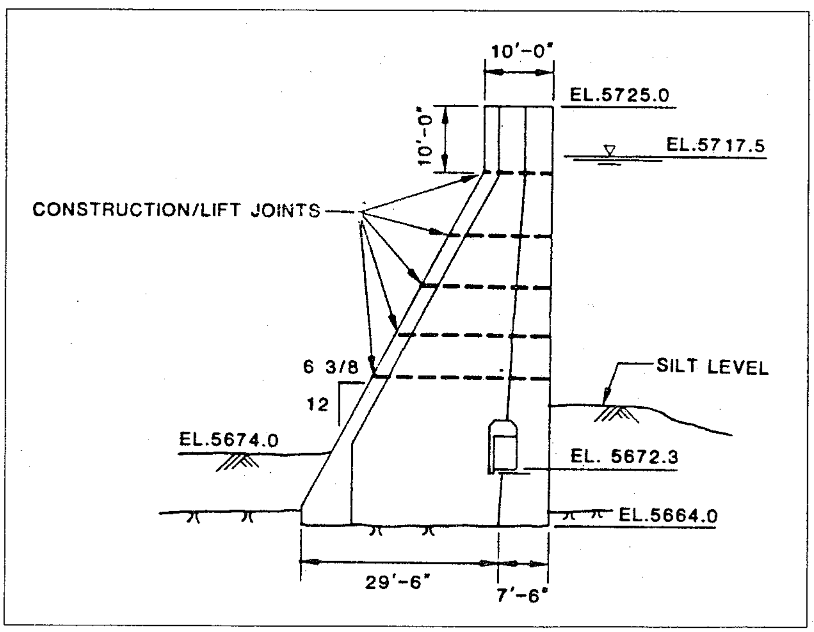

Figure 1. Nonoverflow gravity dam section, Soda Dam, Idaho.

- The surface concrete on the downstream face contained extensive microcracking with soft, carbonatelike fillings (calcium-alkali-silica gel), indicative of alkali-aggregate reactivity.
- Compressive strengths in the downstream face and upper 10 ft were 1,500 to 3,000 psi versus 3,000 to 4,000 psi within the body of the structure.
- Reactive aggregates were identified as part of the concrete especially (rhyolites and other silica-rich aggregates).
- Cracking was attributed to swelling of the calcium-alkali-silica gel by-product of the alkali-aggregate reaction and subsequent cycles of freezing and thawing.

The nonoverflow gravity section was determined to be stable, structurally sound, and strong enough to resist overturning or sliding in its present condition for the normal operating loading condition. However, over time continued seepage of water through cracks and joints could jeopardize this condition by weakening the structure along horizontal construction joints (Figure 2). Once a large enough area was weakened, a sliding failure or increased leakage could result. A decision was made to eliminate the leakage through the structure. Remedial techniques considered included: removing and replacing concrete over the upstream face of the dam, covering the upstream face with a two-component membrane (PVC and geotextile lining), and chemical grouting of construction joints.

Estimated costs for rehabilitation methods are as follows:

Removing and replacing upstream face of structure.	$472,000
Covering upstream face of structure with a lining.	605,000
Chemical grouting	156,000 to 277,000

The actual cost for chemical grouting would be dependent upon the difficulty of localizing and isolating seepage zones. Chemical grouting of joints and cracks was chosen as the most economical and best technical alternative.

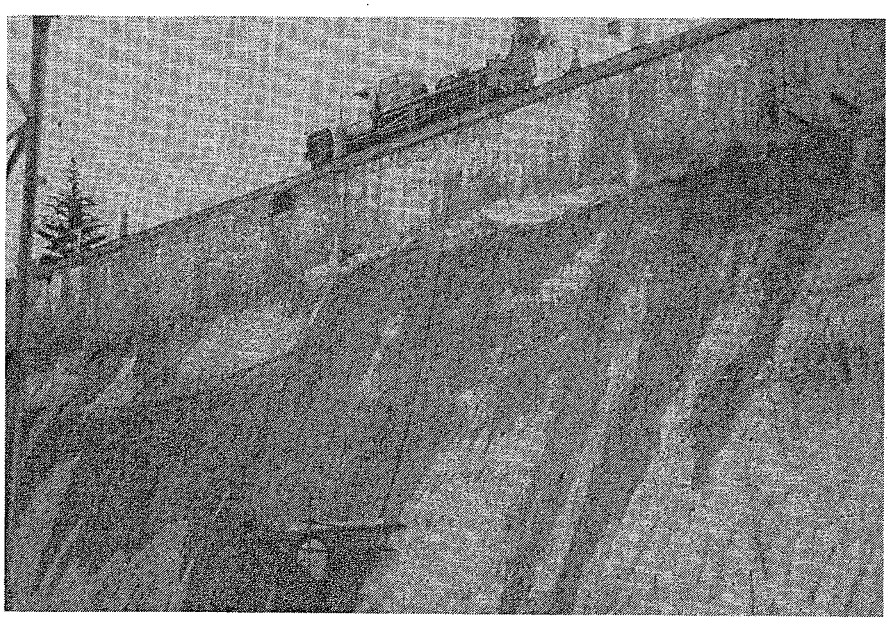

Figure 2. Seepage on downstream face of gravity section.

Repair

A hydrophilic, polyurethane foam chemical grout was chosen for injection into the joints and cracks. This grout is water reactive and expands 10 to 15 times its original volume. The final product is a flexible foam grout that has low permeability and adheres to concrete surfaces.

Initially, a conventional grout injection program was tested on Monolith No. 1. A row of vertical holes was drilled from the top of the structure parallel to the upstream face of the dam and intersecting the joints 2.5 ft from the upstream face of the structure. Grout was injected using a split-spacing technique and low pressures (15 to 80 psi). Due to the low permeability of the joints and the use of low injection pressures, this method was largely ineffective in providing grout penetration. Therefore, an alternate method of grouting the leaking joints from the upstream face was chosen. Grouting pressures were increased to a maximum of 2,000 psi and generally averaged 700 to 1,200 psi. The alternate method was made possible by the lowering of the reservoir to El. 5,680 (45 ft below crest level) to permit replacement of spillway piers. Construction monolith joints and cracks were identified and mapped on the upstream face of the structure, and 800 lin ft of cracks was defined as requiring treatment.

A short testing program revealed that a hole spacing of 1.5 ft would assure maximum grout penetration between holes. Holes 5/8-in. in diam were drilled to intersect the joint/crack a minimum of 10 in. behind the upstream face. Grout injectors, 6-in.-long mechanical packers, were installed into each hole. Water was preinjected for a period of 5 min to test the tightness of the crack, to ensure that the

Figure 3. Chemical grouting of upstream face.

polyurethane grout would be activated, and to maximize grout penetration.

A total of 290 gal of polyurethane grout was injected into 450 holes for the treatment of 630 lin ft of monolith and lift joints (Figure 3). Grout acceptance varied from 0 to 5.0 gal per hole, with only 1 percent of the holes found to be tight. The overall average grout acceptance per linear foot of joint/crack treated was 0.65 gal per lin ft, with higher acceptance in the upper 10-ft section of the dam (area of normal pool elevation fluctuation), which had more deterioration and microcracks. In this zone, maximum grout penetration along microcracks to a distance of 6 ft was realized.

Performance

The downstream face of the dam was not rehabilitated but was left as it was found after removal of the shotcrete. Since the completion of the chemical grouting program in late 1990, seepage through the concrete dam has been essentially eliminated with no measurable leakage encountered. Additional chemical grouting may be performed if further leakage is encountered. If there is no further leakage, no protection of the downstream surface is anticipated to arrest further damage from cycles of freezing and thawing.

The actual cost to complete the chemical grouting program was $196,000, which was within the original estimated range of costs.

Acknowledgment

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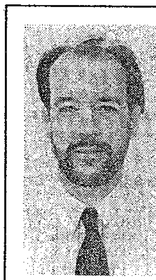

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The Nation's Aging Coastal Infrastructure

by

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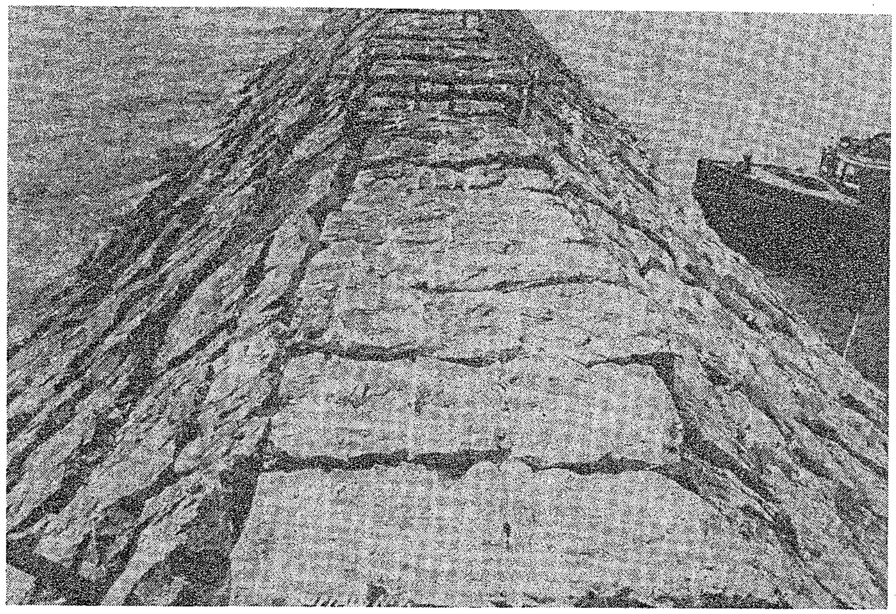

Buffalo, New York, breakwater. The first rubble-mound breakwater constructed on the Great Lakes (1897-1902). Note the laid-up stone armor over the rubble mound.

Because many of the nation's coastal facilities are aged and their condition is not stagnant, the potential for future failures is significant. Of the 265 coastal navigation projects constructed in the United States, 56 percent are over 50 years old. In fact, 30 percent of the US jetty and breakwater projects originated in the 1800's (Table 1). The majority of these coastal structures have existed beyond a reasonable economic life, even though they reside in the most dynamic and challenging of environments, the coastal zone. Understanding the aging process and its effects on these coastal structures will be increasingly important as more of them approach and exceed their design life.

Mechanisms of aging

Typical aging of these structures may be in the form of gradual deterioration. This type of aging is not always readily detected, and because the structure is still functioning, repair is often postponed. Catastrophic failure is often the result of the exceedance of the design condition and may be thought of as "damage" rather than aging. However, continuous, unchecked deterioration may progress to a critical threshold level, triggering catastrophic failure. Although repair of deterioration is usually of lower priority, it is also usually much less expensive than replacement or reconstruction required after catastrophic failure. In some cases, structure abandonment may be the only solution after catastrophic failure.

The aging of coastal structures may be evidenced by gradual degrading of the material or movement and erosion of the structures' components. These damages can

Table 1. Summary of Federal Coastal Navigation Projects

US Army Corps of Engineer Division	States in Database	Total Projects	Pre-1900 Construction		Pre-1940 Construction		Technical Report
			No.	%	No.	%	
New England	ME, NH, MA, RI, CN, VT	52	31	60	37	71	REMR-CO-3, Rpt. 7
North Atlantic	NY, NJ, PA, DE, MD, VA	58	13	22	40	69	REMR-CO-3, Rpt. 5
South Atlantic	NC, SC, GA, FL, AL, MS	32	4	12	14	44	REMR-CO-3, Rpt. 2
Lower Mississippi Valley	LA	10	2	20	3	30	REMR-CO-3, Rpt. 8
Southwestern	TX	12	4	33	6	50	REMR-CO-3, Rpt. 9
South Pacific	CA	28	3	11	11	39	REMR-CO-3, Rpt. 1
North Pacific	OR, WA, AK	49	5	10	17	35	REMR-CO-3, Rpt. 6
Pacific Ocean	HI	14	0	0	4	29	REMR-CO-3, Rpt. 4
North Central	NY, PA, OH, MI, IL, IN, WS, MN	107	45	42	71	66	REMR-CO-3, Rpt. 3
Total		362	107	30	203	56	

occur as a natural deterioration or as the result of changed conditions (i.e., the occurrence of a significant event). They may even be due to design deficiencies during original construction, especially for some of the older designs for which there was little technical guidance.

Projections of a rising sea level and increased storm frequency draw attention to the need to re-evaluate the risk to the coastal structures and their ability to function. Such global climate changes may accelerate the aging process of coastal structures. Existing flood control projects, such as seawalls, surge barrier gates, beach and dune complexes, levees or dikes, and the routing of storm surge flooding, will be less effective. Many of the "hard" (revetments, seawalls, groins, breakwaters, and jetties) and "soft" (beach fill) erosion control devices may have reduced effectiveness and higher maintenance requirements. The level of protection afforded by harbor structures will also be decreased as overtopping rates and transmitted wave energies increase. Toe scour and higher inshore waves can damage structures designed for shallow-water conditions.

Structure versus unit aging

The aging process may affect the structure as a whole and its ability to function or individual units and their ability to service the structural system. Structure aging is frequently the result of a loss of foundation or slope support, diminishment of internal integrity, or damage to individual units that compromises their stability within the structure. It may be the result of selective loss of some units, for example the displacement of the cap or erosion of the core or berm sections. The primary factors contributing to unit aging are static and dynamic loadings on concrete armor units and the mechanics of armor stone breakage. All types of structural elements can be adversely affected by foundation settling, scour, or dynamic loading.

Effects of aging

Monolithic concrete and concrete-faced structures may age by cracking and spalling, whereas concrete armor units may fail because of more dynamic loadings and the buildup of static stresses. Timber cribs and pile structures age as the unit settles, seams open, and core or backfill material is lost (Figure 1). Timber units often deteriorate at the waterline because of marine borings, ice and vessel impact, and abrasion. Steel sheet-pile structures suffer from many of the same types of deterioration with the addition of saline- and electrolytic-induced corrosion.

Rock structures are susceptible to interior settling and loss of units. Rock unit degradation has been experienced in the cracking of Great Lakes limestones (blasting effects), the abrasion of Florida reef-rocks, the brittle exfoliation fracturing of granites of New England, and the weathering of northwestern basalts. Sedimentary sandstones and siltstones may be affected by wet/dry and freeze/thaw cycles, which cause deterioration along bedding planes or concentration along the clay or dissolution stylolites. Sandstones are highly susceptible to surface weathering that can dissolve the calcium carbonate or silicon dioxide cement matrix. They are also very prone to abrasion weathering.

The interaction of unit-to-structure aging and catastrophic failure may be best illustrated by reviewing data from three concrete-armored (dolos) breakwaters. The February 1978 failure of the Port Sines, Portugal, breakwater involved the complete loss of approximately two-thirds of the 42-ton dolos armor layer. Although expert opinions vary regarding the exact cause of failure, it was a catastrophic structural collapse with little forewarning via "aging" or gradual deterioration of individual units.

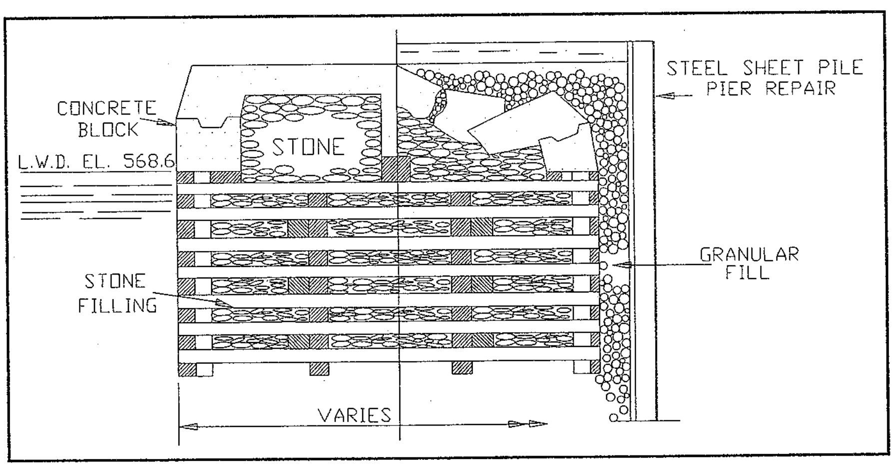

Figure 1. Section of North Pier, Erie, Pennsylvania. Original construction 1825-1900 of vertical-faced, stone-filled timber crib. Later repair included steel sheet-pile facing with granular fill.

In contrast, continuous breakage of 2-ton dolosse on the Cleveland Harbor, Ohio, East Breakwater as the result of wave-induced rocking and ice impacts is an example of unit aging (Figure 2). The reduced stability caused by this unit breakage was compounded by a significant storm and resulted in a localized failure at the head section in April 1982; this situation has caused concern about the long-term stability of other portions of the armor cover.

These two examples led to research into stress-loadings and failure modes of individual concrete armor units at Crescent City, California. This research demonstrated that unit failure may appear to be catastrophic, but may be actually due to a gradual static-load stress buildup in the unit until a threshold of failure is reached (Melby 1992). In the same way, failure of individual units may occur at an incipient level until the integrity of the layer is compromised and the appearance of catastrophic failure is realized.

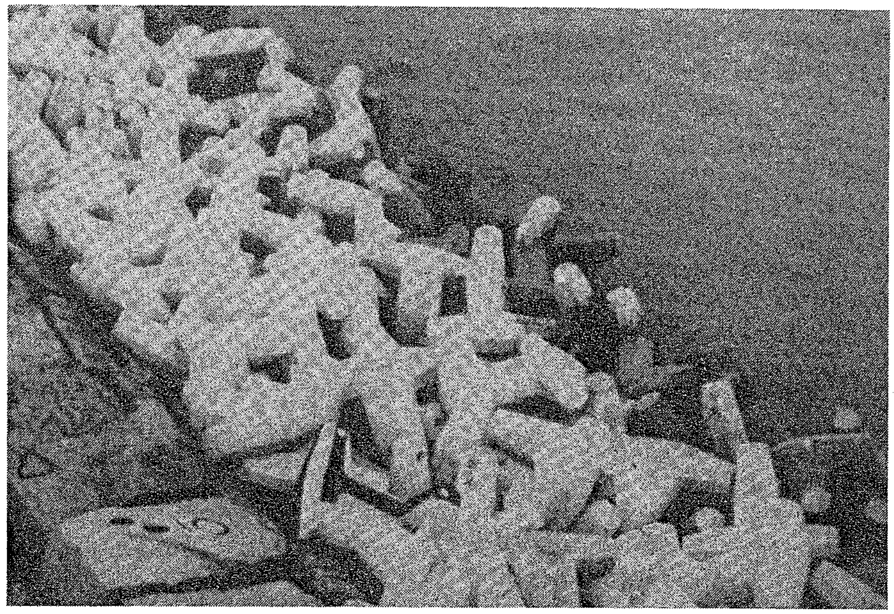

Figure 2. Use of 2-ton dolosse on the Cleveland Harbor, Ohio, East

Condition assessment

Assessing the condition of the structure involves the development and managed application of measurement and monitoring techniques. The complexity and expense associated with documenting and quantifying the condition of a structure range considerably depending on the dynamics of the location, structure condition and accessibility, the function of the structure, and the skills and knowledge of the inspector or responsible engineer.

Field inspections conducted periodically by well-trained individuals can be a valuable and inexpensive way to qualify the subaerial condition of a structure and to identify any suspected deterioration. These inspections may include symptom-targeted walking, boating, and aerial inspections. Similar evaluations of the underwater portion of the structure may be conducted through the use of divers and underwater cameras. When these observational inspections suggest the need for developing a quantitative measure of the structure's condition, some simple measurements can be incorporated into the inspection process. These could be counts of broken units, use of reference markings (i.e., spray-paint marking of cracks (Figure 3)

Figure 3. Adjacent split stones, Cleveland Harbor.

or suspected displacements), periodic surveying of controlled targets, or developing a ground-based photo record at specific stations. A more formalized measurement and monitoring program may involve structure cross-sectional surveys or photogrammetric mapping of the structure surface.

Condition index

Research is presently underway to develop a condition indexing (CI) system for Corps rubble-mound breakwaters and jetties to provide guidance for uniform inspection techniques and to develop a standardized, numerical rating system (see Technical Report REMR-OM-11). This CI system will provide the inspector with guidance in assigning a value from 0 to 100 to indicate the condition of each structural or functional element. A structure element with a rating of 100 is in excellent condition with no noticeable defects, whereas a rating of 0 is applied when the element has completely failed and is performing no function. The ratings for each element are weighted and mathematically combined to develop the CI for the entire structure. Assessment of index ratings can be used to document the evolution of individual structures, to track the rate and characteristics of deterioration, to make comparisons between structures, and to help in managing operation and maintenance programs.

Remote inspection techniques

Remote inspection techniques such as underwater cameras mounted on remote operating vehicles (ROV's) and side-scan sonar can be used to document the underwater condition of a structure. Side-scan sonar is particularly useful for locating armor or core material that has been displaced from the structure, detecting breaks in slope and irregularities in the structure toe, and discovering scour effects (Clausner and Pope 1988; see also Technical Report REMR-CO-11). The REMR program is funding the development of new technology for evaluating the underwater condition of a coastal structure, the Coastal Structure Acoustic Raster Scanner (CSARS) (see *The REMR Bulletin*, Vol. 8, No. 3). CSARS consists of a bottom-sitting, pointable acoustical transducer with driving motors and attitude sensors that send out a directed "pencil beam" sonar pulse to scan the underwater portions of a coastal structure. The resulting data are detailed hydrographic maps of the surface of the structure (Lott, Howell, and Higley 1990).

Use of internal boring and geophysical techniques, such as ground-penetrating radar for detection of voids under the structure cap (in nonsaline settings) and electromagnetics to detect steel sheet pile, may be of value in some situations, but further development is needed prior to general application.

Repair options

Once structure aging and deterioration have been realized, repair options range from minor redressing of the surface layer to complete replacement of the structure. Table 2 lists repair methods and projects where these options have been installed.

Table 2. Methods for Repairing Coastal Structures and Example Projects

Method	Example Projects
Slope and Crest Repair	
Chinking, resurfacing	Frequent practice
Addition of dissimilar armor	Crescent City, CA; Cleveland, OH
Layer reconstruction	East breakwater, Cleveland, OH
Crest raising	North jetty, Barnegat Inlet, NJ
Burial	East jetty, Panama City, FL/old breakwater, Buffalo, NY
Toe and Foundation Repair	
Toe reconstruction	East jetty, Moriches Inlet, NY
Scour apron	South jetty, Ocean City Inlet, MD
Addition of berm	West jetty, Panama City, FL
Core Repair or Void Sealing	
Precast concrete blocks	South jetty, St. Mary's Inlet, FL
Filter cloth	South jetty, Ocean City Inlet, MD
Grout	South jetty, Port Everglades, FL/north breakwater, Milwaukee, WS
Original Replacement	
	South jetty, Barnegat Inlet, NJ

The longer the aging is allowed to progress without check, the more heroic the "fix" that may be necessary. In cases where there have been breakage of individual units, loss of crest height, or side-slope failure, a typical approach is to add riprap to the structure surface (chinking or riprap resurfacing). If the existing cover has been displaced because of foundation failure or scour undermining the structure, it may be necessary to add elements (such as underwater berms or scour aprons) to the structure cross section or to excavate and reconstruct the structure toe. The crest is commonly recapped to increase structural integrity, reduce core loss, and enhance safe public access.

Filling voids within the structure may be necessary in cases where loss of the core material has occurred or where wave transmission and sediment transport through the structure threatens the structure or causes other adverse effects, such as increased channel shoaling or erosion of adjacent beaches. Reducing structure permeability may be accomplished by the addition of filter cloth, precast concrete units, or steel sheet pile. Each of these options is readily incorporated during the original construction; however, some disassembly of the cross section or the addition of a companion element is required when a modification is made to an existing structure. Void sealing by injecting grouts into the structure cross section may be an economically viable way of repairing the interior portions of the structure without requiring major reworking of the cross section (see Technical Reports REMR-CO-8, -CO -15, and -CO-16).

In cases of catastrophic failure, where the integrity of the structure has been lost or where repair can be realized only through a major redesign, it may be necessary to bury or completely replace the structure. Burial of an existing structure probably means that a larger cross section will result. Sometimes the burial is realized by the addition of a new armor cover designed to interlock with the deteriorated old layer as an underlayer. Attention needs to be given to the suitability of the original structure as a foundation for the new work (Figure 4). New construction to replace the remains of an existing structure may be the final repair recourse.

Summary

For a better understanding of how a structure ages, research is needed on the mechanics of scour, the factors that contribute to structure instability, ways of projecting the probability of events that exceed the design criteria, and better tools for evaluating wave-structure interaction. Less expensive and more practical tools for seeing inside the structure and below the waterline will help to document structure aging. Organized procedures for rating the condition of various structures and projecting future scenarios will help in prioritizing the need for repair. Early detection of structure deterioration will allow the development and application of preventative solutions before the advent of catastrophic failure.

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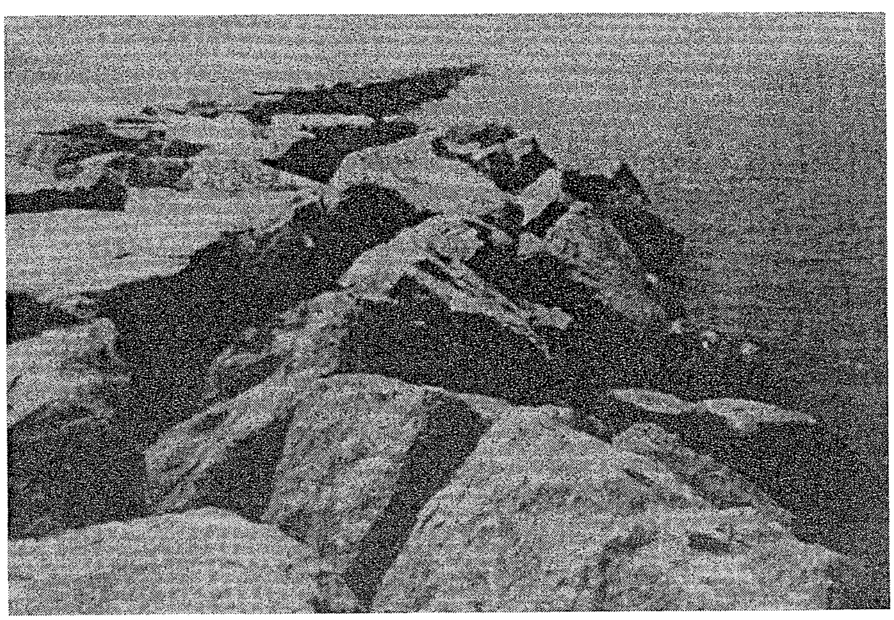

Figure 4. Example of new work, Cleveland Harbor.

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Joan Pope is Chief of the Coastal Structures and Evaluation Branch of the Engineering and Development Division, Coastal Engineering Research Center (CERC), WES. She has been with the Corps of Engineers since 1974 and has been affiliated with CERC since 1983. Her primary area of interest is functional design and performance issues associated with navigation or beach erosion control projects. Ms. Pope received her Bachelor of Science degree in Science Education from the State University of New York at Oneonta and her Master of Science degree in Geology/Oceanography from the Univesity of Rhode Island. She is a member of the American Shore and Beach Preservation Association, Society of Economic Paleontologists and Mineralogists, Coastal Education and Research Foundation, and ASCE Conference Organizing Committee, Coastal Sediments 87 amd Coastal Practices 92.

Stud Pull Electrode

One of the functions of the REMR Research Program is to identify technology that has potential for improving maintenance and repair activities. Equipment breakdowns are time-consuming and costly, and those caused by broken bolts and studs are especially frustrating. In the past, removal of these broken elements required drills, taps, or metal disintegration machinery. A new device has been developed that is reported to provide an efficient, easy-to-use, cost-effective method of extracting broken bolts and studs. This device, called the Stud Pull Electrode, can be used to remove steel studs and bolts in minutes without the use of special equipment (the manufacturer reports a 95-percent success rate). It provides a weld deposit that is resistant to cracking and tough enough to withstand strong impact. For additional information, contact Mike Ferraro, Duratrode representative, at (800) 336-0799.

In the News

Chicago service tunnel

An underwater concrete mixture developed under the REMR Research Program was used successfully to plug the Chicago service tunnel flooded by the Chicago River in April of this year. A core drilled from the plug revealed the quality of the concrete placed underwater to be excellent. POC: Billy Neeley (601) 634-3255.

Precast concrete lock wall panels

A precast concrete stay-in-place forming system developed under the REMR Research Program was recently used to rehabilitate the lock chamber at Troy Lock in the New York District. This work was monitored by several agencies including the New York State Department of Transportation (NYSDOT), which has responsibility for over 50 locks on the New York State Barge Canal System. As a result of this work, NYSDOT is currently using precast panels to rehabilitate Lock 0-6 on the Oswego Canal. POC: Jim McDonald (601) 634-3230.

Well treatment at Superfund site

The technology developed under REMR for rehabilitating relief wells (Blended Chemical High-Temperature) has been used for restoration of flow capacity of collector wells at a Superfund site in Michigan. POC: Roy Leach (601) 634-2727.

STREMR predictions for Mud River

The STREMR numerical model is being used to predict flow velocities in a 25-year flood event for the Mud River near Barboursville, WV. The results of the study will be used to confirm earlier riprap design calculations for a bend in the river near a sewage treatment facility, where sheet-pile walls are now threatened by bank steepening. This application of STREMR will help to ensure that the rehabilitation of the channel is both effective and economical. POC: Stacy Howington (601) 634-2939.

REMR-II Field Review Group Meeting

The third REMR-II Field Review Group (FRG) Meeting was held in Davenport, IA, on 19-21 May 1992, with over 80 people in attendance. Presentations were made by Rock Island District and Corps laboratory personnel. Objectives, accomplishments, products, and benefits for each REMR-II work unit were reviewed. Work units presented were as follows:

- New Concepts in Maintenance and Repair of Concrete Structures
- Evaluation of Existing Repair Materials and Methods
- Nondestructive Evaluation (NDE) Systems for Civil Works Structures
- Repair and Rehabilitation of Dams
- Stability and Remedial Measures for Existing Concrete Structures
- Evaluation and Repair of Steel Hydraulic Structures (HSS)
- Seismic Evaluation, Vulnerability, and Upgrade of Existing Structures
- Predicting Concrete Service Life
- Alternative Treatments for Rehabilitation of Relief Wells and Drains
- Effects of Vegetation on Levee Reliability
- Cost-Effective Shoreline Techniques for Reservoirs
- Levee Rehabilitation
- Assessment of Requirements for Stability Remediation
- Geomechanical Modeling for Stability of Existing Gravity Structures
- Impact of Drains on Uplift Pressures
- Determination of Rock Mass fluid Flow and Strain Effects by Acoustic Emissions Monitoring
- Reduction in Rock Erosion in Spillway Channels by Prevention of Knickpoint Migration
- Evaluation of Stone Degradation and Rock Quality Testing
- Dissemination and Improvement of STREMR Model
- Model for Evaluation and Maintenance of High Velocity Channels
- Evaluation of Training Structures Using Mini and Microcomputers
- Icing of Machinery Components at Corps Structures
- Entrance Channel Current Deflectors
- Toe Stability in a Combined Wave and Flow Environment
- Quantitative Imaging and Inspection of Underwater Portions of Coastal Structures
- Breakwater Concrete Armor Units for Repair
- Continued Monitoring of Grout Sealant Durability Specimens
- Removal of Lead Pigmented Paints from Hydraulic Structures
- Universal VOC Compliant Coating System for Locks and Dams
- Development of In Situ Vibration Signatures as a Maintenance Tool
- Paint Systems for Damp Surfaces
- Development of Uniform Evaluation Procedures/Condition Index for Civil Works Structures
- Development of Maintenance and Repair Guidelines and Management Systems
- Implementation of REMR Management Systems

The meeting concluded with a field trip to Locks and Dams 16 and 18. The Fourth REMR-II FRG Meeting will be held at the Waterways Experiment Station this fall. POC: Bill McCleese (601) 634-2512.

Changes in REMR Key Personnel

Several changes have been made in REMR-II Key Personnel. New Technical Monitors are Don Dressler (CECW-ED), who succeeds Lucian Guthrie for structural work units in the Concrete and Steel Structures area, and Wayne Swartz (CECW-EG), who replaces Lewis Gustafson in the Geotechnical-Rock area. New Field Review Group (FRG) members include John J. Sirak, Jr. (CEORD-CO-OM), who replaces Rod Plybon as the FRG Operations Member from the Ohio River Division, and Greg Baer (CESAD-EN-F), who succeeds Kenneth Griggs as the FRG Engineering Member from the South Atlantic Division.

Featured in This Issue

The REMR Bulletin is published in accordance with AR 25-30 as one of the information exchange functions of the Corps of Engineers. It is primarily intended to be a forum whereby information on repair, evaluation, maintenance, and rehabilitation work done or managed by Corps field offices can be rapidly and widely disseminated to other Corps offices, other US Government agencies, and the engineering community in general. Contribution of articles, news, reviews, notices, and other pertinent types of information are solicited from all sources and will be considered for publication so long as they are relevant to REMR activities. Special consideration will be given to reports of Corps field experience in repair and maintenance of civil works projects. In considering the application of technology described herein, the reader should note that the purpose of *The REMR Bulletin* is information exchange and not the promulgation of Corps policy; thus guidance on recommended practice in any given area should be sought through appropriate channels or in other documents. The contents of this bulletin are not to be used for advertising, or promotional purposes, nor are they to be published without proper credits. Any copyright material released to and used in *The REMR Bulletin* retains its copyright protection, and cannot be reproduced without permission of copyright holder. Citation of trade names does not constitute an official endorsement or approval of the use of such commercial products. *The REMR Bulletin* will be issued on an irregular basis as dictated by the quantity and importance of information available for dissemination. Communications are welcomed and should be made by writing US Army Engineer Waterways Experiment Station, ATTN: Lee Byrne (CEWES-SC-A), 3909 Halls Ferry Road, Vicksburg, MS 39180-6199, or calling 601-634-2587.

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