The REMR Bulletin

of Engineers
Waterways Experiment
Station

News from the Repair, Evaluation, Maintenance,
and Rehabilitation Research Program

Volume 9, Number 3

September 1992

Shoreline Erosion Control on Havel Lake in Germany

by

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A low-cost bioengineering technique for reservoir and lake shoreline erosion control has been successfully used on Havel Lake in Germany and has potential for application in the United States. By creating wetlands behind it, this technique offers the additional advantages of providing sediment entrapment, water quality improvement, aesthetic enhancement, and protection of cultural and archeological resources.

Developed and tested by Lothar Bestmann of Bestmann Ingenieurbiologie (Bioengineering) in Wedel, Germany, this technique was adapted from a method used to regain land lost to the North Sea along the north German coastline. It was further adapted for use in a demonstration study on the Havel Lake in Berlin 8 years ago. Various modifications have been used on reservoirs and lakes near Berlin, Pritzwalk, and other locations throughout Germany.

Havel Lake is a part of the Havel River that runs through Berlin. Its water level is controlled within 0.8 to 1.0 m in the vicinity of Berlin, and wind fetches vary from 2 to 5 km. Originally, the lake had a wetland fringe on most of its perimeter. This edge reduced wave energies and protected the shoreline from erosion. In time, as urbanization impacted on the wetlands, the lake began to lose shoreline. The wetlands were gradually being destroyed by such factors as waves from motorboats (work and sport); choking out by drifting garbage; trampling from people and boats, which kinks the stems of plants; depredation by waterfowl; discharge of toxins and contamination of water by oil, heavy metals, etc.; and shading by trees close to the shore.

The technique used on Havel Lake consists of a combination breakwater with planted wetlands toward the shore (Figure 1).

This method has been applied only in areas of Germany where water levels do not fluctuate more than 1 m, but its use may be acceptable in situations where greater fluctuations exist. It has application for shoreline erosion control on many US reservoirs with dense thickets of young, woody trees (e.g. willow, cottonwood, and alder)

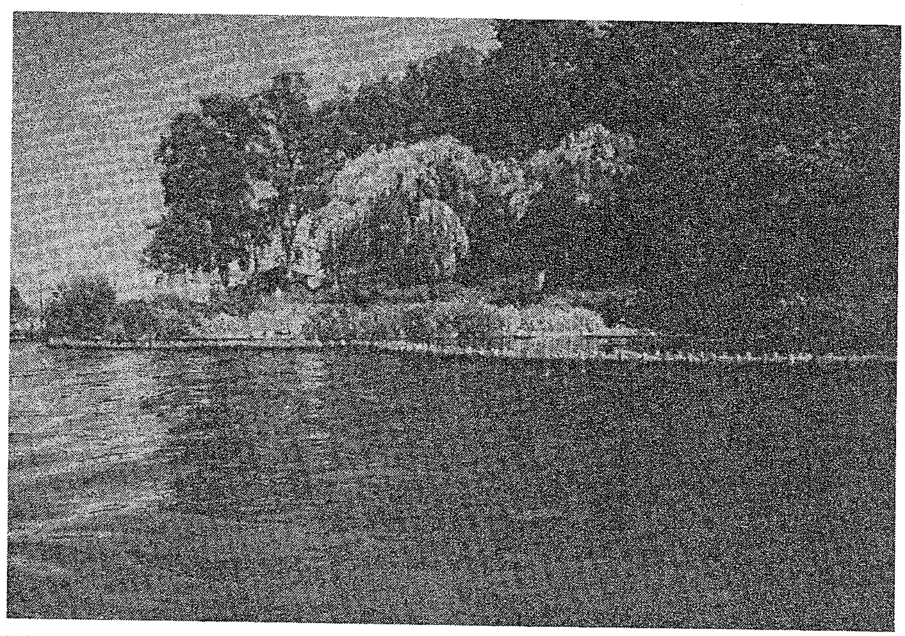


Figure 1. Combination low-cost breakwater with planted wetlands for shoreline erosion control and habitat development.

near them, since these provide the materials used in the breakwater.

There are several options for breakwater construction, and various materials such as stone or rocks, branches and poles, or fiberschines (large coconut fiber rolls (Figure 2)) can be used. The branchbox breakwater was used for Havel Lake. It consists of biodegradable materials composed of long poles and faschines, bundles of small dead branches, such as willow and poplar, collected from woodlands (Figure 3). This breakwater is usually constructed in about 1-m-deep water in the following sequence:

- Poles that are 2- to 3-m-long are positioned vertically in the lake substrate in two rows about 1 m apart. This placement is accomplished initially by a hydraulic jet pump. At this point, the poles are not inserted all the way into the substrate, but are placed deep enough to be secure (Figure 4).
- A 25-cm-thick layer of dead branches is positioned perpendicular to the rows of poles. The branches should be about 2.5 m long. These branches serve as filter material and retard scour at the bottom of the breakwater.
- Faschines are wedged between the rows of poles, and the bundles are secured to the poles by wire rope woven through screw eyes on each pole like a shoelace; each faschine is about 0.5 m in diameter and varies from 2 to 4 m in length. The screw eyes are placed on the poles a few centimetres above the faschines.
- The poles are driven down firmly with a pneumatic hammer mounted on a barge or some other mechanical device that serves the same purpose. This process tightens the whole breakwater system.
- The tops of the poles are sawed off about 30 to 60 cm above the tops of the faschines, and the breakwater is completed (Figure 5).

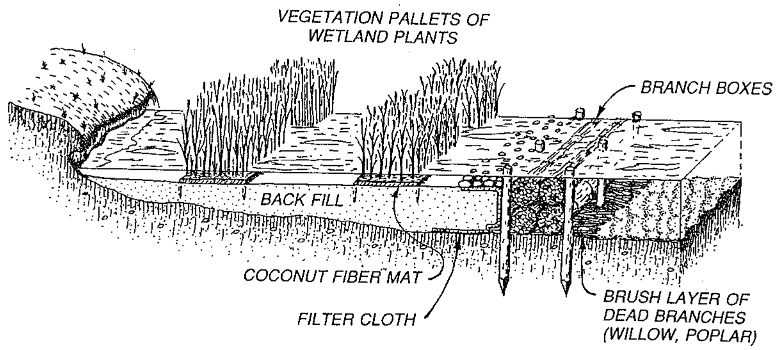


Figure 3. Branchbox breakwater with wetlands shoreward.

After breakwater construction, wetland plants pregrown in pallets and bulbs are transferred intact to the site and installed (see Figure 3). The pallets are secured to the substrate by driving long stakes into them and tying rope between the stakes. Then everything is tightened by driving the stakes farther into the substrate so that all is secure.

Wetland plants most often used in the lake around Berlin include the following:

Acorus calamus	Sweetflag
Carex gracilis	Sedge
Iris pseudacorus	Yellow flag
Phragmites australis	Common reed
Schoenoplectus lacustris	Bulrush
Typha angustifolia	Narrowleaved cattail
Typha latifolia	Broadleaved cattail

These wetland plants and others are usually placed in zones of water levels ranging from approximately 0.5 m below to 0.3 m above the average water level. Wetland plants are often pregrown in a coconut fiber substrate in one of the

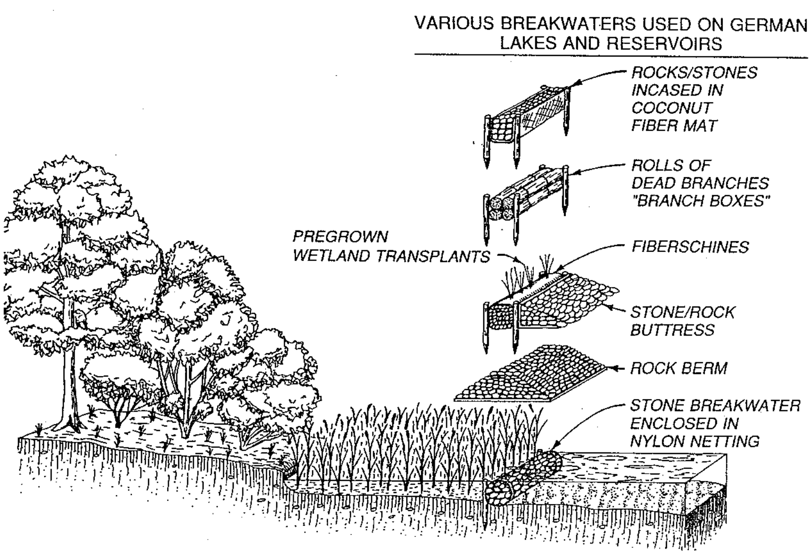


Figure 2. Various combinations of breakwaters and wetlands used on German reservoir and lake shorelines.

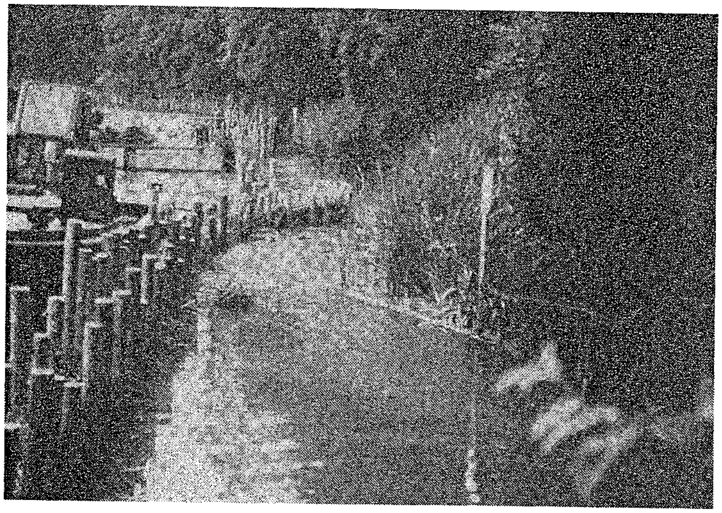


Figure 4. Poles that are initially placed with a jetpump.

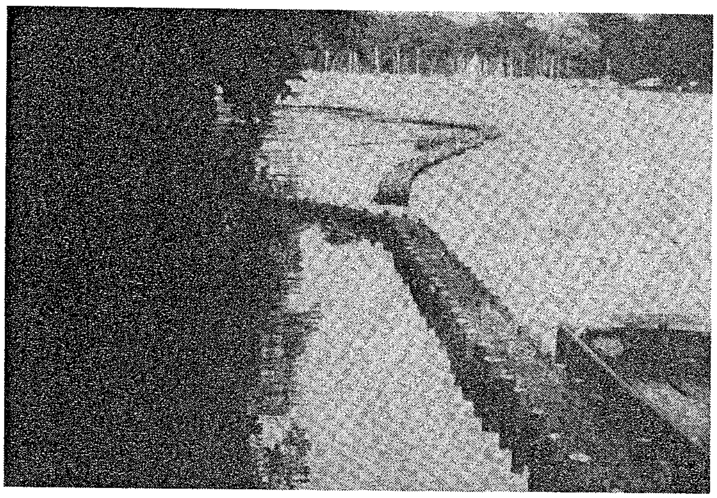


Figure 5. Completed branchbox breakwater.

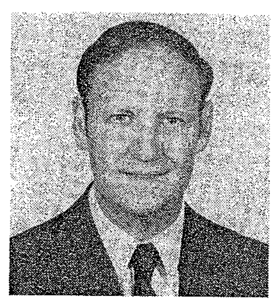
following forms: fiber pallets (80 by 125 cm); coconut fiber vegetation carpets rolled out onsite (0.5 to 2.0 m wide by 5 m long); or 20- by 20- by 20-cm bulbs. All of these lend themselves to immediate transfer to the site and short-term shore stabilization until the vegetation becomes established. Wetlands are not usually planted until the breakwater is in place.

Costs for these wetland systems (1991 prices) including the branchbox breakwater, wetland plants installed as pallets and bulbs, and coconut-fiber filter fabric were between $400 and $460 per linear metre. These costs are for about a 10- to 20-m swath from the breakwater landward. Generally, costs for bioengineering alternatives are a fraction of the cost of traditional alternatives such as riprap armorment. It should be noted that construction costs could be less in Germany because the equipment used there, such as barge-mounted pneumatic hammers and shallow-draft barges and boats, was made for this purpose. However, similar equipment could be manufactured in the United States.

The technique permits effective, low-cost erosion control without destroying shoreline habitat; in fact, the wetlands that are created enhance the shoreline habitat of the reservoir. Through the use of this technique or a modification of it, several kilometres of wetlands have been and continue to be restored along the shore of Havel Lake. At the same time, the shore is being protected from further erosion.

The branchbox breakwater with associated wetlands is a feasible technique for cost effectively controlling shoreline erosion in reservoirs with little water-level fluctuation. It has the added benefit of restoring wetland habitat in harmony with nature. The breakwater is also biodegradable, a fact that makes it more acceptable to environmental agencies and groups. This system is feasible for reservoir shorelines receiving fluctuation more than 1 m, but caution should be exercised and a low-cost demonstration is advised before pursuing large-scale shoreline erosion control efforts on reservoirs of this type.

For additional information, call Hollis H. Allen at (601) 634-3845.



Hollis H. Allen is a botanist with the Environmental Laboratory at Waterways Experiment Station (WES), Vicksburg, MS. He has been with WES for almost 23 years and has conducted studies on man's impacts on the environment and ways to correct negative impacts. Allen has spent a majority of those years using bioengineering techniques, a combination of vegetation and low-cost building materials and structures, on dredged material and reservoir shorelines and on stream and riverbanks for both shoreline erosion control and habitat development for wildlife and fisheries. Allen has attended Oklahoma State University, Oregon State University, and Colorado State University and holds degrees in Forestry and Forest Ecology.

Investigating High-Solids and 100-Percent-Solids Coatings

by

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and

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The Corps of Engineers (CE) has used solution vinyl paints for corrosion protection of hydraulic structures on inland waterways for many years. These coatings have an excellent service life; however, they have a high solvent content. State or regional volatile organic compound (VOC) air-pollution regulations limit the total amount of organic solvents that may be in low-solids paints. Use of low-solids paints, such as solution vinyls, would violate these regulations; use of high-solids or 100-percent-solids coatings would be in compliance with the regulations. Although these regulations are currently in effect only in specific areas of several states, similar regulations may eventually be enacted throughout the United States. To comply with both the existing and anticipated regulations, it is necessary to evaluate potential coatings to replace those currently used.

Laboratory testing

To identify coatings as candidates for field testing, researchers tested high-solids and 100-percent-solids coatings under laboratory conditions that simulate the exposures the coatings experience in use on hydraulic structures. The laboratory testing included two standard high-VOC coatings and two low-VOC, waterborne vinyl coatings to obtain data for comparison.

The coating systems were applied to panels cut from sheets of 24- to 38-mil cold-rolled steel that had been abrasive blasted to the profiles recommended by the coating manufacturers. Application methods included polyfoam applicators, bristle brushes, and conventional or airless spray equipment.

Basic coating properties (pot life, recoating time, and curing time) and applied coating properties (saltwater and freshwater immersion resistance, weathering, adhesion, flexibility, color, chalking, and blistering) were tested. Tests were conducted in accordance with American Society for Testing and Materials (ASTM) standard test methods and continued for at least 3,000 hr.

Field testing

Following the laboratory testing, a number of the coatings having superior performance were applied to hydraulic structures for field evaluation.

A self-priming, epoxy-amine was applied to radial gates on a Bureau of Reclamation structure. This material has a relatively short pot life, which makes application by brush, roller, or single component airless spray equipment quite difficult. Satisfactory application was achieved with various methods by mixing only small amounts of the coating (2 gal or less) at a time and working steadily. Thinning is unnecessary if application is by brush or roller. If thinning is required for a spray, up to 5-percent toluol may be used. Half the volume of the thinner should be added to each component before combining them.

The most effective method of application was plural component airless equipment. No thinning was required for proper application. The target dry film thickness of 16 mils can be achieved with two coats regardless of the application method, provided the material has not been excessively thinned. After 1 year in service, the gates were still receiving excellent protection; however, the coating had chalked and looked somewhat "blotchy." For applications where appearance is important, two additional coats of a compatible moisture-cure aliphatic polyurethane can be applied as weathering coats.

A nonelastomeric polyurethane, self-priming coating was applied to a tainter gate on the Mississippi River Lock and Dam 17 (Figure 1). Application was conducted through the manufacturer by a licensed applicator. The product required an unusually large blast profile. Abrasive blasting with #4 flint grit produced an unacceptable surface profile of less than 4 mils. Therefore, the steel was reblasted using #7 flint grit, which produced an acceptable profile. (The profile measurement exceeded the capabilities of the replica tape and is thought to be between 6 and 8 mils.) Application was conducted using plural component airless equipment. The components were pumped from the container, through heaters, and into the main triple cylinder pump unit. Three cylinders were necessary for the 2:1 mixture ratio. The components passed through a heated hose line and were finally combined in a series of static mixers located between the body and the tip of the airless spray gun. The gun was also supplied with a third hose containing methylene chloride solvent to flush material from the mixers and tip whenever application was interrupted.

Application was plagued by equipment problems. Improper cleaning of a transfer pump may have allowed the isocynate component to crystallize, thus requiring replacement of the pump and hoses. Unsatisfactory temperature controls caused improper mixing and resulted in a considerable amount of lost time and material. These problems may also be responsible for some of the early failures noticed with the coating.

After the problems were addressed, further application progressed rapidly. Multiple coats can be used to attain any desired thickness; however, experience and good application techniques are necessary to attain a reasonably uniform thickness. In the test areas where a 50-mil dry film thickness was desired, measured thicknesses ranged from 27 to 97 mils, with the majority of the readings between 40 and 55 mils. The material was set-to-touch in less than an hour; however, it was still soft enough to be dented with the thumbnail the following day.

After one winter, many of the rivet heads on the downstream waterline area were showing bare steel. After the second winter, these rivet heads were almost 50 percent bare. There were a few scratches through the coating, and there was a significant area of intercoat delamination. This delamination probably was the direct result of the application problems. There was no blistering or other form of coating failure in areas of low abrasion.

An epoxy-polyamide primer with an epoxy-cycloaliphatic polyamine topcoat was applied to the downstream face of a tainter gate on the Mississippi River Lock and Dam 17. The system was composed of two coats of quite typical two-component epoxies. The materials were applied with a single-component airless unit having a 619 tip. Thinning was not necessary. The primer and topcoat were applied on successive days. Thickness of the primer ranged from 3.8 to 5.5 mils. Total thickness ranged from 7.8 to 15 mils with most readings between 9 and 12 mils. After the first winter, the coating appeared to be in near new condition with no signs of defects or damage. After the second winter, however, it was evident that significant failure was taking place. Rivet heads at the downstream waterline were approximately 40 percent bare, and the entire underwater area showed signs of generalized rusting to the extent that the gray coating had taken on a light brownish appearance. Atmospheric areas showed signs of mild chalking, but no other defects.

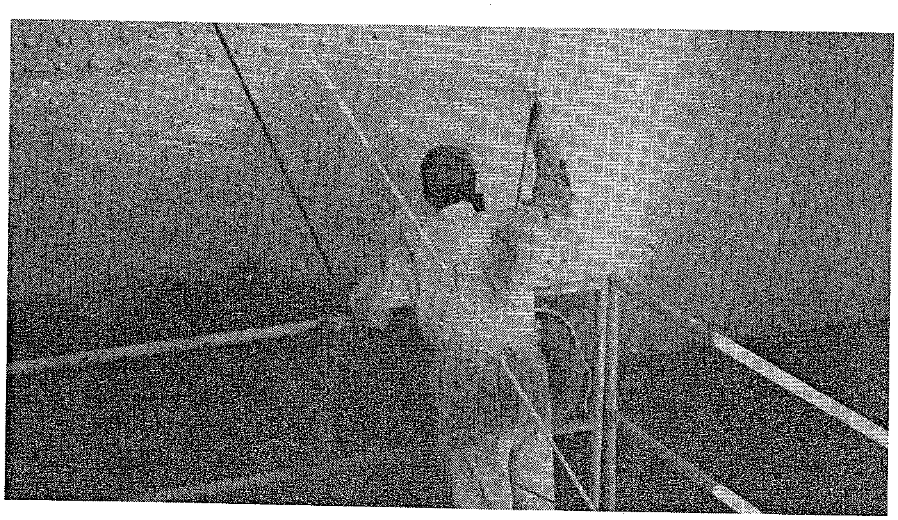


Figure 1. Application of a coating at Mississippi River Lock and Dam 17.

A system composed of a cycloaliphatic amine cured epoxy, a primer, and topcoat was also applied to the downstream face of a tainter gate at Lock and Dam 17 (Figure 2). Like the other epoxy system applied in the same area, this system was composed of two coats of two-component epoxies applied without thinner using a single-component airless unit with a 619 tip. The primer and the topcoat were applied on successive days. Primer thickness ranged from 6 to 9 mils; total thickness ranged from 11 to 18 mils with most readings in the range of 14 to 15 mils. This coating also appeared to be in near new condition after the first winter. Evidence of failure after the second winter again showed on the rivet heads, which were approximately 25 percent bare, and the entire underwater area, which showed initial signs of generalized rusting. Atmospheric areas were chalky, but no other defects were evident.

A self-priming epoxy-polyamide was applied to radial gates on a Bureau of Reclamation structure. The system consisted of multiple coats of a typical two-component epoxy and was applied with a single-component airless unit. Thinning was not necessary. Application properties were excellent. During one portion of the application, the weather was quite cool, so a manufacturer-recommended accelerator was added to the coating before application. The coating was applied in five layers and produced a minimum dry film thickness of 16 mils. In this application, each coat was a different color so that the depth and rate of wear experienced in service could be monitored. In another application, the material was applied to a minimum of 16-mil dry film thickness in two coats. A two-component polyurethane topcoat was added to improve weathering characteristics. The time of exposure of these systems has not been long enough to determine performance characteristics.

A self-priming epoxy-polyamine that can be applied underwater was selected for field testing, but was omitted when researchers learned the manufacturer is no longer in business.

Results

Many of the high-solids and 100-percent-solids coating systems tested require special application equipment. This equipment is available from major equipment suppliers and is used by a number of industrial coating contractors. Some of the manufacturers of the coatings tested have licensed or approved contractors for their systems. However, all of the systems must be properly applied over correctly prepared surfaces if they are to perform satisfactorily or reach their maximum potential. In this respect, they do not differ from "conventional" coating systems.

The higher costs associated with high-solids and 100-percent-solids coating systems can be illusory. Higher material or application costs can be offset by shorter downtimes and lower long-term coating costs. Cost analysis of these coating systems should be based on a life-cycle cost, cost per square foot per year of satisfactory service, and not on initial cost.

The data acquired in the investigation provide control points for the performance recorded under the sets of conditions and film thicknesses in force at the time of the testing. These control points will prove useful for future investigations of the effects of changing the film thickness, number of coats, conditions of testing, etc., for any of the systems in the investigation.

The field evaluation work has highlighted some important concerns relating to both application and performance. Perhaps the most important concern is the difficulty of applying some of the modern coatings. Whereas some coatings were easily mixed and applied with common single-component airless spray equipment, and indeed could have been applied by

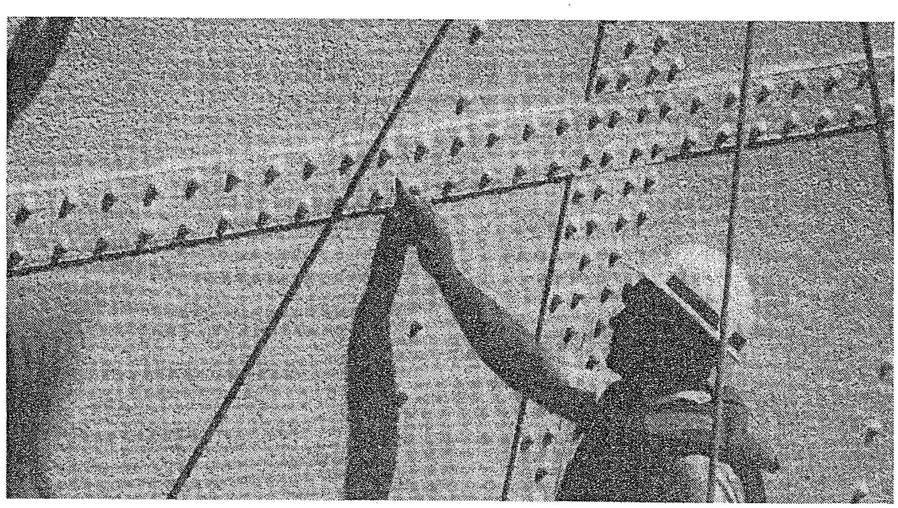


Figure 2. Inspection of coating on tainter gate.

brushes or rollers, one system proved difficult to apply even for a manufacturer's licensed applicator. It is doubtful that a CE inspector could have recognized application irregularities that might have resulted in coating failure. Contracts for application should include manufacturer liability requirements to ensure satisfactory application and performance.

Another aspect highlighted by the field evaluation was the lack of true durability of the low-VOC coatings. Based on the laboratory testing, it was anticipated that there would not be any notable short-term differences in performance between the high-rated, low-VOC coatings and the currently used standard systems. The level of failure noted after 2 years was quite surprising. One would not have expected to see this level of failure with the standard system for 8 to 10 years. This situation reflects on both the durability of the coatings as well as the ability of the short-term laboratory testing to discern long-term durability of immersion coatings.

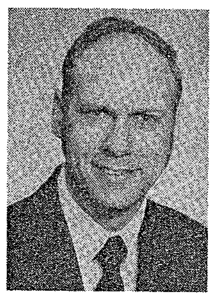
Future research

The results of the investigation suggest additional avenues of exploration. For example, the combination of compatible elements of different generic systems to upgrade such properties as immersion, abrasion, and weathering resistance should be explored. Such systems already exist for bridges and other structures, a notable example being the well-known inorganic zinc/epoxy/aliphatic polyurethane coating system. Coating manufacturers as well as coating users need to be involved in this type of investigation.

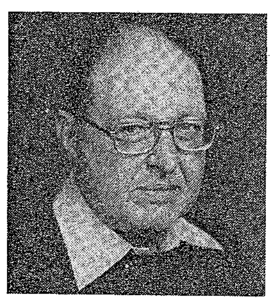
The lack of universally accepted and appropriate performance specifications is a major difficulty when specifying the use of high-solids and 100-percent-solids coatings. The data acquired during this investigation could be used, in part, to create such specifications. Organizations such as the Steel Structures Painting Council, ASTM, and the National Association of Corrosion Engineers that write specifications and standards should be encouraged to develop and approve specifications for high-solids and 100-percent-solids coating systems.

Another major difficulty is the lack of quicker accelerated test procedures for high-performance coatings. Efforts to develop better and quicker accelerated test procedures for high-performance coatings should be supported.

For additional information, call Alfred D. Beitelman at (217) 373-7237 or John S. Baker at (303) 236-6197.



Alfred D. Beitelman is the REMR Electrical and Mechanical Problem Area Leader and is Director of the Paint Technology Center at the US Army Construction Engineering Research Laboratory (CERL), Champaign, IL. He received a Bachelor of Arts degree in Chemistry from Wartburg College, Waverly, IA. Beitelman developed the Paint Test Kit, a screening device that is used by both the military and private industry, and has developed many paint formulations that are used worldwide for painting hydraulic structures.

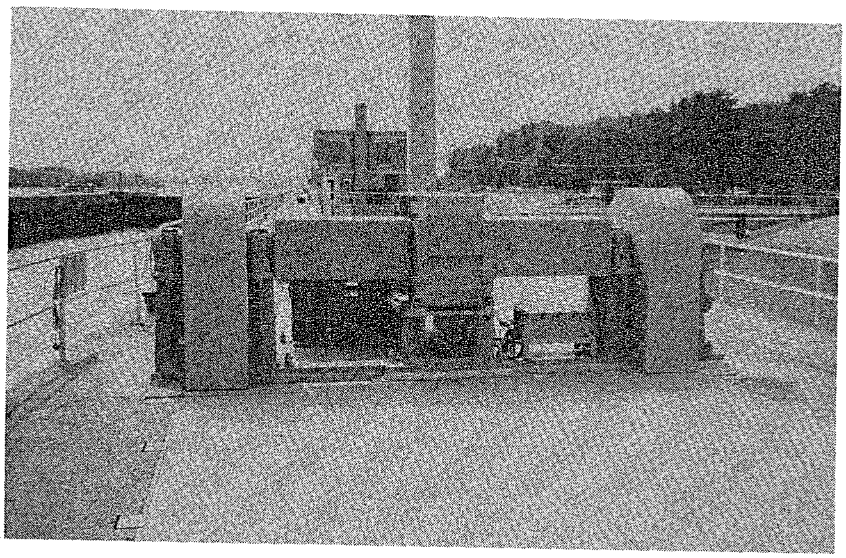


John S. Baker is a Materials Engineer at the Research and Laboratory Services Division of the Bureau of Reclamation in Denver, CO. He received a Bachelor of Arts degree in History from Temple University, Philadelphia, PA, and a Bachelor of Science degree in Engineering from Drexel University, Philadelphia, PA. He has completed many graduate courses in chemistry. Baker's work focuses on coatings and specifications, and he is involved in teaching corrosion and coatings courses.

Use of Synthetic Oils for Enclosed Gear Cases

by

O. S. Marshall, Jr.
US Army Construction Engineering Research Laboratory



Miter gate with enclosed gear cases operating machinery at Lock and Dam No. 2.

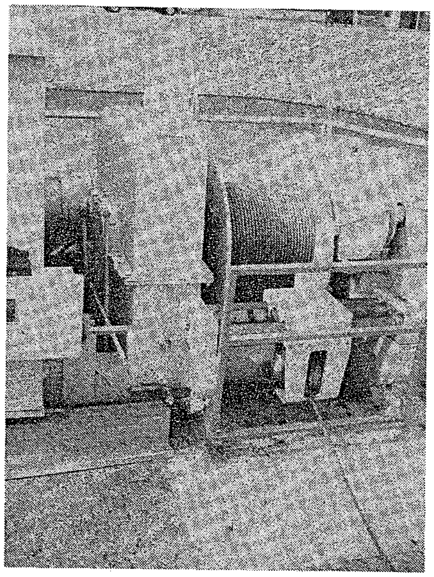
Recent investigations conducted at the US Army Construction Engineering Research Laboratory (CERL) indicate that the use of synthetic lubricating oils in enclosed gear cases can effectively eliminate problems associated with low-temperature operations. The advantages and disadvantages of synthetic lubricants were compared with those of mineral lubricating oils, the cost effectiveness of synthetic oils was evaluated, and a simple mathematical model for determining cost effectiveness was developed.

A mineral oil is not a single molecular substance, but is composed of thousands of compounds. It is this complexity of mineral oils that creates problems. While some of the chemical compounds in these oils have excellent properties for given applications, others do not. In most cases, the quality of oils is improved by adding chemicals such as oxidation inhibitors, rust inhibitors, etc.

Probably the most vexing problem with mineral oils is that viscosity increases as temperature decreases. At extremely low temperatures, oil can become so viscous that it is almost solid. The viscosity index (VI) is a measure used by lubrication engineers to describe the change in the viscosity of the oil for a given reduction in temperature. The less an oil changes in viscosity, the higher its VI rating is. Currently, additives called "VI improvers" are used to produce multigrade all-weather oils. However, this practice has a drawback: VI improvers shear more rapidly than oil. In engine oils, this shear is not critical – or at least it can be kept within tolerable limits. In a gear system, the story is different.

In gear systems, force is concentrated on a very small surface area, and lubrication effectiveness is largely dependent on shear strength. Therefore, VI improvers are *not* the best way to raise the VI rating of an oil in gear systems. Synthetic oils are a better solution and provide an even higher VI rating than can be achieved with VI improvers in mineral oils.

Unlike conventional mineral oils, which are distilled from petroleum, synthetic oils are generated by chemically bonding small molecules into larger ones with desired properties. Synthetic oils are formulated from molecular substances that are nearly pure, so the end products (and their molecular weights) fall within a narrow range. This formulation makes synthetics relatively pure compared with mineral oils. Furthermore, a synthetic oil can be generated with a variety of properties to meet different criteria. The most notable characteristic of synthetics is that they have very high VI ratings without the addition of VI improvers. Also, the fact that they are designed to be less chemically reactive reduces their tendency to oxidize and extends their life significantly.



Barge towing winch with enclosed gear cases.

The major drawback of synthetic oils is their cost. The process by which they are created makes them much more expensive than conventional petroleum-based mineral oils. On the average, synthetics cost five times as much as their mineral oil counterparts. However, when overall equipment operating and maintenance costs are considered, synthetics can be more cost effective than mineral oils for certain applications.

Another drawback to synthetics is that they can act as a solvent or softening agent on certain materials used for seals and coatings. In cases where a synthetic attacks sealing or coating materials, there are three options: (1) use a different synthetic formulated for the same application, (2) replace the affected material with a different material, or (3) avoid the use of synthetics.

The following model was developed to help calculate the cost effectiveness of mineral and synthetic oils:

$$\frac{C_M}{L_M}+\frac{C_H}{L_H}+E>\frac{C_S}{L_S}+\frac{C_R}{L_R}$$

where

C_M = cost of mineral oil per gallon

L_M = life of mineral oil in years

C_H = cost of maintenance of heaters

L_H = heater maintenance cycle in years

E = annual cost of electricity to heat 1 gal of mineral oil

C_S = cost of synthetic oil per gallon

L_S = life of synthetic oil in years

C_R = cost of replacing casing components incompatible with synthetic oils

L_R = life of replacement part

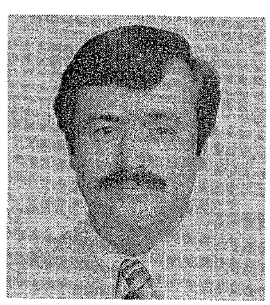
Findings of the CERL study of synthetic lubricants include the following:

- Synthetic oils can effectively eliminate problems associated with low-temperature operations.
- The use of synthetics is not usually cost effective unless there is a special problem to address, such as cold weather operation.
- When heaters are required to liquefy highly viscous mineral oils in cold weather, and this requirement results in the need to change oil every 2 or 3 years, synthetic oils are likely to be a cost-effective alternative.
- The cost effectiveness of synthetic oils must be determined by Corps personnel at the District level.
- When synthetic oils fail, it is usually because of improper application.

As noted, some materials used for coatings and seals in gear casings may be susceptible to chemical attack by some synthetic oils. In such cases, the cost calculation model described previously should be used to determine whether the cost of replacing the vulnerable material with a different product outweighs the benefits of switching to a synthetic oil.

The findings of this research are documented in a draft CERL technical report, "The Use of Synthetic Oils for Enclosed Gear Cases," by O. S. Marshall and W. B. Clifton.

For additional information, call O. S. Marshall at (217) 373-6766.



O. S. Marshall is a Principal Investigator on the Corrosion and Coatings Team of the US Army Construction Engineering Research Laboratory (CERL), Champaign, IL. He earned a Bachelor of Science degree in Chemistry from the University of Idaho, Moscow, ID. He has also done postgraduate work in polymer engineering and chemical engineering at the University of Illinois at Urbana-Champaign. Marshall's research at CERL has included work on polymer applications, steel sheet pilings, copper pipe rehabilitation techniques, lightweight bridging systems, and the PAINTER engineered management system for paints and coatings.

Recent REMR Publications

Khayat, Kamal H. 1991 (Dec). "Underwater Repair of Concrete Damaged by Abrasion-Erosion," Technical Report REMR-CS-37, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

The objective of this research was to develop concrete mixtures and placement methods to repair typical scour holes underwater. Guidelines for selecting concrete-making materials and additives were established, and new tests for assessing various properties were developed to complement existing ones. Approximately 70 concretes were evaluated to optimize mixture proportions. Methodologies detailing construction procedures were developed, and a database was designed and implemented to facilitate the selection of promising concretes for repairs. This research shows that concrete structures with scour holes of various depths and sizes can be successfully repaired underwater. Flat and durable surfaces can be secured with in-place compressive strengths exceeding 8,000 psi and relative density values close to 100 percent of control concrete that has been cast and consolidated above water. These concretes and construction procedures can provide economical, safe, and durable repairs to underwater structures.

Rail, R.D., and Haynes, H.H. 1991 (Dec). "Underwater Stilling Basin Repair Techniques Using Precast or Prefabricated Elements," Technical Report REMR-CS-38, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

The purpose of this study was to investigate methods of repairing stilling basins of hydraulic structures underwater, thereby eliminating costly dewatering operations, and to develop a plan to evaluate products or concepts. The effort focused on methods using precast concrete or prefabricated steel panels. The maximum water depth considered was 70 ft. This report reviews underwater repairs of the Old River Low Sill Control Structure, Upper St. Anthony Falls Lock, and Kinzua Dam. An overview of the required underwater construction tasks is presented (preplanning, mobilization, surface preparation, installation of field anchors and panel supports, installation of panels, concrete placement, and inspection). Construction methods for underwater repairs are discussed, including the use of divers, wall enclosures, caissons, cofferdams, above-water platforms, and submersibles. Panel design factors considered are abrasion resistance, uplift forces, joints, and weight. Other panel considerations include shapes, joints, bond, and supports. Repair schemes, such as large-area, partial-area, small-area, and baffle block repairs, are described.

Avery, Timothy S., and Friant, James E. 1992 (Jan). "Applications and Testing of Resin Grouted Rockbolts," Technical Report REMR-GT-17, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

A few instances of rockbolt failure have been reported where polyester resin had been used as the anchoring grout. All reported instances involved submerged installations. A TVA test report confirmed that in a short hole (15 in.), under submerged conditions, the water can interfere with resin polymerization. This document reports additional laboratory and field tests that showed that water interference is confined to a short zone at the resin-to-water interface. Tests employing a grout length of 2 ft or more on No. 6 rockbolts held their yield load, wet or dry. Larger scale testing at the Bonneville Locks showed similar results. At grouting lengths of about 55 in. or more, yield load on a No. 11 rockbolt was reached, wet or dry. This report finds no deficiency in polyester resin grouted rockbolts or anchors, so long as proper procedures governing installations are followed. The conclusions and recommendations of this report contain suggested procedures and cautions.

McKay, David T. 1992 (Mar). "REMR Management Systems—Navigation Structures; User's Manual for Concrete Navigation Lock Monoliths," Technical Report REMR-OM-12, Construction Engineering Research Laboratory, Champaign, IL.

The US Army Corps of Engineers operates approximately 270 navigation lock chambers constructed of plain or reinforced concrete. Many of these structures require, or will require, significant repairs to ensure safe and efficient operations. Modern engineering technology is providing procedures for performing condition surveys, consistent and quantitative conditions assessment, and database management. Combined with economic analyses, these procedures afford efficient maintenance and repair (M&R) budget planning through the evaluation of current condition and the comparison of various M&R alternatives based on life-cycle costs. Collectively, these procedures are called the REMR Management System. The LOCKWALL program documented in this manual addresses the REMR aspects of concrete navigation lock monoliths.

Fall REMR-II Field Review Group Meeting

The fourth REMR-II Field Review Group (FRG) Meeting is scheduled for 29-30 September 1992 at Waterways Experiment Station, Vicksburg, MS. For additional information, contact Ms. Lee Byrne, REMR Technology Transfer Specialist, at (601) 634-2587.

Request for Articles

Readers who have experience in repair, evaluation, maintenance, or rehabilitation activities are encouraged to share their technology via *The REMR Bulletin*. To submit articles to the bulletin, send a hard copy, disk (WordPerfect, Word Star, ASCI, etc.), figures and/or photographs, and biographical information (plus photo) to Waterways Experiment Station, ATTN: CEWES-SC-A/Lee Byrne, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199.

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