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Guides help standardize lead paint removal

by
Alfred D. Beitelman
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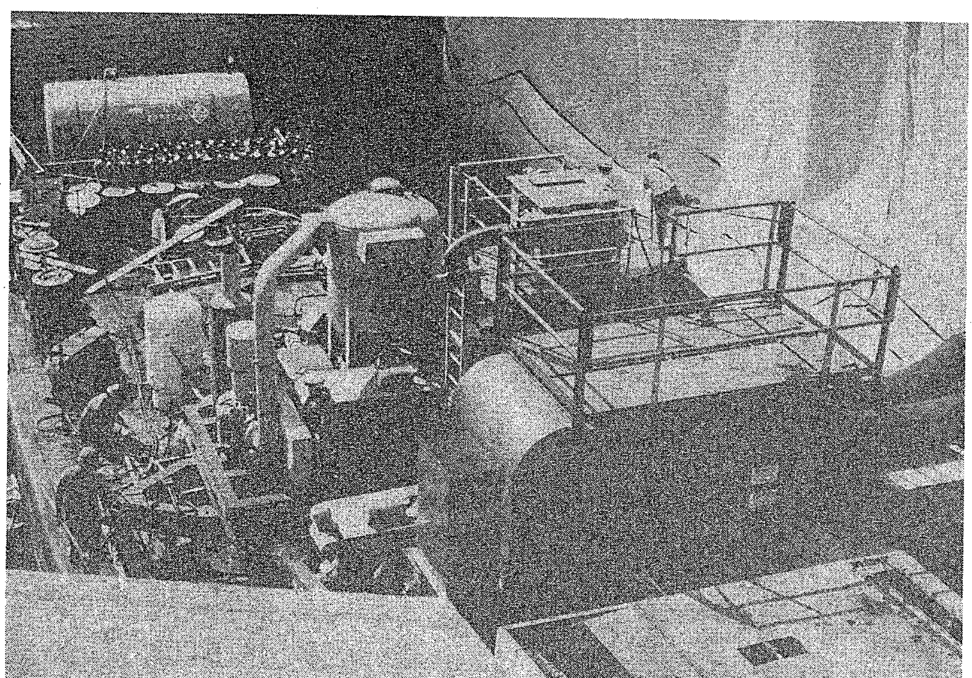
For many years, both the Government and private industry have used lead-based paints on steel structures. Recently enacted hazardous waste laws have resulted in new methods of removal, containment, and disposal of paints containing lead. The adverse health effects of exposure to lead have been known for decades, but the new containment requirements have amplified the hazards and the cost of removal. To deal with this problem, the Steel Structures Painting Council (SSPC) has developed two guides to help standardize the various levels of lead paint containment and disposal.

Interim guides issued by SSPC

In March 1992, the SSPC issued Guide 6I (*Guide for Containing Debris Generated During Paint Removal Operations*) and Guide 7I (*Guide for the Disposal of Lead Contaminated Surface Preparation Debris*). These were designated as interim guides, pending additional collection of data and industry experience. The SSPC sent copies to many civilian facility owners, suppliers, and contractors. As part of a study being conducted by the U.S. Army Engineer Construction Engineering Research Laboratories (CERL), copies were also sent to all Corps Districts and Divisions.

Eighteen months after the guides were distributed, the SSPC surveyed industry and Government representatives on their practices of lead paint removal and use of the guides. The responses indicated the guides were used to prepare specifications for paint removal from a number of structures, including bridges, water towers, loading wharves, and various industrial and manufacturing



Equipment barge for lead paint removal, outside containment structure. Ventilation equipment (bag house) for the containment structure is in the foreground, and the abrasive blasting and recycling equipment is behind the bag house

plant facilities. A portion of the data was analyzed to compare the costs of two different lead abatement options: (a) total removal of the existing paint and repainting and (b) partial overcoating of the deteriorated areas.

Because most projects involved bridges, the overall data were divided into two sets, one for bridges and one for other structures. The results showed that the costs for full removal on bridges varied widely, ranging from less than $3/ft^2 to over $18/ft^2. The average cost was $7.50/ft^2. The cost of overcoating ranged from approximately $1/ft^2 to $5/ft^2, with an average cost of $2.75/ft^2. It costs about 2.4 times as much to do full removal as to overcoat. For structures other than bridges, the costs were typically higher, but the ratio remained relatively constant.

Overall, there were more cases of full removal than overcoating. Contributing to the variability of overcoating costs is the number of highly significant variables affecting the cost, including the amount of surface deterioration, the method for preparing the degraded areas, and the number and type of paints applied to the structure.

Blaster wearing personal monitor in containment structure

The respondents of the survey were also asked to estimate the costs of disposal of hazardous debris. These costs ranged from \$250/ton to over \$1,000/ton, with an average of about \$425/ton.

Variation of practices and costs

The data show a wide variation of practices and costs for industrial lead paint removal. Corps lead removal and overcoating projects will likely have a similar variation. This reflects a number of factors, including:

- Nonuniformity of enforcement and interpretation of regulations.
- Variability in size and accessibility of structure and restrictions (i.e., height of structure, traffic control, or proximity of other work).
- Variability of existing conditions.
- Variability of production rates and efficiencies of removal methods.
- Lack of standard procedures and criteria for containment and disposal of debris.

Using the responses on distribution of costs, the SSPC prepared an approximate breakdown of the costs for full paint removal. This breakdown indicates that the costs associated with environmental and worker protection now significantly exceed those for surface preparation, materials, and labor for applying the paint. Costs associated with the various surface preparation methods will be detailed in a REMR technical report scheduled for publication in FY94 (Smith and Beitelman, in preparation).

Impact of new regulations

In the 18 months since the SSPC guides were issued, major new regulations have been published that will have additional impacts on the practices and costs of industrial lead paint abatement. These include the Occupational Safety and Health Administration's (OSHA's) new Interim Final OSHA "Lead in Construction Standard" (29 CFR 1926.62) and the Environmental Protection Agency (EPA) "Regulation on Training and Certification and Proposed Performance-Based Environmental Compliance Standards."

Currently, the SSPC is revising Guides 6I and 7I. Major changes in Guide 6I include specific containment classes for methods other than abrasive blast cleaning (e.g., water jetting, chemical stripping, and power tool cleaning). The major change in Guide 7I is an addition on treatment options. These revisions should be completed early this year.

Development of guide specification

Also scheduled for release in FY94 is a guide specification on lead removal, being developed under the REMR Research Program and currently in the draft stage. This guide spec, which will supersede CWGS-09940, will include the updated Guides 6I and 7I as well as the changes brought about by the new OSHA and EPA regulations.

Development of improved standards and practices for industrial lead paint removal will make this process safer and more cost effective. This will allow for optimal allocation of Corps maintenance and repair dollars and increased health protection for workers.

For more information, contact Alfred Beitelman at the U.S. Army Construction Engineering Research Laboratories, P.O. Box 9005, Champaign, IL 61826-9005, COMM 217-373-7237 or toll-free 800-USA-CERL.

Blasters exiting through the air lock of Class 1 containment

References

Smith, L., and Beitelman, A. "Methods for removal of lead paint from steel structures," REMR technical report in preparation, U.S. Army Construction Engineering Research Laboratories, Champaign, IL.

***Alfred D. Beitelman**, Director of the Paint Technology Center at the U.S. Army Construction Engineering Research Laboratory, Champaign, IL, is the REMR Electrical and Mechanical Problem Area Leader. He received his 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. He has also developed many paint formulations that are used worldwide for painting hydraulic structures.*

Metallized coatings for repair and maintenance of hydraulic structures

by
Tim Race
U.S. Army Construction Engineering Research Laboratories

For over 30 years, vinyl coatings have been successfully used by the Corps of Engineers to protect hydraulic structures. A Corps vinyl system applied to the gates at Lock and Dam 22 at Hannibal, MO, in 1950 was not reapplied until 1981. In fact, the interiors of the gates, which experienced no abrasion, were inspected and returned to service at that time without repainting. However, in some environments, vinyls have failed within 1 year of application when they are exposed to extreme abrasion. Such has been the case at navigation facilities along the Ohio River. To address the abrasion-related coating failures encountered on the Ohio River, the Construction Engineering Research Laboratories (CERL), Champaign, IL, initiated an evaluation of metallized coatings for the repair and maintenance of gates on Ohio River dams.

Background

Prior to the 1940's, the Corps had established an extensive navigation system along the Ohio River. This system consisted of 53 lock and dam facilities that allowed navigation from Pittsburgh downriver to the confluence of the Mississippi and Ohio Rivers, near Cairo, IL. Beginning in the 1950's, the original system was augmented by the construction of 18 modern locks and dams. Today, only 2 of the original facilities are still in operation. The newer dams traverse a river elevation of just over 400 ft, averaging about 22 ft/dam. The pool elevation change of the new dams is much greater than the old dams, which averaged 8 ft.

Water flow is necessarily higher at the new facilities. To allow downstream access and safe water conditions for pleasure boaters and sportsmen, the facilities were constructed with concrete baffles downstream of the dam gates. The baffles effectively attenuate the flow and allow for safe access. Unfortunately, the flow pattern that is created causes river debris to be retained at the downstream side of the dam. Extreme scouring of the protective coatings used on the gates results (Figure 1).

Standard Corps vinyl systems erode rapidly in this environment, and coating failure and substrate corrosion typically occur in 1 to 2 years. An appreciation of the level of severity of the abrasion at Ohio River dams can be gained by a comparison with coating performance on Mississippi River dams. Abrasion and scouring also occur on the Mississippi River but are much less severe because of lower turbulence. Therefore, CERL investigated the durability and corrosion resistance of metallized coatings as a potential alternative to vinyl systems for use in highly abrasive conditions.

Application

Metallizing, or thermal-spray, is a group of processes by which metallic feedstocks are melted and propelled to the substrate, where they solidify and form a coating. Common processes include

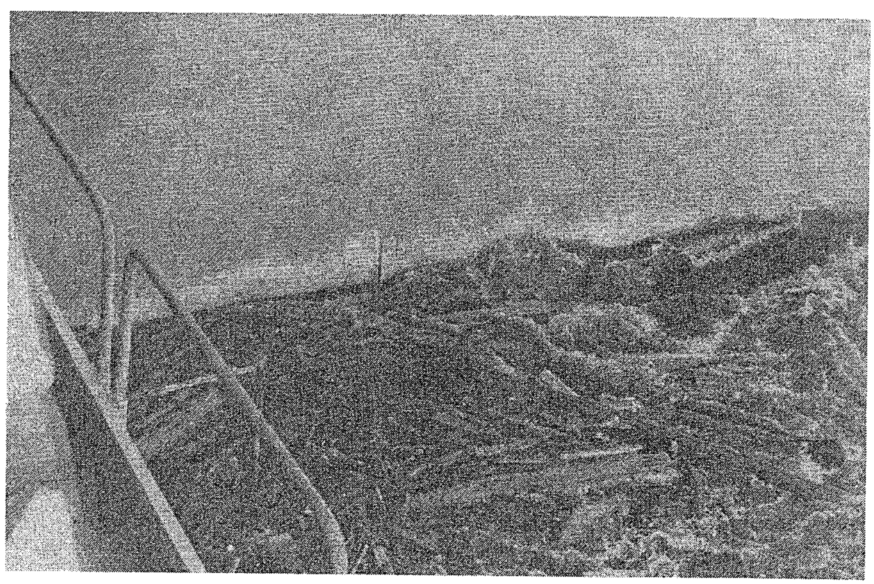


Figure 1. Debris scouring the downstream side of a tainter gate on the Ohio River

wire arc-spray and flame-spray. The arc-spray process applies an electrical potential difference across two wires which melt and are projected to the substrate in a stream of compressed air. Flame-spray uses a fuel gas flame to melt either a metallic powder or wire, which again is transported to the substrate by compressed air. Metallized coatings retain most of the properties of the feedstock material including hardness and corrosion resistance. Thermal spray is a versatile process that is used in many industries. Jet engine fabricators use thermal spray coatings to hardface turbine blades. Some state transportation departments are now specifying zinc thermal spray in place of paints for protecting bridge steel. Automated thermal spray is used routinely to rebuild shafts to the desired diameter.

Tests

Beginning in 1986, a series of metallic test coatings were applied by thermal spray to the downstream skinplate of a tainter gate at Belleville Locks and Dam in the Huntington District. Aluminum-bronze alloy and 18-8 stainless steel were applied by arc-spray. Each of the metallic coatings was sealed with epoxy and vinyl paint systems. An inspection after 6 months detected premature failure of these coatings. Failures were primarily the result of galvanic corrosion caused by water permeation through the metallic coatings to the substrate-coating interface. The aluminum-bronze coating also showed signs of wear from impact and abrasion (Figure 2).

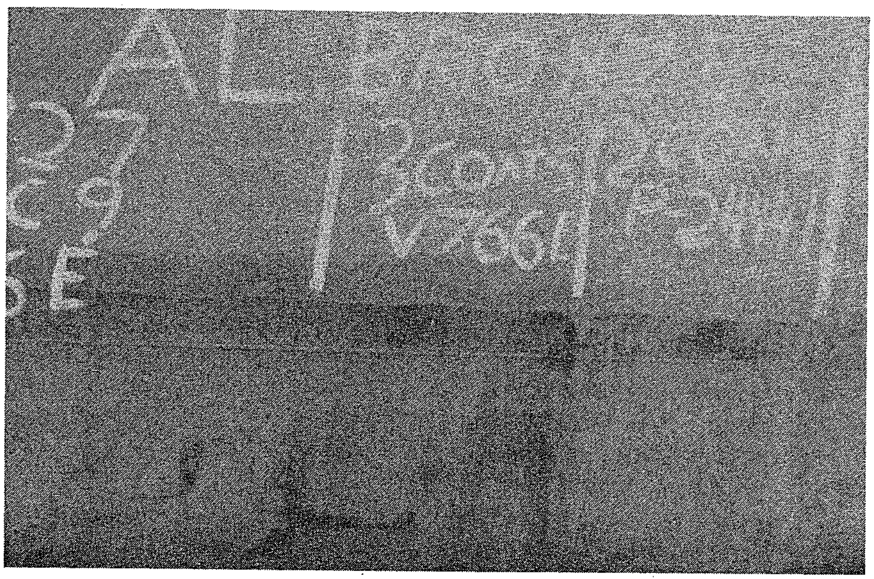


Figure 2. Aluminum-bronze coating after 9 months service

Zinc and 85-15 zinc-aluminum alloy were applied by flame spray in 1987 (Figure 3). The average thickness of these materials was 0.018 in. These materials are not as hard as stainless steel or aluminum bronze; however, they are anodic to steel and will prevent the occurrence of galvanic corrosion of the substrate steel. The need for an anodic coating was readily evident based on the early performance of the stainless steel and aluminum bronze.

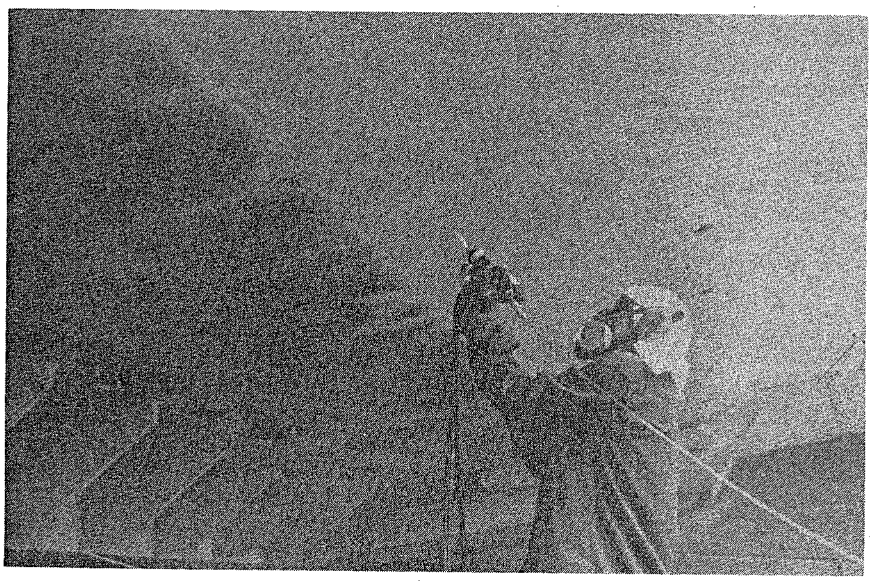


Figure 3. Application of zinc coating by wire flame spray

Results

Annual inspections of the coatings at Belleville have been conducted since 1986. The premature failures observed for the aluminum bronze and stainless steel coatings have progressively worsened. Failures include severe general corrosion and coating delamination.

Inspection of the zinc coating has revealed areas of excessive wear. Sections of the zinc coating that experienced constant immersion were completely eroded in as little as 2 years. Zinc oxide created by the oxidation of the coating is easily eroded; this erosion exposes new zinc, which in turn oxidizes and erodes. Zinc metallizing exposed at the downstream waterline was approximately 90-percent intact after 4 years. The downstream waterline is not in constant immersion and does not experience the high-water velocities found on the lower areas that are in constant immersion.

The zinc-aluminum alloy forms much harder and more cohesive oxidation products. With the exception of some small delaminated patches, very little reduction in film thickness of 85-15 has been detected after 5 years in test (Figure 4). Numerous small areas of coating, approximately 1/2 to 1 in. in diameter, have partially delaminated. Delaminations of this nature are the result of blister formation caused by the expansion of oxidation products within the zinc-aluminum coating. The delamination of the blisters has not exposed or caused corrosion of the substrate. All of the delaminated blisters are on the bottom of the gate where the coating is in constant immersion. Ironically, this area does not receive the severity of abrasion of the vertical portions of the downstream skinplate, where debris continually circulates. Vinyl coatings will provide adequate protection to areas below the waterline. In the splash zone, where debris scours the surface, both the zinc and 85-15 zinc-aluminum alloy outperform vinyl paints with the zinc aluminum providing the highest degree of protection.

Figure 4. Example of 85-15 zinc-aluminum coating after 5 years service

Conclusions

The use of 85-15 zinc-aluminum alloy coating will provide in excess of 5 years of corrosion-free service in highly abrasive immersion applications. Standard Corps vinyl systems typically fail completely in less than 2 years for the same type of exposure. The estimated service life of a 0.015-in.-thick, 85-15 zinc-aluminum coating sealed with vinyl paint is 8 to 12 years. The installed cost of this system is approximately twice the cost of a standard Corps vinyl paint system.

Civil Works Guide Specification CWGS-05306, *Metallizing: Hydraulic Structures*, September 1992, details the use of several metallizing systems and provides application and safety requirements.

For additional information, contact Tim Race at (217) 373-6769.

***Tim Race** is a Principal Investigator for the Corrosion and Coatings Team, Engineering and Materials Division, CERL, Champaign, IL. He holds a B.S. degree in chemistry from the University of Michigan. Race is an active member of the Steel Structures Painting Council.*

Panel heaters used to control ice growth caused by fluctuating water levels

by
F. Donald Haynes, Robert Haehnel, Leonard Zabilansky
Cold Regions Research and Engineering Laboratory

The cold air temperatures of winter can cause ice to literally "grow" on the walls, gates, and machinery at locks and dams, creating a situation that can seriously impair efficient operation of these facilities. As the water level fluctuates in a lock chamber, ice frequently builds up in the form of an ice collar (Figure 1) that can prevent full use of the chamber width and may cause the need to downsize tows. Sometimes ice builds up on the bottom of the gates. The weight added by this ice hampers movement, making it difficult to open or close the gates. This ice buildup can also prevent a good bottom seal when a gate is in a closed position. Heaters placed in the area of such icing can be an effective solution to this problem.

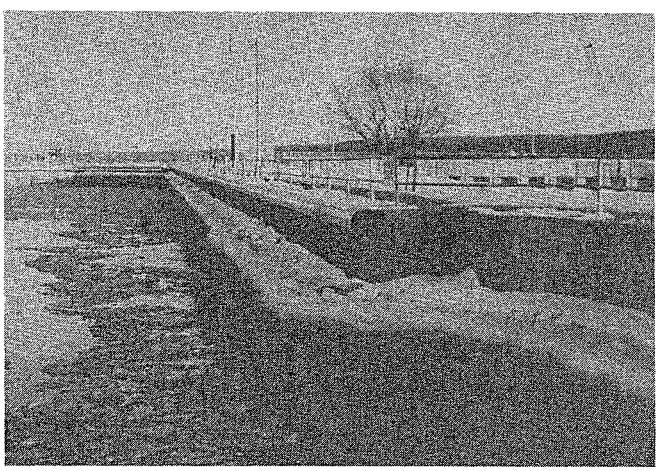


Figure 1. Ice collar formed on a lock wall

Laboratory tests

Under the REMR Research Program, the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) has been conducting a laboratory study of ice growth to find alternative methods of either preventing this buildup or of shedding the ice as it grows. Tests were designed to grow ice on a surface by alternately exposing panels to cold water and cold air. Three panels, each 1 by 12 by 15 in., were used for the tests. These were made of steel, concrete, and high-density polyethylene (HDPE), respectively. Each panel had six self-regulating heat cables placed inside it for a total of 150 W. Two of the panels were tested concurrently in separate barrels located in a room where the temperature was maintained at 12° F (Figure 2). A computer controlled two pumps and two solenoid valves that cycled the freshwater flow from barrel to barrel. A load cell connected to each panel measured the mass of the ice grown. The pressure transducer measured the water level, and this determined the pumping direction. The time required to complete one cycle was 46 min, and the duration of a single test was usually 3 to 4 days. Additional tests are planned with different cycle times and air temperatures.

Test results

In each test, steel was used as the reference panel. Figure 3 shows typical ice growth on a steel panel, and Figure 4 illustrates the accumulative ice load grown on the steel and concrete panels. At the beginning of the test, the concrete absorbed water, a condition that explains the initial jump in load for the concrete. After approximately 7 hr, the ice load curves were almost parallel until the water cycling was stopped. With both panels in the air, the heaters were turned on in each panel. The steel panel shed its ice in about 1 hr, while the concrete took about

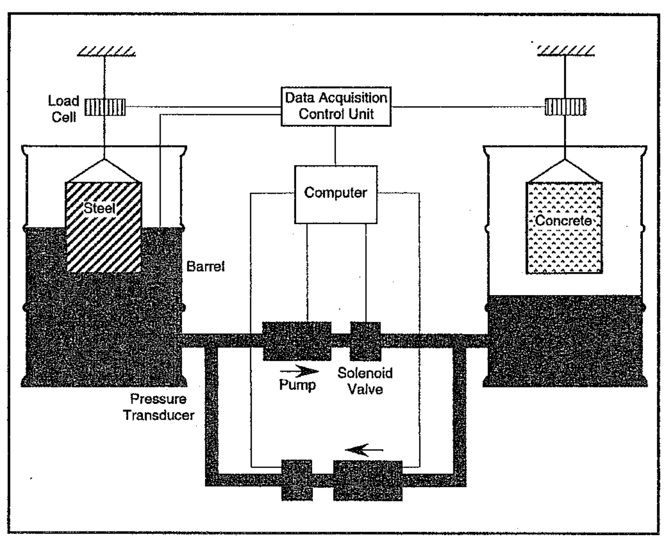


Figure 2. Test setup

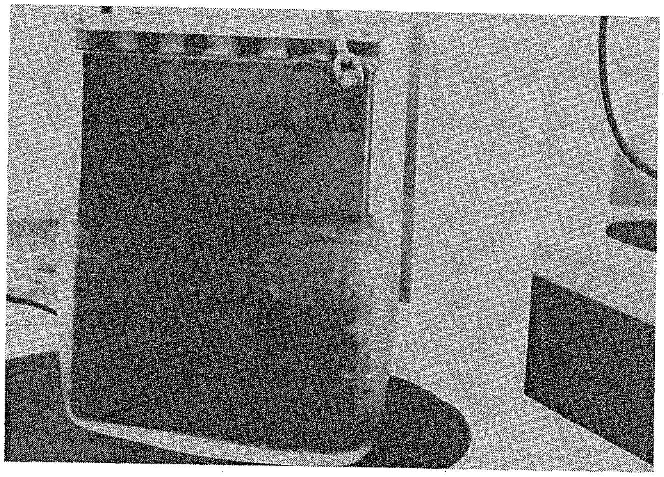


Figure 3. Ice grown on the steel panel

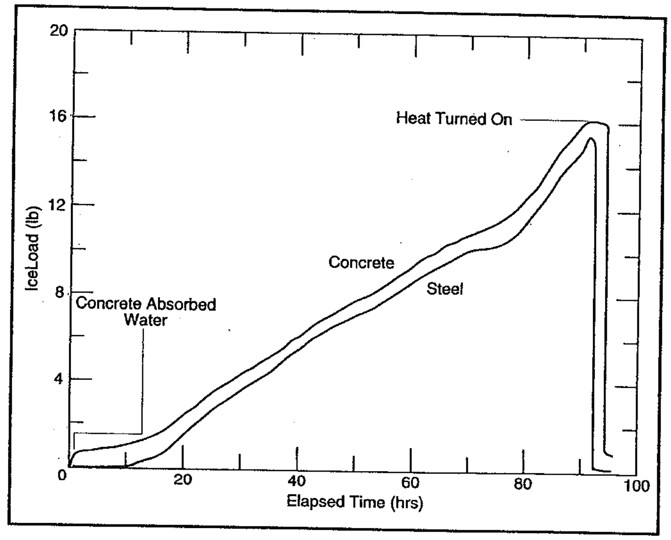


Figure 4. Ice grown on the steel and concrete panels as a function of time including time to shed the ice

2-1/2 hr. Only the ice at the interface had to be melted to cause the entire ice to suddenly release.

Figure 5 gives the results of a test comparing ice grown on steel with that grown on HDPE. Even though the ice load curves are not parallel, the final load was about the same. Again the steel panel shed its ice in about 1 hr, while the HDPE took about 4 hr.

Figure 6 summarizes the time it took to shed the ice for each of the three panels. These shed times can be partially explained by the thermal conductivity of the three materials. For example, the thermal conductivity of steel is 25 Btu/hr-ft-°F; of concrete, 0.79 Btu/hr-ft-°F; and of HDPE, 0.19 Btu/hr-ft-°F. Due to the high thermal conductivity of steel in comparison to concrete and HDPE, the steel panel required much less time to heat up and melt the ice interface, resulting in much lower shed times.

From the preliminary results of the laboratory tests, it appears that the wall material has little effect on the ice growth rates. However, the wall material has a large effect on the ice shedding rates. Therefore, heated wall materials with high thermal conductivities have a clear advantage in controlling ice.

The laboratory tests also indicated that the heater has to melt ice only at the interface in order to shed the ice. The heater can be operated in an intermittent mode to shed ice or in a constant mode to prevent ice from growing on the panel. The latter procedure, however, will generally result in greater costs of electricity.

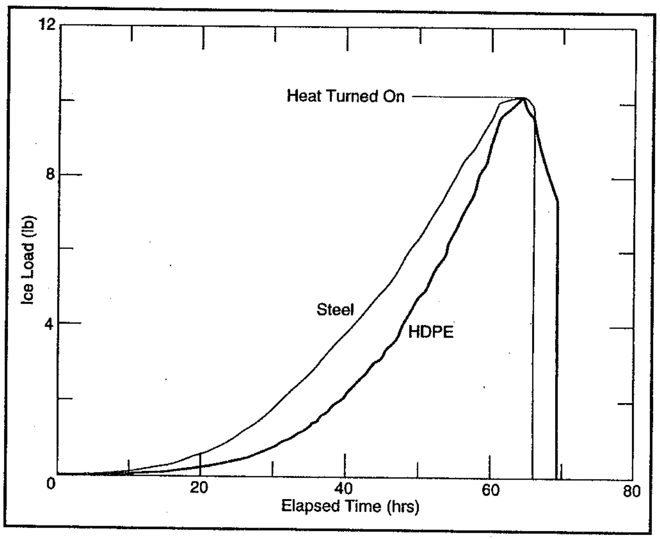


Figure 5. Ice grown on the steel and HDPE panels as a function of time

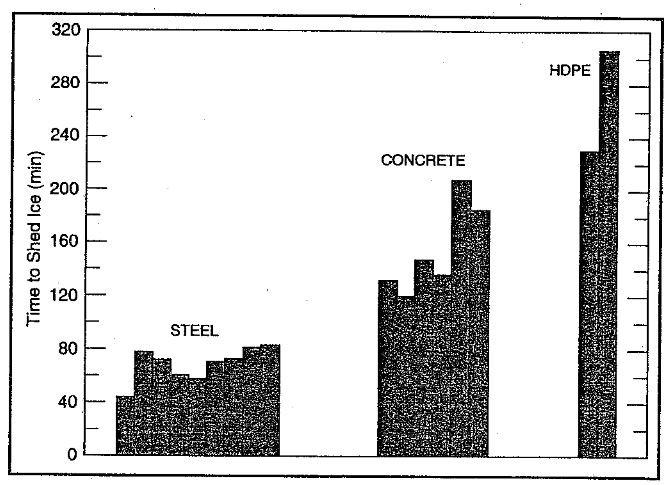


Figure 6. Time required to shed the ice on the three panels

Ice growth model

Figure 7 shows an idealized model for growing ice on a vertical panel by alternately exposing the panel to cold water and cold air. At time 1, when the panel is exposed to cold water, a thin layer of ice, *dx*, starts to grow on the panel. This thickness is a function of the difference between the heat transferred into the existing ice by conduction q_i and the heat transferred from the water to the ice surface, q_w. It is also a function of the ice density, ρ_i and latent heat λ.

Using the number of cycles for the test given in Figure 4, the ice grown per cycle was determined. For the interval between 30 to 90 hr of the test, the ice grown was about 0.135 lb/cycle. The area over which the water wetted the existing ice was about 470 sq in. Using these quantities and the density of ice, a thickness of the ice frozen per cycle was found to be about 0.009 in. This means that only a very thin film of the water that wetted the existing ice was frozen per cycle.

At Time 2 (Figure 7), water is not in contact with the ice, and heat is transferred by conduction and convection to the cold air. The convection heat transfer, *q*, for Time 2 is a function of a convection coefficient, *h*, and the difference between the temperatures of the ice, T_i, and the air, T_a.

Since the ice grows by the freezing of a thin film of water that has wetted the existing ice, it was calculated that this 0.009-in.-thick film freezes in about 10 min. As the water level is decreasing, freezing of the water film is occurring in the air above it. This freezing occurs by convection driven by the temperature difference between the thin water film and the cold air.

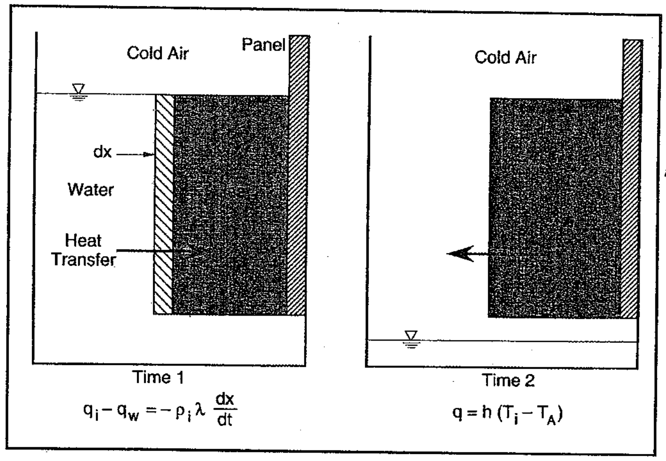


Figure 7. Idealized model of ice growth on a panel with corresponding heat transfer equations

Field applications

When the water level is cycled in lock chambers, an ice collar can grow, as shown in Figures 1 and 8. Wall heaters have been designed at CRREL and described in REMR Technical Note HY-N-1.11 (Supplement 6, *The REMR Notebook*). These aluminum panels are 1-1/4 by 37 by 96 in. in size and can be attached to concrete lock walls with screws. They have sixteen 3-ft-long replaceable self-regulating heat cables rated at 40 W/ft each for a total electrical power of 1,920 W. The first installation of this heater panel has been successful in preventing ice growth at Starved Rock Lock and Dam on the Illinois River (see sidebar, "Panel Wall Heaters Successful at Starved Rock Lock and Dam, Illinois River").

The use of cartridge heaters is being considered for installation on the eight tainter gates that are proposed for the Saugus River flood-control project. These gates were designed to be raised out of the water and will be subjected to tidal action twice a day. The bottom of the gates will be alternately exposed to cold water and cold air during winter months, and ice buildup on the bottom of the gates will be a factor (Figure 9), unless preventive measures are taken. Placement of these heaters inside the pipes located near the bottom

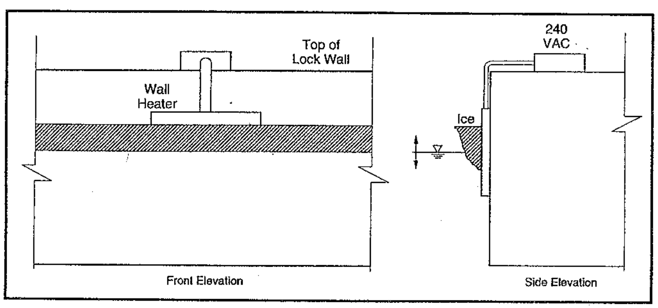


Figure 8. Ice on a lock wall and heater panel used to remove the ice

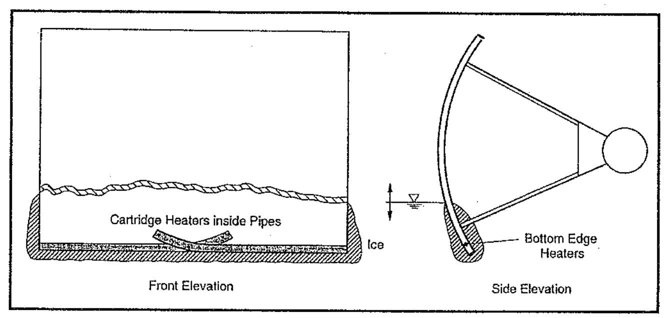


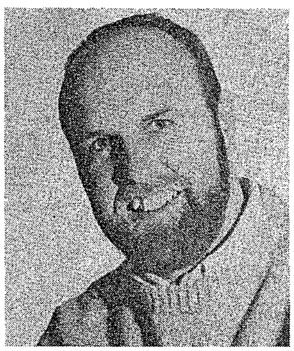
Figure 9. Tainter gate proposed for Saugus River, with ice grown on the bottom due to water level changes

of the gates is recommended to ensure that they are mechanically protected and can be replaced.

It will be important that ice growing on these gates be shed if the facility is to operate efficiently in the winter. In normal operation, the heaters would have to be used only about 2 hr/day to shed any ice grown during tidal water contact with the bottom of the gate. Cartridge heaters may offer a cost-effective method of alleviating icing conditions at this project.

For additional information, call Don Haynes at (603) 646-4184.

***F. Donald Haynes** is a mechanical engineer in the Ice Engineering Research Branch, CRREL, Hanover, NH. He has a B.S. degree in mechanical engineering from the University of Arizona and an M.S. degree in mechanical engineering from Michigan Technological University. Haynes has over 20 years of experience in applied research on icing problems and is currently Principal Investigator for the REMR Research Work Unit on icing problems. He is a Registered Professional Engineer in the State of New Hampshire.*



***Robert Haehnel** is a research mechanical engineer at CRREL and works in the Ice Engineering Research Branch. He holds a B.S. degree in engineering from Brigham Young University. Haehnel has been involved in the REMR Research Program for 2 years and has been with CRREL for 5 years. He is a member of the American Society for Mechanical Engineers.*

***Leonard Zabilansky** is a general engineer at CRREL. In the past 20 years, his research effort has been in the area of ice forces on structures. He is an active member of the American Society of Civil Engineers and the Instrumentation Society of America. Zabilansky is a Registered Professional Engineer in the States of New Hampshire and Connecticut.*

News in Brief

Double congratulations are extended to James E. McDonald, Structures Laboratory, Waterways Experiment Station. McDonald received the 1993 R&D Achievement Award for development of the precast concrete stay-in-place forming system for rehabilitation of navigation lock walls. He is also to be congratulated for his election to the American Concrete Institute Committee on Nominations for 1994. McDonald has been the REMR Problem Area Leader for Concrete and Steel Structures since REMR-I was initiated in 1986 and has been the author of numerous bulletin and journal articles and technical reports.

Panel wall heaters successful at Starved Rock Lock and Dam, Illinois River

by
F. Donald Haynes
Cold Regions Research and Engineering Laboratory

The use of panel wall heaters to control and minimize icing in miter gate recess areas (see REMR Technical Note HY-N-1.11) has proved to be an effective solution to the icing problem at Starved Rock Lock and Dam, Illinois River. A panel heater was installed at this location in December 1993, just in time for one of the worst winters of the decade. The panel was bolted onto the concrete wall in the miter gate recess area (Photo 1) and was very successful in keeping the wall ice free (Photo 2). There was even some effect beyond the perimeter of the panel, which has 48 ft of self-regulating heat cable placed inside it. The heat cable is rated at 40 W/ft at 240 V, for a total power of 1,920 W. One advantage of the self-regulating heat cable is that it automatically reduces its power requirement as it heats up. This eliminates the need for a thermostat. These panels have been recommended for placement on all miter gates recesses at Dresden Island and Marseilles Lock and Dams during their scheduled rehabilitations in 1995.

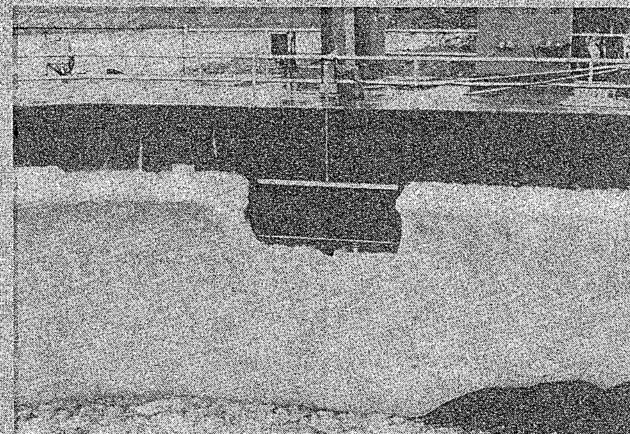


Photo 1

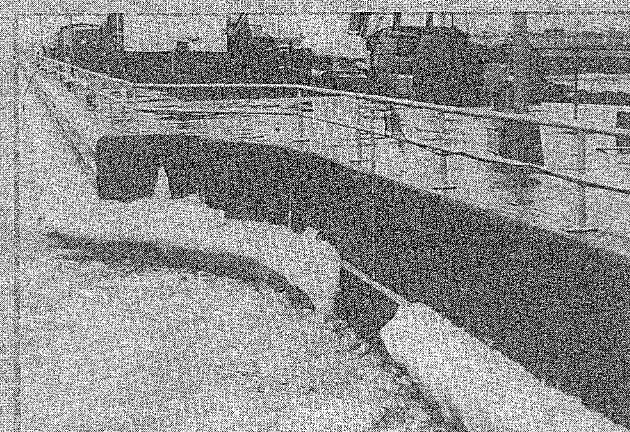


Photo 2

Annual REMR-II Field Review Group Meeting Scheduled for July

The 6th REMR-II Field Review Group (FRG) Meeting is scheduled to be held in the Washington, D.C., area on July 26-28, 1994. During this meeting, the FRG members will review the progress of ongoing work units. In addition, R&D priorities will be addressed.

The meeting will be open to the public as well as to Corps personnel involved in the repair, evaluation, maintenance, and rehabilitation of the Nation's infrastructure. Representatives from all Districts and Divisions are encouraged to attend. For more information, call Lee Byrne at (601) 634-2587.

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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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