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

Repointing Masonry in Older Buildings

by Edward F. O'Neil, U.S. Army Engineer Waterways Experiment Station

The U.S. Army Corps of Engineers (USACE) is responsible for the repair and maintenance of many old structures in its building inventory. For some, preserving their historical integrity is an important consideration; for others, the primary concern is that they continue to be useful and safe. Regardless of the reason for repair, appropriate and high-quality restoration techniques will always serve well for the long-term care of masonry structures.

One form of repair that all masonry buildings will eventually need is repointing, or replacement of deteriorated mortar between the courses of masonry. Sometimes called pointing or tuckpointing, this procedure requires skills that can be learned only from experience. However, a basic knowledge of the reasons for repointing and an understanding of the steps that are necessary to produce a correctly repointed joint will provide the engineer with the proper information in dealing with the contractors hired for the task.

Determining the Need for Repointing

Mortar provides a number of essential qualities to masonry: the strength that holds the brick, stone, or block together; a cushion between individual masonry units; and a water-resistant barrier that prevents moisture and other damaging agents from entering the structure.

Deterioration of the mortar and the mortar masonry interface itself is the main reason for undertaking repointing. All building materials will disintegrate with time and exposure to the elements. Freezing and thawing in cold weather can cause the mortar to deteriorate. Expansion and contraction from extreme thermal changes can exceed the material capabilities of the mortar and cause either crushing or debonding at the masonry and mortar interface. Extreme stress on a structure can cause mortar to crack and debond from the masonry.

A masonry structure needs repointing when an examination of the mortar points out any signs of deterioration: cracks in the mortar, loose or missing mortar, weak or crumbly mortar, gaps between the mortar and the masonry, loose bricks, water leakage on the interior of the wall, or damp spots on the surface of the masonry. These are all warning signs that if ignored can result in further degeneration of the mortar, the masonry, and the overall health of a structure. A number of steps are appropriate to ensure high-quality repointing of a structure.

Execution of the Work

Mortar removal

The first task in repointing is the removal of the deteriorated mortar. Proper joint preparation calls for removal of the affected mortar to a minimum depth of 2-1/2 times the thickness of the mortar joint. In normal brick masonry, this will be about 1 in. (25 mm). In stone masonry it will be about 1-1/2 in. (37 mm) (Mack, Tiller, and Askins 1980). If the mortar is still deteriorated at this depth, it should be removed until sound mortar is found. The depth to the bottom of the cleaned joint should be uniform across the width of the joint to ensure that the new mortar forms a strong base and will not break with movement.

Removal methods

There are three methods for removal of old mortar: the use of hand chisels, rotary power grinders, or power chisels. The method used will depend on the size of the job and the skill of the contractor.

Hand chisels. For small jobs or those where care must be taken to prevent damaging surrounding masonry units, the use of hand tools will cause the least amount of damage to adjacent areas. Hand-held chisels can be chosen to match the width of the joint and ensure that the impact is directed against the mortar and not the masonry. Many sizes and types of chisels are available. The chisel is placed into the joint and struck with a hammer to disintegrate the mortar. A second tool, a joint rake, is then used to clean out the resulting cavity. This method allows precise depths of mortar to be removed. It is the slowest method of the three, but will damage the least number of masonry units.

Rotary power grinders. If the removal task is large, then use of power tools is a consideration. The use of impact chippers and saws or grinders will speed the chore, but can lead to breaking of bricks or overcutting of joints, potentially cutting into adjacent masonry units. Rotary saws grind the mortar from the joints. The width of the saw blade should be smaller than the width of the joint itself to eliminate any damage to the masonry unit. However, this technique leaves a thin layer of mortar attached to the masonry that may be weak and will not provide a good bed for the repointing mortar. Another problem associated with rotary cutters or grinders is that the grinding wheel will not be able to clear the extreme ends of head joints without sawing into the brick above or below the joint being prepared. This means that the head joints will have to be finished by hand anyway to provide a properly prepared joint bed.

Power chisels. Power chisels are automatic impact tools. While they are less likely to cause damage than grinding wheels, the operator can get careless or weary after long periods of use, and some damage can occur from impacts that strike the masonry rather than the mortar joint.

Extreme care should be taken when power tools are used. The contractor chosen to do the repointing should be skilled in the use of these tools and should be required to demonstrate his skill on a predetermined portion of the building. Test panels should be chosen on an inconspicuous part of the building and should incorporate all types of masonry that are to be cleaned. The contractor's skill will be well demonstrated if he produces prepared joints that are clean and are to the proper depth and he has not damaged the masonry through cutting, chipping, or otherwise marring it in the process. The test panel can be used again to test the color and texture of the repointing mortar, as well as the contractor's skill in applying mortar to the joint.

Since the use of power tools is less accurate and thorough than the use of hand chisels, the final preparation of the joint should always be done by hand to leave a proper cavity into which the repointing mortar can be placed.

Figure 1. View of cleaned Mississippi River Commission Building, Vicksburg, MS

Selecting the Mortar

Constituents

Most mortars used in repointing will consist of sand, lime or cement, and water. There may be additional additives such as colorants or historic components, but these are unusual and less frequently found. In historic structures, the matching of the constituents of the mortar to those of the original structure may be very important. In other structures, the importance of the constituents may be directed more to providing specific material properties. Whichever the direction, good-quality materials will provide the best mortar.

Sand

Sand for mortar should be clean, preferably rounded, properly graded, and the proper color and texture. The sand will probably be the component that most readily affects the appearance of the mortar. From this point of view, it should be chosen to provide a final mortar that matches the original in both color and texture. This should be true for all structures since the color and texture of the repointed mortar will affect how the repointing is viewed in the overall context of the remainder of the building regardless of its historical significance.

Sand that meets American Society for Testing and Materials (ASTM) Specification C (ASTM 1997a) will have the proper gradation and be free from contaminants. Proper gradation will ensure greater workability of the mortar and provide a texture that is appropriate for current and historic mortars. Where historical correctness is mandatory, sands should be matched to those found in the original mortar. A sample of mortar from the removed material should be collected and crushed and the powders removed to leave the sand for examination. This sand should be observed under low-power magnification to find its color and surface shape.

Sands used for mortar will be either rounded as in beach or river sand, or angular as in crushed or manufactured sand. While the shape of the sand should be matched to that in the original mortar, rounded sands will make a better mortar than angular varieties. Round aggregates produce a more workable mortar and allow better packing of the mortar into small spaces in the joint and greater adherence of the mortar to the masonry. This will most likely be the choice for older mortars that were traditionally made from rounded sands because these materials were readily available and manufactured sands were more expensive to produce.

Lime or cement

The binder in masonry mortars is generally lime. Lime conforming to ASTM C 207, Type S (ASTM 1997c), will serve the purpose of binder and will resist shrinkage and drying during curing. When portland cement is used, it should conform to ASTM C 150, Type II (ASTM 1997b). Portland cement can be mixed with lime in quantities up to about 20 percent without changing the properties of the mortar too severely. The greater the amount of cement added, the greater will be the strength of the mortar, the speed of setting, and the shrinkage of the mortar. The resulting mortar will be harder and less flexible with higher amounts of portland cement. Cements used for mortar purposes should be low in alkali (less than 0.6-percent alkalis and less than 0.15-percent soluble alkalis) to minimize the chance of efflorescence.

Mortars made from lime will be softer than those made with large amounts of cement. As will be explained, softer mortars are generally more desirable. Lime mortars tend to expand slightly on hydration and will help close any hairline cracks that may form. Water passing through lime mortar will dissolve some of the lime and deposit it in small hairline cracks, which will further help seal them.

Water

The water used to make mortar should be clean, potable, and free from chemicals that would alter its pH. Water containing minerals that color the water may also adversely color the mortar.

Additives

Generally speaking, additives should not be necessary in either modern or historic mortars. They are mostly ineffective in high-lime mortars and in some instances can be detrimental. Plasticizers that might be used to provide a more fluid mortar are very expensive, and the desired plasticity of the mortar can be achieved with proper mixture proportioning without the need for the plasticizer. Bonding agents to assist bond between old and new mortar are not needed either. A properly prepared joint that has been well cleaned will provide an adequate surface for new mortar adherence. Properly pointed masonry will effectively drain moisture from the joint and thus minimize situations where water could collect and freeze. Since freezing and thawing should not be a serious problem, air-entraining additives should not be necessary. Entraining air in mortar will make it more plastic, but will also cause a reduction in its strength.

Mortar properties

Repointing mortar should be soft and flexible rather than hard and rigid. Lime mortars are ideal for this purpose because the lime produces limited but adequate strength such that the resulting mortar will be soft. Lime mortars are also flexible. Rigid mortars that are harder than the surrounding masonry can cause damage to the masonry if the materials expand. In a wall subjected to high temperature, the masonry units will expand, and if the mortar is rigid and hard, there is the possibility that the mortar will chip edges and corners of the masonry unit, particularly if the masonry unit is soft. In cold weather, components of a masonry wall will contract, and a rigid mortar will not move with the contraction. In this situation, the mortar will crack, generally at the interface of the masonry and mortar, and this crack will now be a pathway for water to get into the structure.

Mixture Proportions

The exact mixture proportions for mortar for repointing masonry will vary depending on the type of structure, the material properties of the masonry and the mortar, the importance of historical accuracy, and the availability of materials. If historical accuracy is important, an analysis of the mortar should be conducted to match both physical and chemical requirements. If requirements are less stringent, the basic properties of color, texture, and strength of mortar should be followed. A good mixture proportion to start with could be the following:

5-6 parts lime
10-12 parts sand
1-2 parts portland cement
(preferably white portland).

The amount of water used should be just enough to provide a plastic mixture that will give a smooth surface when the back of a trowel is used to smooth the surface of the mortar. Proper consitency is also achieved when the trowel leaves a sharp, vertical edge.

Repointing the Joint

Placement

Once the mortar has been mixed, the joint should be filled as follows. A suitable length of joint should be chosen to repair at one time. This will depend on the amount of mortar that has been made and the volume of joint that can be repointed before the mortar becomes unusable. Standard practice suggests that the mortar should be used within 30 min of final mixing and that retempering of the mortar (adding water to renew its plasticity) should be avoided. Several feet of joint can be repointed at a time. The back of the joint should be filled first. Approximately 1/4 in. (6 mm) of mortar should be placed in the back of the joint and packed well into the corners and bottom of the opening. This should be allowed to set until the mortar is thumb-print hard. Then a second layer approximately 1/4 in. (6 mm) should be tamped in on top of the first layer. This process should be continued until the joint has been filled. The importance of letting each layer harden will prevent shrinkage damage to the entire joint. By the time the mortar is thumbprint hard, most of its shrinkage has taken place, and the next layer of mortar will not be affected by the previous one. This process will also minimize overall mortar shrinkage and ensure a good bond to the surrounding mortar and masonry.

The joints should not be overly filled with mortar. Overfilling will leave an appearance of an extra-wide joint that will look uneven due to the geometry of the masonry. Older masonry units are often chipped or rounded on their edges from either wear or durability damage. If too much mortar is placed into the joint, the mortar will fill into these spaces and result in an uneven appearance. Also, the very thin layer of mortar deposited on these chips and irregularities will be susceptible to spalling and cracking from movement of the masonry. However, if the repointing effort is stopped just short of flush with the outer face of the masonry, the appearance of the joint will be uniform and confined to the width of the mortar joint, and there will be no thin sections of the mortar to break or chip.

Tooling

Tooling of the final layer of the mortar should be done when the mortar has just set and is again thumb-print hard. The tooling will play an important part in the overall look of the masonry repointing work. To keep the look of the building uniform, all repointed mortar should be tooled in the same manner as the original work. Using original tooling techniques will make the joints appear similar to surrounding areas that may not have been repointed, and even if the entire project is being repointed, the original tooling technique will preserve the historic quality of the facade. There are many different styles of tooling, and there are proper tools to form each type. For more information on these types, refer to U.S. Department of the Interior, Preservation Brief No. 2 (Mack, Tiller, and Askins 1980).

Aging and Curing

New mortar will not look old without some special treatment to make it blend with other areas of the facade that were not repointed. Old mortar is weathered to the point that the surface lime has been worn away and the sand particles in the matrix have been exposed by age. The characteristic color of the aged mortar will therefore be dependent on the color of the sand.

There are two accepted methods of achieving this older look on the mortar. The first involves brushing the joint immediately after tooling it. The brushing will roughen up the surface, bringing a number of sand grains to the surface and giving it a weathered look. The second method involves spraying the joints with a fine mist of water to remove some of the lime and expose the sand particles. Both methods work well to achieve this effect. If the sand was properly chosen for its matching color, these procedures will help make the new mortar match the older mortar.

New mortar should be cured to prevent loss of moisture from the fresh mixture and to encourage proper hardening. Two commonly used methods to achieve this are (a) covering the wall with burlap that is kept wet and (b) providing a moisture barrier such as plastic sheeting to keep the moisture in the mortar. The curing process should last for 2 to 3 days if possible.

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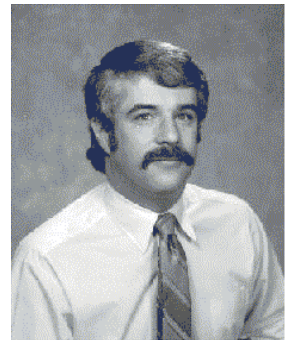

In summary, regardless of the degree of historical accuracy necessary in a repointing operation, appropriate steps should be taken to provide a high-quality process of replacing deteriorated mortar in masonry structures.

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References

American Society for Testing and Materials. (1997). *1997 Annual Book of ASTM Standards*. Philadelphia, PA.
a. Designation C 144. "Standard Specification for Aggregate for Masonry Mortar."
b. Designation C 150. "Standard Specification for Portland Cement."
c. Designation C 207. (1992) "Standard Specification for Hydrated Line for Masonry Purposes."

Mack, R.C., Tiller, D.T.C., and Askins, J.S. (1980). "Repointing Mortar Joints in Historic Brick Buildings," Preservation Brief No. 2, U.S. Department of the Interior, National Park Service, U.S. Government Printing Office, Washington, D.C.

O'Neil, E.F. (1995). "Repair and Maintenance of Masonry Structures: Case Histories," Technical Report REMR-CS-46, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

REMR Management System for Earth and Rock-Fill Embankment Dams

by Stuart Foltz, U.S. Army Construction Engineering Laboratories and Victor Torrey, U.S. Army Engineer Waterways Experiment Station

Background

The U.S. Army Corps of Engineers (USACE) owns and operates over 500 large dams and spends approximately $200 million annually on their maintenance. Most of these dams have significant earth and rock-fill embankment sections. Funding for maintenance and repair (M&R) of these structures is becoming increasingly difficult to obtain. All levels of management are also asking for increasingly detailed justification before approving work. These resource limitations and justification demands require that M&R needs be prioritized with increasing care and that funds be spent efficiently. Accordingly, a quantitative rating system for assessing the condition of embankment dams is being developed at the U.S. Army Construction Engineering Laboratories (USACERL).

REMR Management System

The REMR Management System for embankment dams is designed to assist managers with their M&R planning and budgeting. The rating system provides objective information to aid managers in prioritizing M&R for these dams. In addition, a computer application employing this condition rating system is being created at USACERL to provide an automated decision support tool to engineers and managers who plan REMR activities for embankment dams.

The management system contains standardized inspection and condition rating procedures. It will be computerized and include data storage and handling capabilities, automated calculations, and reporting for work planning and budgeting purposes.

The system features a 100-point Condition Index (CI) that rates the structure on its physical condition and the extent to which it is performing its intended function. The index is primarily a planning tool with the index values serving as an indicator of the general condition level of the structure. The index is meant to focus management attention on those structures most likely to warrant immediate repair or further evaluation. In addition, the CI values can be used to monitor change in general conditions over time and can serve as an approximate comparison of the conditions of different structures.

In addition to calculating the CI for the dam, the system uses the collected information to produce priority rankings for the components. These numerical priority rankings are based on the condition and relative importance of the components and can be used to assist in prioritizing specific M&R tasks based on their effect on the performance of the dam.

Analysis of the dam begins when an engineer or engineers who are knowledgeable of the dam prioritize the subsystems and components of the dam. They first develop importance weightings in a guided process using what are called "interaction matrices." Application of the management system includes an inspection of the embankment according to the standard procedure established for the system. Importance weightings and inspection information are entered into the system to compute the CI.

Benefits and Savings

This computerized REMR Management System provides procedures for performing condition surveys, consistent and quantitative condition assessment, and database management. The embankment CI is primarily a tool for assisting in the prioritization and justification of M&R expenditures. There are a number of directly and indirectly related, associated objectives for the embankment dam CI.

- It has already been used to re-prioritize requirements for instrumentation and monitoring of dams.
- It can aid the engineer in evaluating the relative importance of existing deficiencies.
- It can aid the engineer in communicating with management regarding the importance and severity of these deficiencies.
- It is a useful tool for assisting journeyman engineers in understanding how more experienced engineers make their evaluations.
- It is a good measure of changes in condition or performance over time. Among other uses, on a system level, this feature can be used by managers to determine whether long-term funding is adequate to maintain their facilities.

The ultimate goal is to achieve the best possible condition for embankment dam structures at any given funding level. Combined with economic analyses, these procedures assist in efficient M&R budget planning through the evaluation of current condition and comparison of various M&R alternatives.

Status

The REMR Management System for embankment dams is scheduled for completion and fielding in FY98. It has been partially field tested and is currently undergoing final review and documentation. Training is currently being scheduled through Stuart Foltz at USACERL. Please contact him for further information. Although software for embankment dams is not yet available, the most current REMR software can be found on the Internet at *http://www.cecer.army.mil/fl/remr/remr.html.*

For additional information, contact Stuart Foltz, COMM 217-352-6511, ext 7301; toll-free 800-USA-CERL; FAX 217-373-6740; Internet *s-foltz@cecer.army.mil*; or USACERL, ATTN: CECER-FL-P, P.O. Box 9005, Champaign, IL 61826-9005.

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Victor H. Torrey III is a research civil engineer in the Earthquake Engineering and Geosciences Division, Geotechnical Laboratory, WES. Torrey has been involved with various applied and research aspects of soil mechanics for over 37 years and has authored more than 100 reports and articles relating to soil mechanics design, dam engineering, construction, in situ testing, laboratory testing, and soil properties. He received his Bachelor's and Master's degrees in civil engineering from Mississippi State University and a Ph.D. from Texas A&M University. He is a Registered Professional Engineer in the State of Mississippi.

USACERL Offers Support for REMR Condition Index Inspections

by Dave McKay, U.S. Army Construction Engineering Research Laboratories

The Facilities Technology Lab of the U.S. Army Construction Engineering Research Laboratories (USACERL) has offered support services to U.S. Army Engineer Districts performing REMR Condition Index (CI) inspections. Over the last 24 months, USACERL provided inspection services for eight navigation lock and dam sites. Indexes for miter gates, miter gate operating equipment, concrete lockwall monoliths, and concrete dam monoliths were obtained. The work was performed under reimbursable purchase orders for the Rock Island and St. Paul Districts.

CIs have been required input for certain work category codes within the Automated Budget System, which is used for managing the Corps' annual Operations and Maintenance (O&M) budget. The CIs result from tangible measurements and serve as a gage of physical deterioration. The numeric indices, varying from 0 to 100, are indicative of the current condition of a structure, and to some extent, its safety and function relative to design parameters. The inspection procedures and instrumentation are designed so that the resulting CIs are repeatable, regardless of the crew performing the inspections. Thus, a Corps-wide uniform standard for condition assessment is available. Amongst other data, the CIs are part of the criteria to be used in prioritizing O&M work packages that fall within 10 percent of the baseline cutoff.

Besides their intended use at the Headquarters level, the CIs are useful at the field level, too. The most direct benefit is derived from taking a closer, more systematic look at the structure than is usually done during periodic inspections. Very often while performing CI procedures, USACERL inspectors have discovered problems about which the lockmasters, lock crew, and District engineers were previously unaware; e.g., for horizontally framed miter gate leaves, measurable gaps between the quoin bearing blocks indicate that most of the gate's load is transferred to the gate anchorages and pintle instead of into the quoin and mass concrete. This condition obviously shortens the fatigue life of the anchorage steel. The problem probably existed from the day the gate was installed, but it is easily corrected.

Another field level benefit is in the data, which provide benchmarks for reference purposes. At one site, USACERL inspectors were asked to look at a miter gate that had been recently hit by a tow. USACERL inspectors took measurements, compared them to measurements that had been taken at the same site 2 years earlier, and discovered that the damage was slight. Therefore, maintenance could be deferred. It is also significant that the damage could actually be quantified. It is now possible to establish trends in deterioration, a potential O&M tool.

Though few people in the Corps who are familiar with the CI fault the legitimacy of the data and procedures, some question the value of the CIs when compared to the cost of doing the inspections. It should be noted that the inland navigation CI procedures were designed to be conducted by lock personnel, or engineers at the GS-09 level; this is not happening in many Districts. Higher level engineers or contractors are performing the inspections. It should also be noted that the greatest benefits obtained from using the CI system are realized when the Districts perform the rating inspections themselves (as opposed to contracting the work out). The more structured approach to these inspections makes engineers more familiar with their facilities and affords a means to quantify or gauge physical deterioration. The indexes in and of themselves have meaning and value, but the inspector's experience of performing a few simple measurements carries value too. As with any new system, there will be a learning curve to overcome. Once the procedures come naturally, the cost of doing them is far from prohibitive.

While USACERL is not discouraging solicitation for full inspection services, it is encouraging Districts to train their personnel to perform these inspections. For more information regarding REMR CI rating systems, and possible support through USACERL, the Civil Works

A Rock Island engineer records leaks at the miter bearing locks

business areas and corresponding points of contact are listed below.

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High-Performance Materials and Systems Research Program

The second program review for the High-Performance Materials and Systems (HPM&S) Research Program was held April 21, 1998, at the U.S. Army Engineer Waterways Experiment Station (WES). Attendees included representatives from U.S. Army Corps of Engineers (USACE) Districts, Divisions, Laboratories, and Headquarters. The purpose of the meeting was to provide HPM&S Field Review Group (FRG) members the opportunity to review ongoing status of funded work units and to consider proposed new starts.

Research efforts funded under the HPM&S Research Program include application of new technology for maintenance and repair of concrete structures, high-performance repair materials for concrete structures, high-performance repair concrete database, overcoating lead-based paint, development of low-cost, high-strength concrete, demonstration of new coating technologies, high-performance paint systems, fiber-reinforced plastic composite gates and sheet piling, and environmentally acceptable lubricants.

During the meeting, the FRG members emphasized the need for rapid transfer of HPM&S-developed technology to the USACE field. The HPM&S Homepage on the Internet will be a major vehicle for disseminating HPM&S technology on a timely basis. This Website is currently under construction and should be online soon at *http://www.wes.army.mil/SL/hpms.htm.* The site will include the HPM&S bulletins, technical notes, fact sheets, points of contact, and schedules of upcoming events.

The next HPM&S Program Review will be held in the spring of 1999.

For information pertaining to HPM&S research, contact Bill McCleese, HPM&S Program Manager, by calling (601) 634-2512 or by e-mailing to *mccleesw@mail.wes.army.mil*. For information regarding the HPM&S Website, contact Lee Byrne, Technology Transfer Specialist, by calling (601) 634-2587 or by e-mailing to *byrnel@mail.wes.army.mil*.

HPM&S Program Review

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 U.S. 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 U.S. Army Engineer Waterways Experiment Station, ATTN: Lee Byrne (CEWES-SC-A), 3909 Halls Ferry Road, Vicksburg, MS 39180-6199, or calling (601) 634-2587; e-mail: *byrnee@mail.wes.army.mil*.

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