TA7
W342.R5
V.6
no.1

y Corps
eers

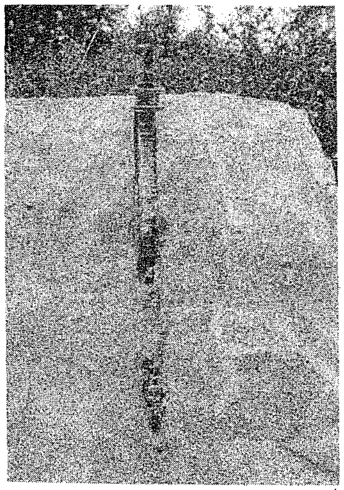
LIBRARY
USE ONLY

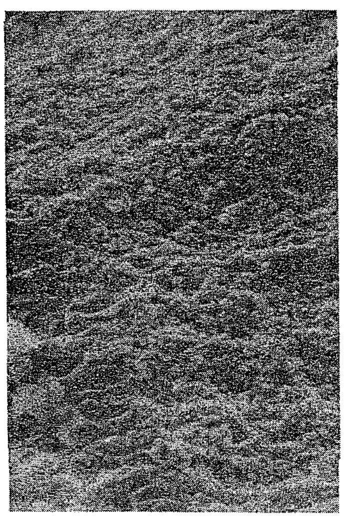
US-CE-C Property of the
United States Government

The REMR Bulletin

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

VOL 6, NO. 1 IINFORMATION EXCHANGE BULLETIN FEB 1989





Installation of anchors in a test block

RESEARCH PROGRAM

Performance of Polyester Resin Grouted Rockbolts Installed Under Wet Conditions

by
Tim Avery
US Army Engineer Waterways Experiment Station

Polyester resin has been used extensively in the geotechnical community for anchoring rock bolts in tunnels and rock slopes. Quite often inflow or standing water is present in the borehole during installation. Findings published in *The REMR Bulletin** indicated that a significant reduction in strength and a higher creep rate is exhibited when bolts are installed in concrete with polyester resin in shallow (1 ft), submerged holes. These findings have generated concern in the geotechnical community regarding the ultimate performance of rock bolts previously installed under similar conditions.

Because of the concern generated by the Bulletin article, Waterways Experiment Station (WES) contracted with the Bureau of Mines Denver Research Center in 1987 to initiate a test program to determine what effect water present during installation would have on anchors

* McDonald, J. E. 1986. "Results from TVA Testing of Grouting Systems for Concrete Anchors," *The REMR Bulletin*, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

longer than 1 ft that are installed with polyester resin.

DENVER RESEARCH CENTER LABORATORY WORK

Polyester resins are either oil or water based, the base being the carrying agent for the benzoyl peroxide catalyst, which causes the resin to polymerize and cure to a solid state. The questions concerning the polyester-resin rock-bolt systems are what effect does water in a borehole have on the dispersion of the catalyst and does this dispersion affect the overall strength of the polyester-resin rock-bolt system.

The test program is shown in Figure 1. Three conditions of wetness were tested: damp, displaced, and submerged. The water was pumped out of the holes designated "damp," and the resin cartridges were installed. The holes designated "displaced" indicate that the volume of the resin and bolt were greater than the volume of the hole; therefore, any water in the hole would be displaced by the resin and bolt during installation and mixing. The holes designated "submerged" had a greater volume than the installed bolt and resin did; therefore, water in the hole would not be completely displaced during installation. Dry holes were necessary to provide a baseline for pull-out test comparison. The "damp" and "water displaced" holes were designed to isolate water effects when the grout column was not submerged. (The term "column foot" (col-ft) will be used to refer to 1 ft of grouted hole containing the bolt.)

TEST SETUP

Concrete blocks with an unconfined compressive strength of 4,000 psi were cast for the test. Concrete's use as the host material was judged suitable in these tests as its characteristics are comparable to those of most rock encountered in rock-bolt installations. One argument against the use of concrete is that its alkalinity is higher than that of most rocks encountered on civil engineering projects, and some research has suggested that high alkaline environments may have negative effects on some polyester resins. However, in geotechnical applications, most rock is slightly

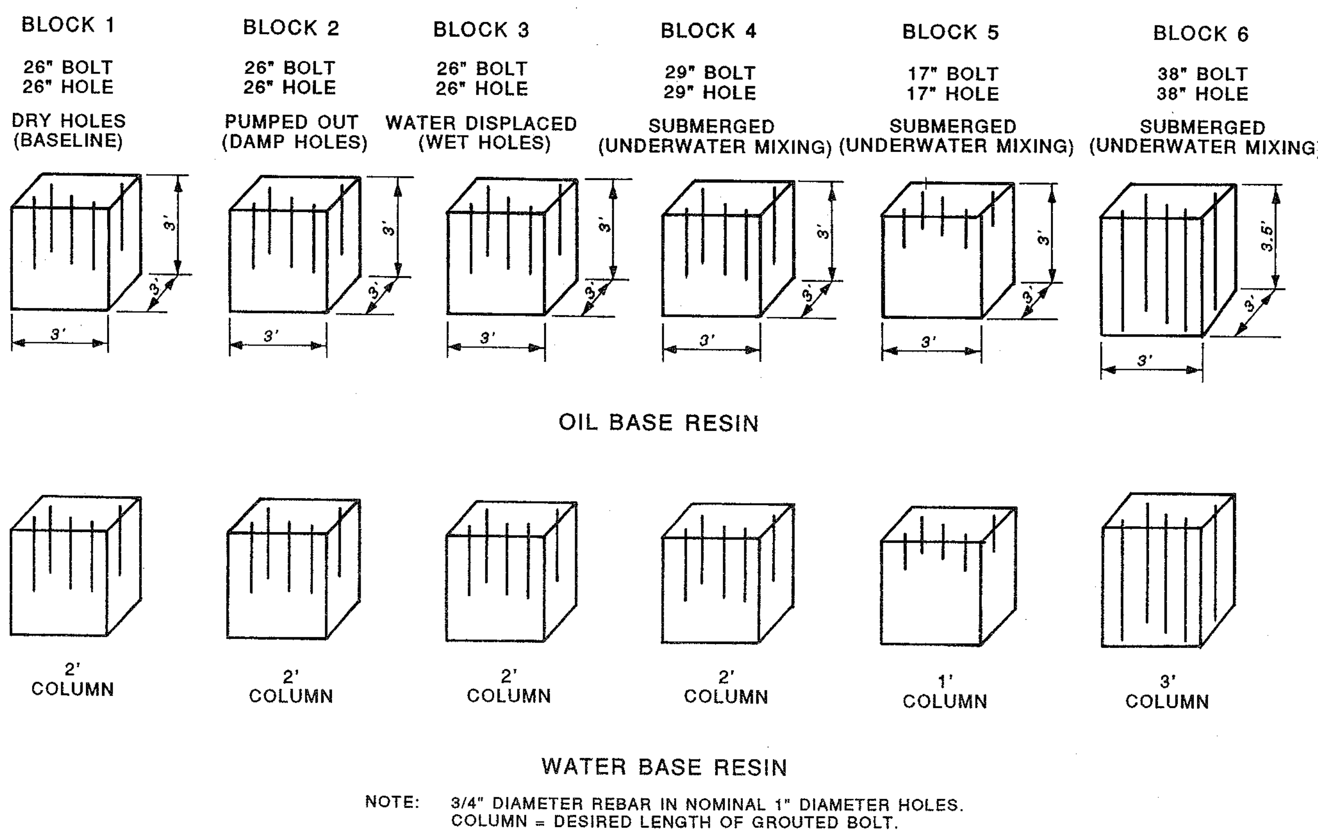


Figure 1. Bolt pull-out tests in concrete blocks

acidic or only mildly alkaline and, therefore, should present only a minor threat to the chemical stability of the resin.

The concrete blocks were cured for 28 days before testing began. Holes were drilled with a masonry diamond-core drill bit that had a nominal 1-in. outside diam. Hole depths were selected to accommodate the appropriate column lengths of both the grout and the bolt for the water conditions in which the anchors were to be tested. All holes, with the exception of those for the dry-condition tests, were kept full of water for a period of 2 weeks before the bolts were installed. This procedure was followed to ensure that the blocks were saturated in order to duplicate as nearly as possible underwater conditions.

The headed bolts used throughout this test were No. 6, Grade 60 steel. The bolts had a minimum load capacity of approximately 26,000 lb and a nominal bolt diam of 0.75 in.

Oil-based and water-based polyester resins were used. Both resins were ordered with a 2-min gel time. The oil-based polyester resin cartridge was 0.9 in. in diam and 12 in. long; the water-based polyester resin cartridge was 0.9 in. in diam and 17 in. long.

INSTALLATION PROCEDURES

The grout tube was inserted into the hole first, and then the bolt was inserted to rest on the grout tube. A Turmag hand drill and chuck were placed on top of the bolt and forced downward to insert the bolt fully into the hole.

The resin manufacturer's specifications for installing bolts in both types of resin were to spin the bolt for 5 to 10 sec after full insertion at 350 to 600 rpm. Slow spinning of the bolt to assist in insertion was an option suggested by the manufacturer. After the resin and the catalyst were mixed, the installer held the bolt in place for a short time during curing. The resin was cured for 16 to 20 hr before pull tests were conducted.

PULL-OUT TEST PROCEDURE

A hydraulic, rock-bolt, pull-out testing apparatus was used to provide test loading in 1,000-lb increments up to 30,000 lb of load. The hydraulic ram was activated with a standard hand-operated pump with a gage calibrated to read force in the desired increments. An extensometer with a calibrated gage reading in 0.001-in increments was mounted between the arm on the pull-head and the surface of the block.

PULL-OUT TEST RESULTS

Minor distortions resulted in some negative readings in the test results. The puller was not seated properly on top of the block because of the blocks' uneven surface, and the bolt head bottom surface was not exactly parallel to the top of the block. Even with a soft aluminum plate between the puller and the concrete surface some unusual readings occurred. These difficulties did not significantly affect the test results. In most cases, the larger initial positive or negative readings simply moved the curve right or left on the graph but maintained nearly the same slope and about the same relative displacement after an adjustment for the initial seating was made. The objective to determine whether grout failure would occur because of the influence of water was accomplished.

Typically, resin-grouted bolts are installed in 2 col-ft of grout or more; consequently, there is a preponderance of tests on the 2-col-ft designs. The pull-out test results show that only one failure occurred up to 30,000 lb of load in bolts installed under wet conditions when 2 col-ft of grout or more was used. This failure was probably caused not by water present in the hole but by "glove fingering," a phenomenon that occurs when a bolt spins inside the grout tube's mylar skin, mixing the resin without shredding the skin and thus preventing the grout from setting up securely against the borehole wall (Figure 2).

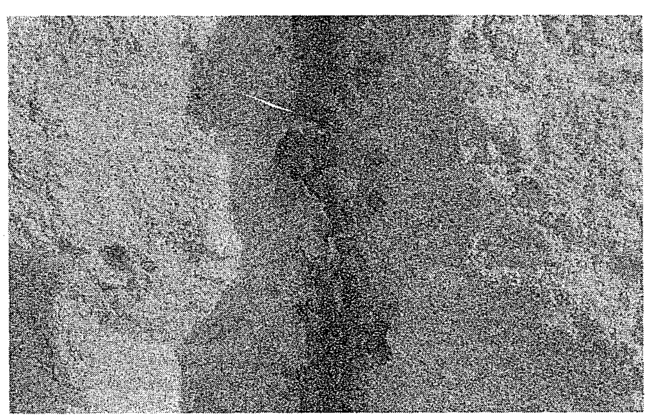


Figure 2. Closeup of lower portion of hole in which "glove fingering" has occurred

Anchors installed in 2 and 3 col-ft of oil-based resin under submerged conditions show a noticeable difference in test results in comparison with results of anchors installed in 2 col-ft of oil-based resin in dry holes. The 2-ft-long submerged-installed anchors exhibited nearly twice the displacement of the 2-ft-long dry-installed anchors. The greater amount of displacement for the submerged conditions could be the result of a weaker upper zone of a water-resin emulsion which resulted during mixing. Such a weakened upper zone would allow greater deformation of the bolt and act as an ungrouted free length.

The results of pull-out tests on anchors installed in sumberged holes in 3 col-ft of oil- and water-based resins showed no failures. However, there was greater elongation of the bolts in the water-based installation. The water-based installations exhibited between 0.04 and 0.23 in. of displacement, while the oil-based installations exhibited between 0.04 and 0.12 in. of displacement. This difference was likely caused by there having been less grout in the water-based hole, leaving a portion of the top of the bolt ungrouted.

The most significant result of the testing occurred in the blocks in which only 1 col-ft of grout was used. All of the oil-based installations failed at relatively low loads (7,000 to 17,000 lb), while the water-based resin installations exhibited significantly greater strengths (22,000 to 30,000 lb). These were the last two installations; therefore, they received the most consistent installation procedures. Five pull-out tests of each type are not enough to provide conclusive data, but there is a distinct difference in the strength exhibited by the two.

Both of the blocks with the 1-ft anchors were broken to expose holes 1 and 4. Figure 3 shows the

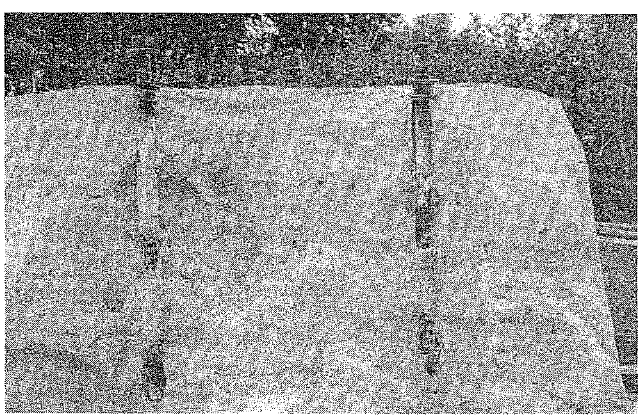


Figure 3. Exposed holes in 1 col/ft of oil-based resin

block in which the oil-based resin was installed. Both holes show a poor column of grout. Hole 1 failed at about 7,000 lb, while hole 4 held to almost 17,000 lb.

Figure 4 shows the block with the water-based resin. The two exposed holes show a much better column of grout near the bottom than did those in the block with the oil-based resin. Hole 1 held about 30,000 lb; hole 4, about 22,000. This difference between the water-based and the oil-based resin is not very evident where the lower part of both holes looks relatively competent. It appears that oil-based resin resists the presence of water, while the water-based resin may assimilate some of it, and because of this assimilation retain more of its strength when installed under wet conditions.

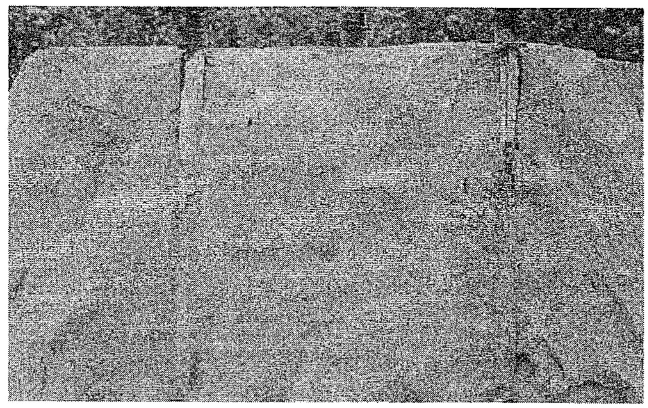


Figure 4. Exposed holes in 1 col/ft of water-based resin

Several other blocks were broken to expose the grout column. Close observation reveals that most failures occurred at the bolt-grout interface and not at the grout-concrete interface. In some cases, the inside surface of the grout was still soft, indicating that the grout had not mixed and cured properly at the bolt-grout interface. No bolt failures were observed in any test even though the test load was well above the minimum yield strength of the bolt.

CONCLUSIONS

In a sealed, submerged borehole, water appears to affect the resin by mixing with the top 12 to 14 in. to form an emulsion. This emulsion may be too diluted to catalyze effectively, and thus the resin may not set. Resin under this zone is more representative of the test conducted on "damp" holes and is not affected by the presence of water.

From the analysis of the test data, it appears that water is detrimental to the successful curing of polyester resins only in situations involving very short anchors (less than 2 ft).

RECOMMENDATIONS

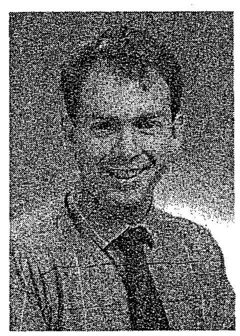
A simple solution to this problem is to drill the bore hole 1 ft deeper than desired and to add an additional cartridge of resin. Also, keeping the hole diameter no larger than 1/4 in. beyond the diam of the bolt will limit the empty volume of the hole which water can occupy. An additional benefit of keeping the annulus as small as possible is the reduction of creep potential of the anchor.

In addition, certain installation methods can also reduce the potential for the emulsification of water and resin. One method is to tamp cartridges firmly into the hole prior to inserting and spinning the bolt so that the resin cartridge is compressed in the hole and the ambient water expelled. Following this step, it would be advantageous to rotate the bolt slowly through the resin to the bottom of the hole and then to increase the rpms to the speed desired for mixing. Finally, in holes shorter than 6 ft, a faster-set resin such as is used by the mining industry will reduce the time required for mixing and thereby reduce the emulsification potential of the resin and water.

SUMMARY

Polyester resin was first introduced in this country's mining industry in the early 1970s. The mining industry today installs upwards of 60 million bolts per year with resin. While they do not rely as heavily on permanence as civil works construction does, their proven success with the resin system under extreme environmental conditions attests to the resin's durability. The key factor is to insure that the resin is not being used for installations that are beyond its capability (a determination that is not always apparent) and that the resin is installed properly. When different or unusual conditions are encountered, the resin manufacturer should always be consulted. Furthermore, pull tests should be conducted before a committment is made to use resin in difficult ground conditions or on unusual anchoring projects.

For further information contact Tim Avery at (206) 872-0500.



Tim Avery received his M. S. degree in 1986 in the field of geological engineering from the University of Arizona, Tuscon, Arizona. At the US Army Engineer Waterways Experiment Station Mr. Avery worked in the Rock Mechanics Application Group, Engineering Geological and Rock Mechanics Division, Geotechnical Laboratory. After leaving WES Mr Avery worked in the Geotechnical Branch of the Portland District, US Army Corps of Engineers, before moving to his present assignment as Sales Engineer, The Robbins Company, Seattle, Washington.

Deposition of Calcium Carbonate in Foundation Drain Holes

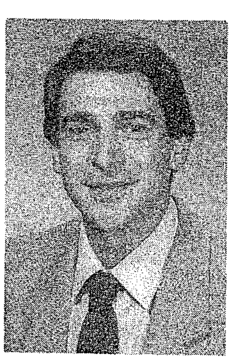
by
Andrew Schaffer
US Army Engineer Waterways Experiment Station

The performance and rehabilitation of foundation drain holes (rock drains) beneath gravity structures have been identified as major concerns affecting the reevaluation of stability. Frequent observations indicate that rock drains decrease in efficiency over time because of the deposition of calcium carbonate. Such decreases in drain efficiency generally result in increases in uplift pressures.

In 1988, a drilling investigation was undertaken to determine the extent and nature of the calcium carbonate incrustation that forms on the walls and in the joints intersecting a rock drain. The site for the investigation was Old Hickory Dam, located on the Cumberland River northeast of Nashville, TN. Old Hickory is a concrete gravity dam that was built in the mid-1950's. Its drains have never been redrilled, but they have been probed with rods and flushed with water on a regular basis since 1962.

The spillway section of the dam is founded on the Cannon Formation, an argillaceous limestone of Ordovician age. The incrustation encountered during drilling (Cannon C) was gray to dark gray, finely crystalline, and often wavy bedded; it contained laminations of hard, black shale.

Drilling was performed with a Sprague and Henwood 40C double-post drill. A 3-in.-diam drain was overcored to 8 in. so that the incrustation in and directly around the drain could be recovered. In addition, 3-in.-diam (NX) holes were drilled around the overcore so that the rock mass could be inspected farther from the drain. The relative locations of the holes are shown in Figure 1. The two holes nearest the overcore are 6 in. from the original drain; the far hole is 12 in. from the drain.



Andrew Schaffer is a research civil engineer in the Engineering Geology and Rock Mechanics Division, Geotechnical Laboratory, Waterways Experiment Station. He has been with the laboratory since 1986 and has been involved in a number of projects in the field of rock mechanics. Mr. Schaffer received his B. S. and M. S. degrees in geological engineering from the University of Arizona. He is principal investigator for REMR Work Unit 32414, "Improved Performance of Rock Drains."

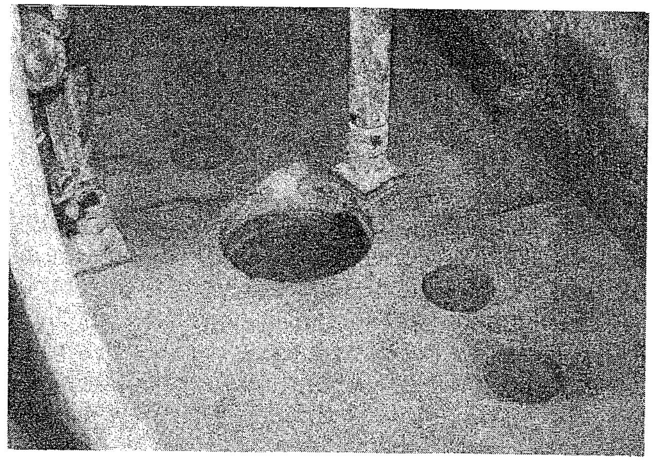


Figure 1. Relative locations of holes drilled in the investigation

Drilling Investigation

Several encrusted bedding plane joints within shale seams at depths of 13 to 17 ft were recovered by overcoring. Investigators observed a significant increase in ground-water inflow after drilling through this zone. Figure 2 shows one such overcored seam. The NX cores are in their relative positions and show the same layer of rock at that depth. It is apparent from this rock and the other recovered joints that most of the calcium carbonate is contained in the overcore. In all cases, the NX cores show the surrounding rock to be free of calcite. In each joint a small ring of incrustation has formed in the first 0.25 to 0.375 in. from the drain wall. In summation, the problem of calcification in joints is a very localized one.

The calcification that occurs inside the drain is persistent throughout the entire depth of the hole. A photomicrograph of the incrustation inside the drain (Figure 3) shows the bulk of the incrustant to be an oolitic limestone that is poorly

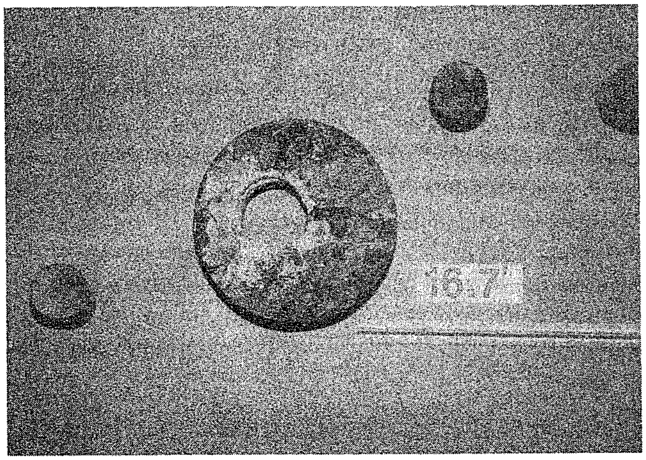


Figure 2. Calcification in shale seam

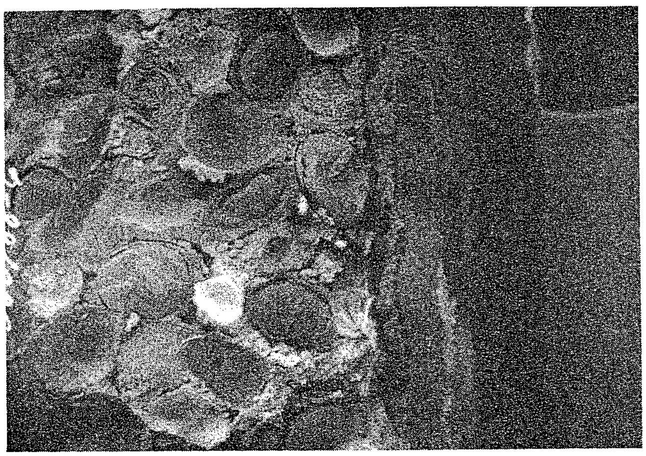


Figure 3. Photomicrograph of calcium carbonate inside the drain

cemented together. A 140X magnification of this material (Figure 4) reveals that it is coarse, crystalline, and porous. In contrast, the material shown on the right in Figure 3 is entirely different. This material has been in direct contact with the drain hole wall. It is approximately 1 mm thick throughout the depth of the hole. A 425X magnification of this material (Figure 5) reveals that it is hard, dense, and microscopic. This incrustation on the walls appears chiefly responsible for the reduction of drain inflows. Also, the joint material was found to exhibit both crystal habits, although a higher proportion of dense incrustant was observed. The drain chosen for overcoring has a history of hole blockages at depths of 20 to 23 ft. Although it had been opened during cleanings, the drain was plugged throughout the 3-ft interval (Figure 6). However, no flow was recovered at this depth by overcoring. In addition, the blockage was well below the zone where all of the ground-water flow was occurring, an indication that other conditions were responsible for its formation.

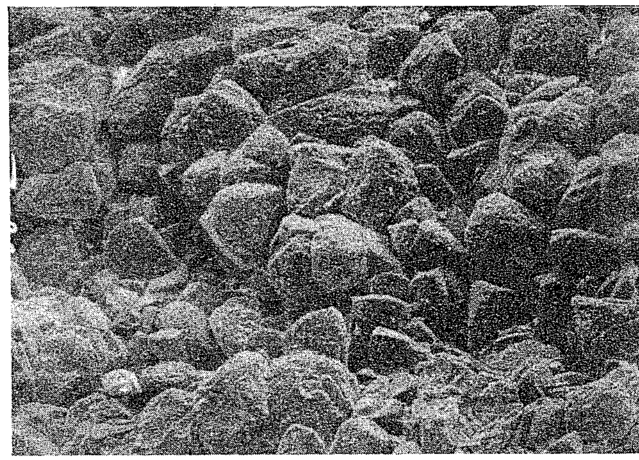


Figure 4. Photomicrograph of coarse, crystalline incrustant corresponding to left side of Figure 3, 140X magnification

Figure 5. Photomicrograph of microcrystalline incrustant in direct contact with the wall of the drain hole

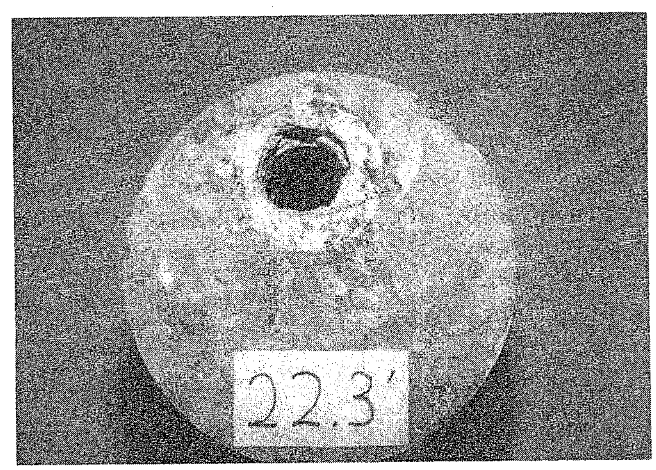


Figure 6. Hole blockage

Conclusions

Calcification was found to occur in joints that intersect foundation drain holes, implying that simply cleaning the interiors of the drains will not remove everything. However, the incrustation was found to be of limited extent, occurring less than 6 in. from the drain. A large percentage of the material forms as a small ring immediately around the drain hole. Therefore, if permeability enhancement of the surrounding rock mass is to be contemplated, only a small volume of rock needs to be treated. If redrilling is to be performed, even a slight enlargement of the hole will give some measure of improvement.

Inside the drain, the calcium carbonate in direct contact with the wall presents the greatest problem and will prove to be the most difficult to remove by an alternative cleaning method such as a water jet or a rotary pipe cleaner. Blockages, on the other hand, were found not to be directly related to inflow. Although they should be cleaned to maintain an open hole, simply removing them will not necessarily improve the performance of a drain.

For further information, contact Andy Schaffer at (601) 634-2362.

Effects of a Stearic-Acid Based Admixture on Water Repellency of Concrete

by
Kim Titus
National Park Service

Many reinforced-concrete structures in the United States are suffering from serious deterioration as a result of fresh- and saltwater seepage into the concrete. Moisture in the presence of oxygen causes corrosion of the reinforcement and subsequent cracking and failure of the concrete cover over the reinforcement (Figure 1). If chloride is in the water, the probability of corrosion is much greater.

Water-repellent concrete will retard the movement of water into and through the concrete and, therefore, delay the corrosion of the reinforcement; however, if the concrete is not water-repellent, the water will be able to penetrate to the steel much faster. Water repellency, therefore, may be extremely important as it may significantly influence the service life of reinforced concrete structures exposed to water.

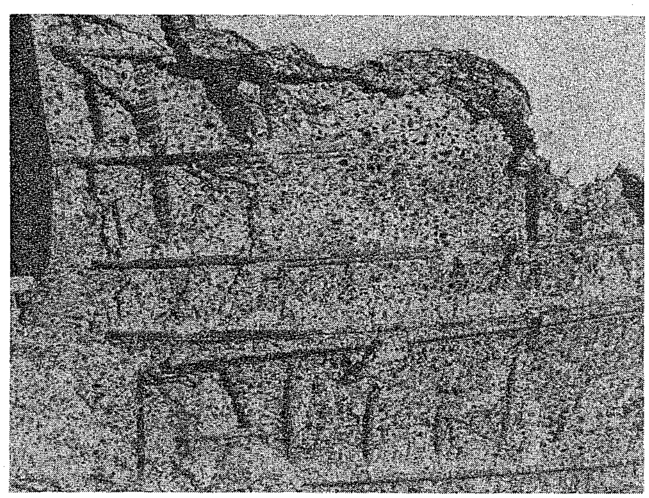


Figure 1. Moisture in the presence of oxygen causes corrosion of the concrete reinforcement steel. Water-repellent concrete will retard the movement of water through the concrete and extend the service life of a structure

Background

A limitation of conventional concrete, even that of good quality, is that voids in the concrete account for 8 to 14 percent of the total volume. Water is able to pass through this space by several processes: vapor diffusion, surface diffusion of absorbed films, capillarity driven by surface tension forces, and penetration caused by external hydrostatic pressure.

Generally the movement of water by vapor transmission, such as drying after proper curing, is not a problem. However, where concrete is in contact with moisture, such as below the water table or in damp soil, water can be drawn through the concrete into the structure. This absorption of moisture can lead to objectionable dampness as well as damage to floor coverings, furnishings, or equipment. Water transmission under such conditions can also result in the dangerous accumulation of aggressive salts in the concrete, leading to corrosion of the reinforcing steel and deterioration of the concrete itself. Capillarity may cause similar problems in concrete exposed to periodic wetting with water containing salt or other aggressive agents such as in the intertidal or splash zones. Therefore, control of water (salt) movement may be critical to achieving required performance and durability (Aldred 1988a, 1988b). Capillary continuity will not be present in concrete after moist curing unless the water-to-cement ratio (W/C) is high. Concrete stored moist will not have capillary continuity after the indicated length of time after casting, depending on W/C:

W/C	*Time After Casting*
0.4	3 days
0.5	14 days
0.6	6 months
0.7	1 year
0.8	never

Designers have often attempted to isolate the concrete from water by using surface coatings. It is difficult, however, to ensure that there are no weak points or faults caused by workmanship, mechanical damage, or service conditions. Through these weak points, water, along with dissolved salts or acids, that penetrates the concrete can lead to leakage, dampness, and possibly corrosion, all of which are difficult to repair effectively.

Attention also has been focused on concrete admixtures that are claimed to reduce the ability of water to enter and move through the concrete. Some admixtures currently being used for water repellency include soaps, butyl stearate, and certain petroleum products. American Concrete Institute (ACI) Committee 212 describes these admixtures as follows (ACI 1986):

- Soaps comprise salts of fatty acids, usually calcium or ammonium stearate or oleate. The soap content is usually 20 percent or less, the remaining being calcium chloride or lime. Total soap added should not exceed 0.2 percent by weight of cement. Soaps cause entrainment of air during mixing.
- Butyl stearate reportedly performs better than soap as a water repellent. It does not entrain air and has a negligible effect on strength. It is added as an emulsion with the stearate being 1 percent by weight of the cement.
- Petroleum products, including mineral oils, asphalt emulsions, and certain cutbacks have proved to be effective under pressure.

Laboratory Test

Adam Neville (Neville 1988) of A&M Neville Engineering Ltd. recently reviewed a technical report prepared by Taywood Engineering Ltd. Research Laboratories in 1988. The report presents the results of several tests on two heat-cured concretes made using fly ash, the essential difference being the use of a stearic-acid admixture (Taywood Engineering 1988). The following summarizes Professor Neville's comments concerning the test results.

The test specimens were cast insulated so as to simulate a precast concrete unit 300 mm thick. The tests performed were the following:

- Compressive strength of 100-mm test cubes, temperature match cured
- Water sorptivity of cores.
- Water absorption of cores.
- Water permeability of cores.
- Salt penetration into test specimens.

The concrete with the admixture had a somewhat higher compressive strength than the control. This higher strength indicates that the admixture has no adverse effect on the structure of the hydrated cement paste. The water sorptivity test was developed by Taywood Engineering, who also devised a method for correlating water sorptivity with the initial surface absorption test (ISAT) method of British Standard 1881 (British Standards Institution 1983). The sorptivity values are 0.142 mm/min for the control and 0.032 mm/min for the concrete with the admixture. The ratio of the two values is about 4.5:1, indicating a very large reduction in the sorption properties of the admixture concrete, no doubt because of its hydrophobic and pore-blocking properties. The surface absorption values also showed a marked difference between the two concretes. Even as early as 10 min into the test, the ISAT value for the admixture concrete was 4.5 times smaller than for the control. This ratio remains after 2 hr.

The water sorptivity value obtained in the tests for control (0.142) falls within the "acceptable" category (0.12 to 0.23 mm/min) as prescribed by Taywood Engineering. The admixture concrete had a value of 0.032, which was well into the "very good" category (0.12 mm/min or better). In the water absorption test, the admixture concrete showed a much better performance (0.47 percent) than control (1.59 percent).

The tests for permeability were performed on two samples for each concrete: one from 0 to 50 mm and the other from 50 to 100 mm from the surface as cast. From 0 to 50 mm the permeability coefficients were 2.23×10^{-12} m/sec for control and 1.12×10^{-12} m/sec for the admixture concrete. The difference between the two values is not significant. From 50 to 100 mm the values differ considerably, being 14.3×10^{-13} and 1.45×10^{-13} for control and admixture concrete, respectively. This improvement of an order of magnitude in the permeability of the admixture concrete is significant. Professor Neville states that the absence of a significant difference in permeability in the 0- to 50-mm part may be related to variations in curing or that perhaps the effectiveness of pore blocking as a result of the use of the admixture occurs only a small distance from the surface of the concrete as cast because the admixture product has to coalesce. This process of coalescence occurs under the initial pressure of external water; therefore, the product is forced some distance inward.

The tests for chloride penetration consisted of four cycles of wetting and drying. The results show a lower chloride content in the admixture concrete than in the control in the outer 5 mm and no difference in depths up to 55 mm. Professor Neville states that these data are not conclusive because the number of cycles was inadequate to drive the chlorides deep into the concrete. Chloride salts move inward by a series of steps involving wetting, evaporation of water, deposition of salt crystals, rewetting and dissolution of crystals, diffusion of chloride ions from a zone of higher concentration to a zone of lower concentration, and so on. This process takes time, and Professor Neville feels that 50 to 100 cycles are necessary for any difference to be discerned (Neville 1988). There is some supporting evidence that such a difference between admixture concrete and control exists. Tests performed by Trow Inc., consulting engineers in Brampton, Ontario, Canada, showed that after 90 cycles, the admixture concrete had a much lower chloride content than the control. The critical discrimination between the two concretes should be based on their ability to affect water movement. All three relevant tests, namely sorptivity, water absorption, and hydrostatic pressure, showed a significant superiority of the admixture concrete. The control concrete was also a high-quality concrete. Professor Neville states, "The question to be considered is whether such upgrading is necessary or justified, bearing in mind the additional cost of the admixture system" (Neville 1988). The answer depends on the intended life of the structure, cost of repairs, the ease with which repairs can be made, and the economic repercussions of any disruptions caused by the repairs. According to Professor Neville the test data on penetrability given in the Taywood Engineering Report indicate that the use of the admixture would greatly slow down any movement of water through the concrete. The value of this slower water penetration is worthy of consideration.

For further information, contact Bill McCleese at (601) 634-2512.

Kim Titus is Project Supervisor of Construction for the Department of Interior, National Park Service, Denver Service Center. She received her B.S. degree in civil engineering from the Colorado School of Mines. Ms. Titus has been Inspector and Project Supervisor for various construction projects for the Bureau of Reclamation and the National Park Service. The projects have included pumping and wastewater treatment plants, canals, visitor centers, boat docks, and posttensioned effluent storage tanks.

References

Aldred, James M. 1988a. "Sorptivity as an Indication of Concrete Durability in Marine Environment," Second International Conference on Performance of Concrete on Marine Environment, Supplementary Papers, St Andrews, N. B. Canada, pp 215-243.

Aldred, James M.. 1988b. "Tests on the Short Term and Long Term Performance of Waterproofing Admixtures," Technical Note, Cementaids (SEA) Pte Ltd, Singapore.

American Concrete Institute Committee 212. 1986. "Admixtures for Concrete," ACI Manual of Concrete Practice, 30 pp.

British Standards Institution. 1983. "Method for Determination of Water Absorption," BS 1881, Part 122.

Neville, Adam. 1988. "Interpretation of Tests Comparing Heat-Cured PFA Concretes with and without the Everdure Caltite System," London.

Taywood Engineering. 1988. "Properties of Caltite Concrete Subject to Marine Exposure," Technical Note 1276, London.

News in Brief

The "REMRNET Update" article in the last *REMR* bulletin had a typographical error in the ID which precluded access to the OnTyme system. The following procedures should be used to access REMRNET:

please log in: EMSACORPS

ID? CORPS.DAENRDBB

KEY? 8-YOURKEY

Log-in procedures may change in February as a result of modifications to the OnTyme system. Additional information will be provided as necessary. Questions should be addressed to the REMRNET monitor at (601) 634-3243 or by leaving a message for OnTyme ID CEWE.S-SC-A (note new ID syntax).

■ ■ ■

Appreciation is extended to Mrs. Lee Byrne for her special assistance in the transfer of technology for the *REMR* Research Program since May 1988. Mrs Byrne is an editor in the Information Products Division, Information Technology Laboratory.

■ ■ ■

Ms. Elke Briuer has been selected as the Technology Transfer Specialist for the *REMR* Research Program. Ms. Briuer comes to Waterways from San Antonio, Texas, where she was a Public Affairs Specialist for the US Army 5th Recruiting Brigade, Advertising and Public Affairs.

Supplement 2 to *REMR* Notebook Ready

Subscribers should be receiving Supplement 2 to the *REMR* Notebook during February. The cover sheet, as well as updated index, will be mailed separately.

Request for Articles

Attention:	Readers with experience in REMR activities
Subject:	Request for articles, reports, photographs, news, and notices about your REMR activities
What to do:	Send us a draft of your article. Furnish any illustrations you have (original glossy photographs and line drawings)
What we'll do:	Publish your article under your byline. Provide you with editorial assistance if needed
Contact us:	By writing—Commander and Director, US Army Engineer Waterways Experiment Station, ATTN: CEWES-SC-A, PO Box 631, Vicksburg, MS 39181-0631 By calling—Bill McCleese, (601) 634-2512

REMR Research Program

KEY PERSONNEL

	Office	Office Symbol	Commercial No.
DRD Coordinator, HQUSACE			
Jesse A. Pfeiffer, Jr.	Civil Works Programs	CERD-C	202-272-0257
Overview Committee, HQUSACE			
James E. Crews (Chairman)	Operations Branch	CECW-OM	202-272-0242
Tony C. Liu	Structures Branch	CEEC-ED	202-272-8672
Program Management			
William F. McCleese (Program Manager)	Structures Laboratory, WES	CEWES-SC-A	601-634-2512
CPT Greg May (Deputy Program Manager)	Structures Laboratory, WES	CEWES-SC-A	601-634-3243
Elke Briuer (Technology Transfer Specialist)	Structures Laboratory, WES	CEWES-SC-A	601-634-2587
Problem Area Leaders			
James E. McDonald (Concrete and Steel Structures)	Structures Laboratory, WES	CEWES-SC-R	601-634-3230
G. Britt Mitchell (Geotechnical—Soils)	Geotechnical Laboratory, WES	CEWES-GE-E	601-634-2640
Jerry S. Huie (Geotechnical—Rock)	Geotechnical Laboratory, WES	CEWES-GR-M	601-634-2613
Glenn A. Pickering (Hydraulics)	Hydraulics Laboratory, WES	CEWES-HS-L	601-634-3344
D. D. Davidson (Coastal)	Coastal Engineering Research Center, WES	CEWES-CW-R	601-634-2722
Ashok Kumar (Electrical and Mechanical)	Construction Engineering Research Laboratory	CECEL-EM	217-373-7235
John Cullinane (Environmental Impacts)	Environmental Laboratory, WES	CEWES-EE-S	601-634-3723
Anthony M. Kao (Operations Management)	Construction Engineering Research Laboratory	CECEL-EM	217-373-7238
Field Review Group			
OPERATIONS MEMBERS:			
Thomas Pfeffer	Missouri River Division	CEMRD-CO-O	402-221-7289
James C. Wong	New England Division	CENED-OD-P	617-647-8411
Robert Neal	North Central Division	CENCD-CO	312-353-6378
John J. Sirak, Jr.	Ohio River Division	CEORD-CO-M	513-684-3418
Carl F. Kress	South Pacific Division	CESPD-CO-O	415-556-8549
Jerry Smith	Southwest Division	CESWD-CO-O	214-767-2433
ENGINEERING MEMBERS:			
Victor M. Agostinelli	Lower Mississippi Valley Division	CELMV-ED-TS	601-634-5932
Eugene Brickman	North Atlantic Division	CENAD-EN-MG	212-264-7141
John G. Oliver	North Pacific Division	CENPD-EN-T	503-221-3859
Henry Nakashima	Pacific Ocean Division	CEPOD-ED-T	808-438-7045
James W. Erwin	South Atlantic Division	CESAD-EN-F	404-221-4256

2/89

List of *The REMR Bulletin* Articles

Number	*Date*	*Title*
Vol 1, No. 1	Jan 1984	The REMR Research Program
Vol 1, No. 2	Apr 1984	Mobile District Hosts Third Field Review Group Meeting
Vol 1, No. 3	Jul 1984	Acrylic Latex Concrete Repair, by Rosemarie Braatz
		Seattle District Testing Novel Approach to Reducing Spillway Leakage at Chief Joseph Dam, by Paul Johnson
Vol 1, No. 4	Oct 1984	Memphis District Turns Riverward for Levee Rehabilitation, by Joseph Keithley, Jr., and Paul Miller
		CAGE Project Can Aid Data Gathering and Analysis for Geotechnical Applications, by Wipawi Vanadit-Ellis
		Construction of Soil-Cement Columns by Jet-Injection Grouting, by Max Gibbs, Paul Pettit, and Georgio Guatteri
Vol 2, No. 1	Mar 1985	Mining Tool Adapted to Concrete Removal for Lock Wall Rehabilitation Project, by Warren Parr
		Corps-BuRec Effort Results in High-Resolution Acoustic Mapping System, by Henry Thornton
Vol 2, No. 2	Jun 1985	French Drilling Machine Shows Advantages in Excavating for Concrete Cutoff Wall, by Charles Hess
		Geophysical Methods Applied to Detect and Map Seepage Paths at Clearwater Dam, by Dwain Butler
Vol 2, No. 3	Sep 1985	New Technique for Waterstop Replacement Used at Pine Flat Dam, by Debra Tanis
		Performance of Repairs to Stop Leakage in Intake Structures, by James McKenzie and Roy Campbell
Vol 3, No. 1	Apr 1986	Current Methods for Repairing Scoured Areas Downstream from Stilling Basins, by John Hite, Jr.
		Research Under Way on Problems with Estuarine and Deep-Draft Navigation Channel Training Structures, by Robert Athow, Jr., and Michael Trawle
Vol 3, No. 2	Sep 1986	Floating Debris Control Systems for Hydroelectric Plant Intakes, by Roscoe Perham
		Protection of Lock Gates from Vessel Impact, by Sandra McKay
Vol 3, No. 3	Dec 1986	Results from TVA Testing of Grouting Systems for Concrete Anchors, by James McDonald and Floyd Best
		Precast Panels Speed Rehabilitation of Placer Creek Channel, by Kathy Hacker
Vol 4, No. 1	Jul 1987	Precast Concrete Stay-In-Place Forming System for Lock Wall Rehabilitation, by James McDonald
		Remedial Measures to Control Excessive Leakage at Richard B. Russell Dam, by Gary Close and John Hager
Vol 4, No. 2	Oct 1987	Anti-Washout Admixtures for Use in Underwater Concrete Placement, by Kenneth Saucier and Billy Neeley
		Use of Fiber-Reinforced Acrylic Polymer Modified Concrete as Repair Material at Lock 2, by Michael Dahlquist
Vol 4, No. 3	Nov 1987	Nondestructive Testing of Foundation at Lock No. 2, Mississippi River, by Michael Dahlquist
		Chemical Grout Used to Stop Water Leakage in Control Towers and Conduits, by Rick Lewis and Larry Brockman
		Chemical and Asphaltic Grouts for Sealing Coastal Structures to Sand Infiltration and Wave Transmission, by David Simpson
Vol 4, No. 4	Dec 1987	Concrete Rehabilitation at Lock and Dam No. 20, Mississippi River, by Jerry Wickersham
		Epoxy Repair of Cracked Wooden Roof Trusses, by MAJ Sean Wachutka
		Stabilized Channel Maintenance and Aquatic Habitat, by Douglas Shields, Jr.

(Continued)

List of *The REMR Bulletin* Articles (Concluded)

Number	Date	Title
Vol 5, No. 1	Mar 1988	Spillway Rehabilitation at Grapevine Lake, Fort Worth District, by Ronald Turner and Bob Fletcher
		Ultrasonic Pulse-Echo Measurements of the Concrete Sea Wall at Marina Del Rey, Los Angeles County, California, by Henry Thornton and Michel Alexander
		Environmental Impacts of Stilling Basin Dewaterings, by Marc Zimmerman
Vol 5, No. 2	Jul 1988	Evaluation of Vinylester Resin for Anchor Embedment in Concrete, by James McDonald
		Floating Debris Boom Evaluation Program Summary, by Roscoe Perham
		Comparison of Corps of Engineers' and US Bureau of Reclamation's Methods for Calculating Uplift Pressures, by Carl Pace
Vol 5, No. 3	Sep 1988	Use of New Well Redevelopment Techniques on Relief Wells in Upper Wood River Drainage and Levee District, by Joseph A. Kissane
		Determination of Relief Well Infestation with the Use of a Bacterial Activity Test (BAT) Kit, by Roy Leach
		Jetty Repair Projects: Potential Beneficial Impacts, by Douglas G. Clarke

COVER PHOTOS

Exposed holes in 1 col/ft of oil-based resin.

Photomicrograph of microcrystalline incrustant in direct contact with the wall of the drain hole.

The REMR *Bulletin*

The REMR Bulletin is published in accordance with AR 310-2 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. Contributions 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, publication, or promotional purposes. 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 the Commander and Director, US Army Engineer Waterways Experiment Station, ATTN: Bill McCleese (CEWES-SC-A), PO Box 631, Vicksburg, MS 39181-0631, or calling 601-634-2587.

DWAYNE G. LEE
Colonel, Corps of Engineers
Commander and Director

Library Branch
Technical Information Center
U.S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

DEPARTMENT OF THE ARMY
WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS
PO BOX 631
VICKSBURG, MISSISSIPPI 39181-0631

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

CEWES-SC-A

3 5925 00362 3979