

The CERCuilar

Coastal Engineering Research Center

Vol CERC-97-1

January 1997

New Criteria to Reduce Project Costs

by Fred E. Camfield¹

Laboratory investigations were recently conducted at the U.S. Army Engineer Waterways Experiment Station (WES) Coastal and Hydraulics Laboratory (CHL) to improve design criteria for selectively placed armor stone on coastal structures to reduce the cost of future construction. Present field practice is to place quarystone armor units to provide the best fit obtainable for particular site conditions. The selective placement of quarystones one at a time to achieve the best fit, often called standard placement, is known to provide better stability and a tighter interlocking of the armor stones (Camfield 1996a). The tighter fit of armor stones using this placement method may allow the use of a single layer of armor stones.

Objectives of the investigations were to determine the feasibility of single armor layer construction, and reduce the required size of armor stones. Smaller stone would be easier to obtain from a quarry (CIRIA/CUR 1991), easier to transport, and could be placed with smaller equipment. Use of a single armor layer instead of two layers required for randomly placed stones would substantially decrease the total tonnage of stones required. Based on experience with construction costs, it is estimated that costs could be reduced as much as 25 to

30 percent for some coastal structures.

Laboratory Investigations

Investigations were conducted in a 2-ft-wide laboratory flume using monochromatic and spectral waves (Figure 1). Model revetment structures with single armor layers were constructed on slopes of 1:1.5 (vertical:horizontal), 1:2, and 1:3. A foreslope of 1:50 was used in front of the structure. The model revetments were constructed to be "impermeable" with a dense sand embankment overlain with filter cloth under the revetments. Layers of smaller bedding stone were used under the model armor stone.

Experiments were conducted with waves breaking on the model revetments. A total of 11 model revetments were evaluated to incipient failure. Incipient failure was defined as the condition where armor stones began to be displaced (at least one armor stone displaced or strong movement; i.e., waves lifting an armor stone completely up and dropping it back into place). For the structures tested, this was displacement or strong movement of less than 1 percent of the armor stones. Actual "failure" of an armor

layer is not easily defined. The incipient failure noted typically left a small hole in the armor layer as the other stones remained interlinked. Continued testing with larger waves would eventually displace an additional stone, which typically left a second hole in the armor layer. For the investigations conducted, the smaller underlayer stone was never displaced from the structure.

Based on the Hudson equation (*Shore Protection Manual*, 1984), stability coefficients at incipient failure (as defined above) ranged from $K_D = 4$ (where one or more stones were not as well placed during construction) up to a maximum $K_D = 23$ (where stones were very well placed). No consistent trend was found in these results to relate wave period to stability. It was noted that individual stones responded to some wave periods, but not necessarily the longest wave period (Camfield 1996b).

Considerations of Revetment Slope

Factors affecting the design decision regarding structure slope will vary between project sites. This is often dictated by site conditions; e.g., the natural ground slope at a shoreline. In general, steep slopes will use less stone, and the stone may be more easily placed because the reach requirement of the equipment is shorter. The stones used in the model investigations tended to stack together tighter on the 1:1.5 slope and tended to have higher stability coefficients than the model

¹Fred Camfield was a Research Hydraulic Engineer with the WES Coastal and Hydraulics Laboratory prior to his retirement in December 1996.

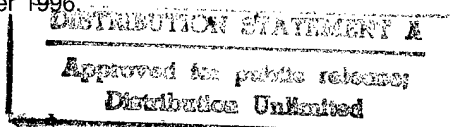




Figure 1. Laboratory investigation of selective placement of quarrystone armor units

revetments with flatter slopes (Camfield 1996c). However, the model revetments constructed with a 1:1.5 slope exhibited slope failure (the entire armor layer tended to slip downward) if the toe of the armor layer was not keyed in well at the bottom, so careful construction of the revetment toe is required. Also, stronger wave reflection would be expected with a steeper slope. Specific model conditions for the 1:1.5 revetment slope produced strong wave-structure interaction, which is believed to be dependent on the combination of wave and site variables. Parameters determining wave-structure interaction are not yet well-defined. As wave-structure interaction may produce the critical condition for structural failure, structures designed for steeper slopes should be carefully model tested.

Recommendations

Model revetments constructed with a single layer of armor stones

performed well in the laboratory tests. A single layer of armor stones is recommended for coastal revetments in those cases where stones will be selectively placed. This will substantially reduce the tonnage of armor stones required for a project. Use of steeper structure slopes, where practical, will also reduce the amount of stone required and may result in higher stability for well-constructed revetments. Based on the present model results, a stability coefficient of $K_D = 4$ is recommended for selectively placed quarrystone armor units used in revetments. This value is believed to be conservative for well-placed quarrystones and is double the K_D value recommended for randomly placed stone. Reduction of stone size by use of the higher K_D value may allow the use of quarries which would not be able to supply larger sized stones, and could result in a more competitive price for the stones.

References

- Camfield, F. E. (1996a). "Guidelines for quarrystone armor units," *Journal of Construction Engineering and Management*, in preparation, 1996.
- Camfield, F. E. (1996b). "Natural periods of armor stones," *Proc., 25th Inter. Conf. on Coast. Engrg.*, American Society of Civil Engineers, New York.
- Camfield, F. E. (1996c). "Quarrystone revetment armor layers," *Journal of Waterway, Port, Coastal and Ocean Engineering*, in preparation, 1996.
- CIRIA/CUR. (1991). *Manual on the use of rock in coastal and shoreline engineering*. A. A. Balkema, Rotterdam.
- Shore Protection Manual*. (1984). 4th ed., 2 Vols., U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center, U.S. Government Printing Office, Washington, DC.

Durability of Grouts used for Sealing Voids in Breakwaters and Jetties

Lyndell Hales¹ and Dan Wilson²

Background

Many U.S. Army Corps of Engineers rubble-mound breakwaters and jetties have become permeable to sand transport and wave transmission, conditions which result in increased operations and maintenance dredging costs, risks and delays to navigation, and damage to moored vessels by excessive wave activity. Causes of the permeability may be wave damage to armor stone and concomitant loss of core material, differential settling of rubble stone below a monolithic cap, or the use of only large stone to build the original structure. Void dimensions may vary from a few centimeters up to a meter or more in diameter, and be interconnected to allow passage of both sand and wave energy.

Some Corps coastal districts have applied drilling and grouting techniques for sealing rubble-mound structure voids by using cementitious and chemical grouts for creating a vertical barrier curtain through a series of vertical holes drilled along the center line of the structure. Uncertainties exist regarding the ability to actually place grout and effectively create such a barrier underwater. Therefore, extensive physical model research, long-term evaluation of specimens at three durability weathering stations (Treat Island, ME; Duck, NC, and Miami, FL), and monitoring of a prototype jetty sealing project were conducted by the U.S. Army Engineer Waterways Experiment Station (WES) Coastal and Hydraulics Laboratory

(CHL) and Structures Laboratory (SL) as part of the Corps' Repair, Evaluation, Maintenance, and Rehabilitation (REMR) research program. Only the evaluation of specimens placed at the Treat Island, ME, long-term cold-region weathering station is reported here.

Grouts

Cementitious mixtures have been the grouts most often used for sealing voids in coastal structures. Admixtures are needed to accelerate the setting time to minimize dilution or erosion by water. Chemical mixtures consisting of sodium silicate-portland cement and sodium silicate-diacetin also have been used in the coastal environment. When mixed with portland cement to form a one-solution process, the set time is on the order of a few minutes. There exists evidence that the durability of the sodium-silicate chemical mixtures are inadequate for long-term solutions. The most effective grouts are cementitious mixtures.

Regardless of the types of grouts being applied, or whether the materials are being injected to stabilize the sand layer beneath a rubble-mound structure or to fill the voids in the structure above the sand bottom, the procedure is essentially the same. The sealing process involves drilling through stone or concrete to reach the lowest elevation to be sealed, and then placing a quantity of grout in layers of 0.5-m lifts starting from the bottom of the drilled hole. The estimated volume

of material to place in each lift is determined from field investigations conducted during the planning stages.

Injected Barrier Considerations

The thickness of the injected barrier curtain theoretically is of little concern. A two-dimensional barrier of finite small thickness should be just as effective as a barrier of large thickness. Grouting, however, results in a three-dimensional sealed space. Optimizing the grout hole spacing based on drilling cost, grout intake, subsurface conditions, and material costs is crucial to the economic planning of a program.

If the structure is being grouted to prevent sand transmission only, the existing sand layer should be stabilized first. After sand stabilization, the top elevation to which the barrier will be constructed should exceed the height to which sediment presently moves or, in the future, probably will move against the structure by currents and waves. The sand layer also should be stabilized to a bottom elevation sufficient to block the flow of sediments moving through the structure. Grouting probably will not extend below the bottom elevation of the structure unless stabilizing the foundation is an objective. If both sand and wave energy transmission are problems at a site, then void sealing should extend from the top of the stabilized sand layer to approximately mean high water elevation.

¹Lyndell Hales is a Research Hydraulic Engineer with the WES Coastal and Hydraulics Laboratory.

²Dan Wilson is a Materials Engineering Technician with the WES Structures Laboratory.

The length of the grout barrier should bracket the locations of sediment permeation or wave transmission.

Purpose of the Durability Investigations

The grout durability time-dependent investigations were formulated to determine how two chemical grouts (sodium silicate-portland cement and sodium silicate-diacetin) and two cementitious grouts (WES mixture and Buhne Point mixture) would endure under near-actual field conditions. Effects of environmental exposure to waves, currents, freezing and thawing cycles, wetting and drying cycles, biological influences, and chemical reactions were experienced. A monitoring effort was established to determine the performance with time of grout materials in a field environment. Representative grout samples of each grout mixture used in the physical model experiments were cast as specimens and placed in locations with varied climatic conditions. Since the specimen exposure is direct and unconfined within a structure, the evaluation is believed to be more severe and extreme than if the material were placed within a structure.

Evaluation Methods

Evaluation methods were nondestructive, which reduced the number of specimens required to conduct the investigation. The cementitious mixtures were cast into cylinders with dimensions of 305 mm (length) and 152 mm (diameter). All evaluations were conducted by the WES SL in accordance with the appropriate ASTM standards.

Compressive strength. Evaluations were performed at 28 days in accordance with ASTM Standard C 39-94 to determine the compressive strength of a large number of the cementitious specimens that were cast at the same time as the specimens that were placed at the field weathering stations.

Ultrasonic pulse velocity. The ASTM Standard C 597-83 evaluation method covers the determination of the pulse velocity of propagation of compressional waves in concrete. This method may be used to indicate changes in the properties of concrete.

Fundamental transverse resonate frequency. The ASTM Standard C 215-91 evaluation method detects changes in the dynamic E of model or field specimens that are undergoing exposure to weathering or other types of potentially deteriorating influences. This method may be used to assess the uniformity of field concrete.

Treat Island Specimen Evaluation

Treat Island is located in Cobscook Bay, approximately 1.2 km from Eastport, ME. The Corps has utilized this site as an exposure station for monitoring the effects of natural weathering of concrete materials since 1936. Ten specimens each of the WES mixture and Buhne Point mixture, and ten specimens each of the two chemical grout specimens, were placed during July 1987 on a 36.6-m-long by 12.2-m-wide platform located at mean tide level, and removed during August 1995. This placement

allowed the specimens to experience wetting and drying as well as freezing and thawing cycles. Nondestructive evaluation was performed at placement and by WES SL researchers (Figure 1) during the summers of 1989, 1991, 1992, 1994, and 1995. Over the course of the 8-year evaluation period, repeated freezing and thawing caused spalling and loss of some material from the ends of the Buhne Point mixture specimens (Figure 2). However, no apparent cracks were visible along the surface of the cylinders, and the pulse velocity readings indicated the integrity of the mass was being maintained, as there appeared to be minimal changes in the properties of all specimens (WES mixture and Buhne Point mixture). Ultrasonic pulse velocity and transverse flexural frequency evaluation results are presented in Figures 3 and 4, respectively.

Conclusions

Based on the 8-year exposure field evaluations at Treat Island, ME, the following conclusions were reached (Hales and Wilson 1996):

- Pulse velocity and flexural frequency indicated the integrity of the specimen mass was being maintained, as there appeared to be minimal changes in the properties of these cementitious grouts.



Figure 1. WES Structures Laboratory researcher conducting nondestructive evaluations on cementitious specimens at Treat Island, ME, weathering station

- Maximum variation in pulse velocity among individual specimens of the WES mixture approached 19 percent, and for the Buhne Point mixture approached 9 percent. Maximum variation in flexural frequency among individual specimens of the WES mixture approached 12 percent, and for the Buhne Point mixture, approached 21 percent.
- Either the WES mixture or the Buhne Point mixture will be satisfactory to use as sealing material to rehabilitate existing Corps rubble-mound breakwaters and jetties by void sealing to prevent passage of excessive wave energy and sediment through such structures.
- The chemical grout specimens (sodium silicate-portland cement and sodium silicate-diacetin) totally vanished within a few months of exposure time (less than 1 year). Hence, these materials are not recommended for void sealing of rubble-mound breakwaters and jetties.

References

- Rosati, J. D., and Denes, T. A. (1990). "Field evaluation of Port Everglades, Florida, rehabilitation of South Jetty by void sealing", Technical Report REMR-CO-15, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Simpson, D. P., and Thomas, J. L. (1990) "Laboratory techniques for evaluating effectiveness of sealing voids in rubble-mound breakwaters and jetties with grouts and concretes", Technical Report REMR-CO-13, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Hales, L. Z., and Wilson, D. E. (1996) "Durability of cementitious mixtures used for sealing voids in rubble-mound breakwaters and jetties", *Proceedings, Third International Conference on Concrete in the Marine Environment*, St. Andrews-by-the-Sea, New Brunswick, Canada, pp. 423-445.



Figure 2. Spalling of ends of Buhne Point mixture after 8-year exposure at Treat Island, ME, weathering station

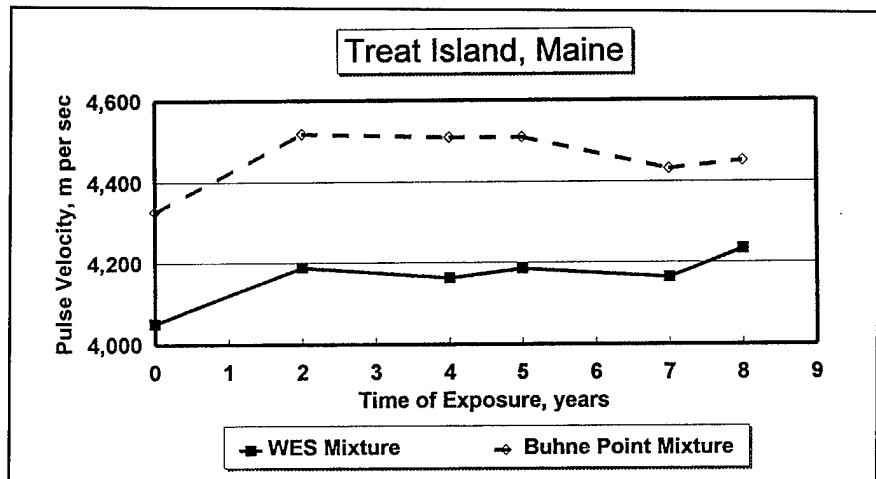


Figure 3. Average pulse velocity versus exposure time for cementitious specimens at Treat Island, ME, weathering station

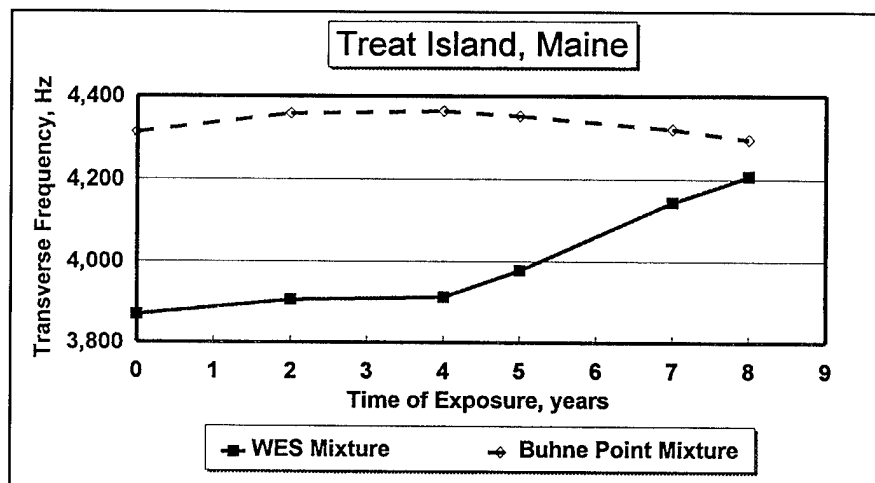


Figure 4. Average flexural frequency versus exposure time for cementitious specimens at Treat Island, ME, weathering station



In Memoriam

Michelle Thevenot, 31 years of age, passed away 21 December 1996 after a lengthy battle with cancer. Michelle was a research hydraulic engineer with the U.S. Army Engineer Waterways Experiment Station (WES) Coastal and Hydraulics Laboratory (CHL), having come to work at WES in 1986. She was exceptionally talented with a most promising future in her chosen profession, as exemplified by her receipt of the Gustave Willems Award from the U.S. Section of the Permanent International Association of Navigation Congresses for an outstanding technical paper. She was a candidate for the degree of Doctor of Philosophy in Civil Engineering from Louisiana State University, scheduled for receipt in May 1997. Funeral services were held in New Orleans, Louisiana. She will be sadly missed by her friends and co-workers at WES, and by her professional acquaintances everywhere. Michelle is survived by her husband, Robert, and a 4-year-old son, Zachary.

Coastal Engineering Education Program (CEEP) Students at WES

Background

In an address to the Coastal Engineering Research Board (CERB), LTG E. R. Heiberg III, then Chief of Engineers, noted the Corps of Engineers unique role in developing the field of coastal engineering, and the necessity for maintaining expertise in this critical mission area. He said the Corps must "grow our own" coastal engineers. The Coastal Engineering Education Program (CEEP) is a resulting CERB initiative, and was developed based on evaluations of field needs and personnel development requirements.

Although the program was developed based on needs of the Corps, it is not limited to Corps employees. All qualified individuals will be considered for admission.

Description of CEEP

The 1-year CEEP is designed to provide students with the basic academic course work and practical training essential for solving modern-day coastal engineering problems. The program is conducted once every 3 years. Program graduates will have the fundamental knowledge and tools necessary to perform coastal engineering functions within the Corps of Engineers. The program is offered through the U.S. Army Engineer Waterways Experiment Station (WES) Graduate Institute jointly by Texas A&M University (TAMU) and the WES Coastal and Hydraulics Laboratory (CHL). A Master of Engineering (ME) degree will be awarded by TAMU upon successful completion of the program.

Students spend the fall semester at TAMU in College Station, TX, and the spring semester at the WES CHL in Vicksburg, MS. This will be followed by field work at the CHL Field Research Facility (FRF) in Duck, NC, during the period between the spring and summer semesters. The 10-week summer semester will be spent at the WES CHL.

1996-97 CEEP Students

The present 1996-97 CEEP began in August 1996, and consists of five students (Figure 1, left to right, bottom row: Wendell D. Mears, Mobile District; and Lori L. Hadley, WES CHL; top row: Bradd R. Schwichtenberg, Los Angeles District; Karl B. Brown, Galveston

District; and Louis J. B. Moreno, Spain).

The next session of the CEEP will be held during the 1999-00 academic year starting in August 1999.

Points of Contact

For more information about CEEP, contact Dr. C. H. Pennington, Director, WES Graduate Institute, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199, telephone (601) 634-3549, fax (601) 634-4180, or either Dr. Billy L. Edge or Dr. Robert E. Randall, Ocean Engineering Program, Texas A&M University, College Station, TX, 77843-3136, telephone (409) 847-8712 or (409) 845-4515, fax (409) 862-1542.



Figure 1. 1996-97 Coastal Engineering Education Program (CEEP students)

Meeting of the Civilian Coastal Engineering Research Board

The civilian members of the Coastal Engineering Research Board (CERB) were hosted in the San Francisco area at their recent meeting by military member Brigadier General Richard Capka, Commander, South Pacific Division (SPD). The formats of the Board's semiannual meetings were changed recently to include one meeting of the full Board and one meeting of the civilian members hosted by a military member. In the latter case, the civilian members gain a better understanding of the problems faced in field offices, and the field offices receive the benefit of the Board members providing review and guidance on specific projects.

Civilian Board members, Dr. Robert G. Dean, University of Florida, and Dr. Edward K. Noda,

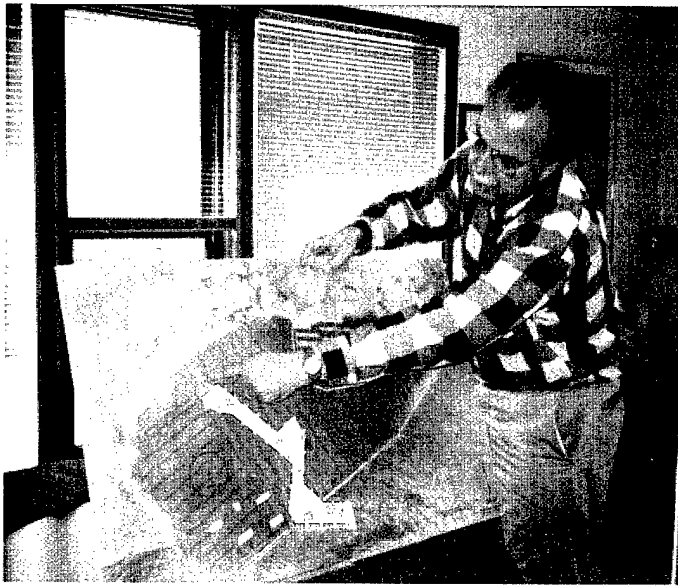
Edward K. Noda and Associates, Honolulu, HI, attended this meeting. The third member had not been appointed at the time of the meeting.

Also participating in the meeting were Messrs. John H. Lockhart, Jr., and Charles B. Chesnutt, Headquarters, U.S. Army Corps of Engineers; Dr. James R. Houston, Director, Mr. Charles C. Calhoun, Jr., Assistant Director, and Ms. Sharon L. Hanks, CERB Administrator, all from the U.S. Army Engineer Waterways Experiment Station's Coastal and Hydraulics Laboratory (CHL). The technical program was coordinated by Mr. George W. Domurat, SPD, with assistance from Mr. William Appleton, San Francisco District; Messrs. Arthur T. Shak and David M. Mesa, Los Angeles District; Dr. Edward F. Thompson,

substituting for Mr. Robert R. Bottin, CHL; Mr. Rick Algert, Harbor Master, Morro Bay; Mr. James Stilwell, Interim General Manager, Captain Dan Tamko, Harbor Master, and Mr. John Draper, Assistant Harbor Master, Pillar Point Harbor; and Mr. Robert Battalio, Moffatt and Nichol, Engineers. The participation of The Honorable Cathy Novak, Mayor of the City of Morro Bay, is appreciated.

A report on the meeting will be included as part of the Proceedings of the full Board meeting. Proceedings of the meeting will be made available to the public. Point of contact is Ms. Sharon L. Hanks, WES, CHL, (601) 634-2004. The next CERB meeting is scheduled for 24-26 June 1997 in Chicago, IL.





Notes from the Front Line...

Coastal Engineering Course

The Coastal Engineering I PROSPECT course was conducted at the U.S. Army Engineer Waterways Experiment Station (WES) Coastal and Hydraulics Laboratory (CHL) on 28 Oct - 1 Nov 1996. This course emphasizes coastal processes, including waves and sediment motion. Tours of active models at the WES Coastal Engineering Research Center were included in the session. The 18 attendees were from Corps of Engineers Division and District offices and WES, and included the following: Richard W. Broussard and Frank Duarte (New Orleans District); Doland Cheung and Dan Pomerantz (Los Angeles District); Joseph Forcina, Paul Sabalis, and

Herman Wine (New York District); Jeffrey Gangal and Syed Zahid (Galveston District); Julie Jackson (Savannah District); Darlene Rowen (Buffalo District); William Sanner (Ft. Worth District); John Studstill (Mobile District); Amy Vanderheiden (Seattle District); Richard Furman and Raymond Gealing (Ohio River Division); Joseph MacKay (New England Division); and Darla McVan (WES CHL). POC for information on coastal engineering courses is Dr. Yen-Hsi Chu, (601) 634-2067 or e-mail y.chu@cerc.wes.army.mil.

Dredging Operations and Environmental Research Program

The Dredging Operations and Environmental Research (DOER)

Program was initiated at WES at the start of FY97. This program (\$48 million over 8 years) approaches the Corps' dredging technology needs in a balanced operational-environmental manner, which assures that all aspects of the dredging project manager's requirements are met. DOER focus areas include risk management, nearshore placement of dredged material, instrumentation and monitoring, contaminated sediments, environmental windows, and innovative dredging technologies. Point of contact for the DOER Program is Mr. E. Clark McNair, Coastal and Hydraulics Laboratory, (601) 634-2070 or mcnair@ex1.wes.army.mil.

Publications of Coastal Interest

Coastal Environment: Environmental Problems in Coastal Regions, edited by A. J. Ferrante and C. A. Brebbia, deals with many issues that surround the modeling of environmental problems in coastal regions, addressed in seven sections: Pollution Management and Decision Analysis; Hazard Mitigation and Risk Analysis; Drift and Evolution in Coastal Regions and Beaches; Oil Slicks and Spills; Pollutant Transport and Dispersion; Atmospheric Pollution and Control; and Hydrodynamics and Pollutant Transport Modeling. This 1996 book is available from Computational Mechanics Inc., 25 Bridge Street, Billerica, MA 01821, phone (508)

667-5841, fax (508) 667-7582. Price \$144.

Current Topics in Wetland Biochemistry, Vol 2, edited by W. H. Patrick, Jr., and J. A. Nyman, contains five sections: Sediment Accretion in Coastal Wetlands, a Review and a Simulation Model Process; Methane from Irrigated Rice Cultivation; Biological Fate of Coal Mine Drainage Pollutants in Constructed Waterways; Nutrient Enrichment and Decomposition in Wetland Ecosystems; and Wetland Mercury Research, a Review with Case Studies. This 1996 book is available from Karen Gros, Wetland Biogeochemistry Institute, Louisiana State

University, Baton Rouge, LA 70803. Price \$20.

Scientific Diving: A General Code of Practice, edited by N. C. Flemming and M. D. Max, provides guidance to research institutions, diving administrators, and scientific divers. This *Code* operates at a level between legislative rules and a diving manual by giving discretionary advice based on the wide experience of many experts. This 1996 book was prepared by the Scientific Committee of the World Underwater Federation for UNESCO, and is available from Best Publishing Company, P.O. Box 30100, Flagstaff, AZ 86003-0100, phone (800) 468-1055, fax (520) 526-0370. Price \$37.95.

Calendar of Coastal Events

- Mar 24 - 27, 1997 **California and the World Ocean '97**, Town and Country Hotel, San Diego, California, POC: Orville Magoon, (707) 987-0114, fax (707) 987-9351, e-mail otmagoon@aol.com
- Apr. 6 - 11, 1997 **3rd International Ocean Pollution Symposium**, Fort Pierce, FL, USA, POC: e-mail costilow@boi.edu
- Apr. 13 - 17, 1997 **Waves in Shallow Environment (WISE)**, San Francisco, CA, USA, POC: C. Linwood Vincent, Office of Naval Research, 800 N. Quincy St., Room 428, Arlington, VA 22217-5000, phone (703) 696-4118, e-mail l.vincent@cerc.wes.army.mil
- Apr 21 - 25, 1997 **European Geophysical Society**, 22nd General Assembly, Vienna, Austria, e-mail egs@linax1.mpae.gwdg.de, web <http://www.mpae.gwdg.de/EGS/EGS.html>
- Apr. 22 - 25, 1997 **19th Annual National Hurricane Conference**, Hyatt Regency Hotel, 1200 Louisiana St., Houston, TX, USA, POC: Linda Tait, phone (904) 561-1163, fax (904) 561-1172
- May 1 - 5, 1997 **Offshore Technology Conference**, Houston, TX, USA, POC: ASCE, 1801 Alexander Bell Drive, Reston, VA 20191, phone (703) 295-6000, fax (703) 295-6222, e-mail conf@asce.org
- May 17 - 19, 1997 **Remote Sensing for Marine and Coastal Environments**, Orlando, FL, USA, POC: ERIM/Marine Conference, P.O. Box 134001, Ann Arbor, MI 48113-4001, phone (313) 994-1200 ext 3234, fax (313) 994-5123, e-mail wallman@erim.org
- May 19 - 23, 1997 **Coastal Ecology**, Charleston, SC, USA, POC: e-mail dooleyj@smtp.hnd.usace.army.mil
- May 25 - 30, 1997 **Offshore and Polar Engineering Conference**, Honolulu, Hawaii, POC: ISOPE-97, (303) 273-3673, fax (303) 420-3760
- May 27 - 30, 1997 **American Geophysical Union**, Spring Meeting, Baltimore, MD, USA
- Jun 1 - 5, 1997 **International Association for Great Lakes Research**, Buffalo, NY, USA, POC: IAGLR Office, 2200 Bonisteel Blvd, University of Michigan, Ann Arbor, MI 48109
- Jun 23 - 25, 1997 **Coastal Engineering 97: Computer Modelling of Seas and Coastal Regions**, La Coruna, Spain, POC: Sue Owen, phone 44 (0) 1703 293 223, fax 44 (0) 1703 292 853, e-mail sue@wessex.witcmi.ac.uk
- Jun 23 - 27, 1997 **Coastal Dynamics 97: International Conference on Coastal Research Through Large-Scale Experiments**, University of Plymouth, United Kingdom, POC: Denise Horne, phone 44 (0) 1752 233 304, fax 44 (0) 1752 233 310, e-mail dhorne@plymouth.ac.uk
- Jun 28 - Jul 1, 1997 **Western Dredging Association XVIII Annual Meeting and 30th Annual Texas A&M University Dredging Seminar**, Charleston, SC, USA, POC: Ronald E. Wills, Hartman Associates, 810 3rd Ave., Suite 408, Seattle, WA 98104, phone (206) 382-0388.
- Jul 1 - 9, 1997 **IAMAS/IAPSO Joint Assembly**, Melbourne, Australia, e-mail mscarlett@peg.apc.org, web <http://www.dar.csiro.au/pub/events/assemblies/info.html>
- Jul 20 - 26, 1997 **Coastal Zone 97: Charting the Future of Coastal Zone Management; The Next 25 Years**, Boston Park Plaza Hotel, Boston, MA, USA.
- Aug 10 - 15, 1997 **International Association for Hydraulic Research, 27th IAHR Congress: Water for a Changing Global Community**, San Francisco, CA, USA, POC: ASCE, 1801 Alexander Bell Drive, Reston VA 20191, phone (703)295-6000, fax (703)295-6222, e-mail conf@asce.org

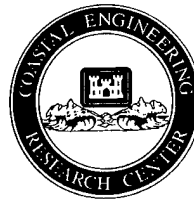


US Army Corps
of Engineers
Waterways Experiment
Station

The Corps' Coastal Vision Statement

We will, as the National Coastal Engineer:

- Continue our leadership in the protection, optimization, and enhancement of the Nation's coastal zone resources.
- Increase our contribution to the Nation's economy, quality of life, public safety, and environmental stewardship.



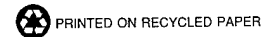
The **CERCular**
Coastal Engineering Research Center

This bulletin is published in accordance with AR 25-30 as an information dissemination function of the U.S. Army Engineer Waterways Experiment Station. The publication is part of the technology transfer mission of CERC under PL 79-166 and PL 99-802. Results from ongoing research programs will be presented. Special emphasis will be placed on articles relating to application of research results or technology to specific project needs. Additional information is provided on the CERC Homepage at:

http://bigfoot.cerc.wes.army.mil/CERC_homepage.html

Contributions of pertinent information are solicited from all sources and will be considered for publication. Communications are welcomed and should be addressed to the U.S. Army Engineer Waterways Experiment Station, Coastal and Hydraulics Laboratory, ATTN: Dr. Lyndell Z. Hales, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199, or call (601) 634-3207, FAX (601) 634-4253, Internet: l.hales@cerc.wes.army.mil

ROBERT W. WHALIN, PhD, PE
Director, WES



BULK RATE
U.S. POSTAGE PAID
Vicksburg, MS
Permit No. 85

DEPARTMENT OF THE ARMY
WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS
3909 HALLS FERRY ROAD
VICKSBURG, MISSISSIPPI 39180-6199
OFFICIAL BUSINESS
CEWES-CV-1