

# CERL

FY97

## CIVIL WORKS ANNUAL REPORT

19990528 024



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AQI 99-08 1546

INTERNET DOCUMENT INFORMATION FORM

**A . Report Title: CERL FY97 Civil Works Annual Report**

**B. DATE Report Downloaded From the Internet: 05/27/99**

**C. Report's Point of Contact: (Name, Organization, Address, Office  
Symbol, & Ph #):** US Army Corps of Engineers  
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**D. Currently Applicable Classification Level: Unclassified**

**E. Distribution Statement A: Approved for Public Release**

**F. The foregoing information was compiled and provided by:  
DTIC-OCA, Initials: \_\_VM\_\_ Preparation Date 05/27/99**

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# **CERL Civil Works**

## **Annual Report for Fiscal Year 1997**

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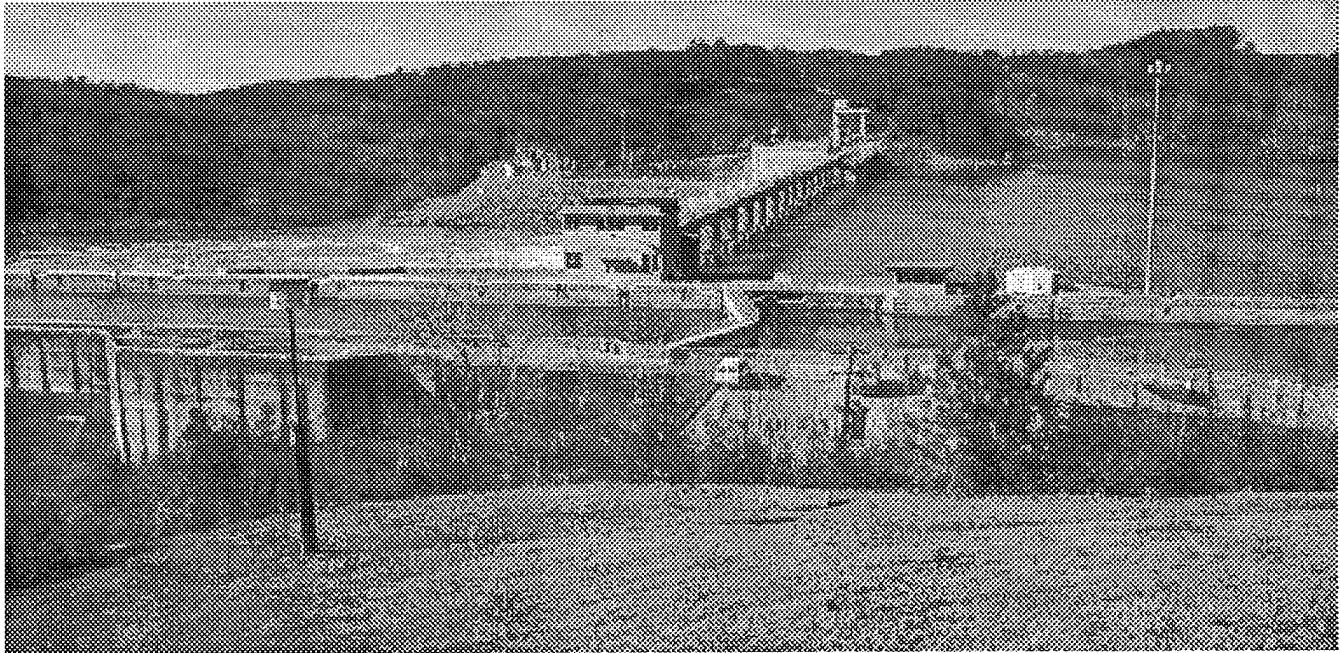
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**On the cover:** The durability and corrosion-resistance of paints and coatings can have a great impact on the life-cycle cost of operating Civil Works facilities such as locks and dams. CERL paint research and field support help to ensure that District O&M personnel have access to the best coatings available for their specific applications.



## **The CERL Civil Works Research and Support Program**

The U.S. Army Construction Engineering Research Laboratories (CERL) has served the Army with valuable scientific and engineering expertise for more than 25 years. CERL is the designated lead R&D unit in the Corps of Engineers for finding technology-based solutions to many pressing infrastructure problems on military installations. But CERL also has a dedicated R&D program in the Civil Works area, and a significant portion of CERL's work in Military Programs is applicable to Civil Works needs.

This document summarizes CERL's FY97 Civil Works accomplishments and highlights research, development, and technical assistance capabilities of interest to Corps District personnel.

### **Program Focus**

CERL's Civil Works research, development, and technical support activities focus on improving maintenance and repair management, techniques, and cost efficiency. Contributions in these areas have included work in corrosion control, protective coatings, removal of lead-based paint, high-performance materials applications, and

O&M management systems. Also of timely interest to Army Engineer Districts, CERL's expertise addresses various environmental implications of operating and maintaining a large, complex Army Civil Works infrastructure, complementing other environmental capabilities found within the Corps of Engineers.

### **Capabilities and Resources**

CERL has a strong complement of test and evaluation facilities in house to support Civil Works R&D. These include a paint laboratory, a thermal spray coatings test bed, a welding technology lab, and a scanning electron microscope that can image details as small as 50 angstroms.

Of emerging importance in civil engineering applications is CERL's Triaxial Earthquake and Shake Simulator, one of the most powerful and versatile shake tables found anywhere. This apparatus can simulate limitless shock, seismic, and vibrational environments – both experimental and site-specific.

CERL in-house resources are strongly leveraged through a longtime research partnership

with the University of Illinois at Urbana-Champaign (UIUC). This alliance provides CERL researchers access to some of the finest research facilities in the nation, including those in the College of Engineering and the National Center for Supercomputing Applications.

## R&D Programs

### Electrical/Mechanical Research

*Thermal Spray Metallic Coatings.* A major study was initiated in the area of metallizing. This is the first significant study conducted in the industry on the effects of various operating parameters on the quality of arc-spray metal coatings. Several Army Engineer Districts are using metallizing instead of painting for the corrosion protection of dam gates. Metallizing is much more abrasion-resistant than paint and produces none of the pollution normally associated with paints. The use of a new arc-spray process could reduce metallizing process costs significantly. Early results of this study have been used to update the guide specification for metallizing.

(POC: Vince Hock, v-hock@cecer.army.mil)

*Greaseless Bushings.* Greaseless bushings have performed reliably on CW structures for the Corps of Engineers, but they may pose environmental and operational problems. Private industry has developed many types of greaseless bushings that offer obvious advantages, but most have been developed for continually operating systems such as motors, not for intermittently

loaded heavy equipment such as lock gates. Since live testing of new bushings on Civil Works structures carries the risk of failure and unacceptable downtime, research was needed to identify acceptable greaseless substitutes for conventional bushings. In FY97, CERL completed a rating system for greaseless bushings based on swelling data in oil, water, and in field service conditions. These data also are being used to update the Corps guide specification on bushings and to develop Engineering Instructions for the field.

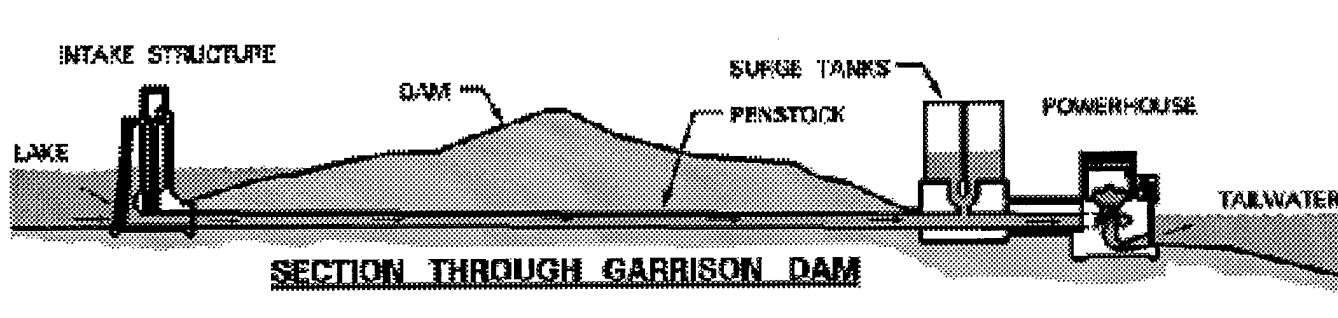
(POC: Robert Weber, r-weber@cecer.army.mil)

*Ceramic-Coated Piston Rods.* The Corps of Engineers uses many hydraulic pistons that include ceramic-coated piston rods, which provide improved performance, durability, corrosion resistance, abrasion resistance, etc. Ceramic-coated piston rods are available commercially, but some have failed after only 2 years of service, indicating the need for research and updated CW specifications.

In FY97 CERL evaluated interlayer materials, generic coating materials, and sealers in a series of tests designed to evaluate the utility of the coating. The results of these tests are being used to recommend modifications to the Corps guide specification and to provide engineering information for future specification of ceramic coating materials.

(POC: Robert Weber, r-weber@cecer.army.mil)

*Water Hammer and Mass Oscillation (WHAMO).* Fluid distribution systems and hydropower plants (below) can be severely damaged by water hammer, which is the forceful



slam, bang, or shudder that occurs in pipes when a sudden change in fluid velocity creates a large change in fluid pressure. The problem can be mitigated by designing and operating these systems to minimize unfavorable changes in water velocity. Simulations using the WHAMO computer program allow accurate calculations of the expected forces and stresses at various points in the system so appropriate materials and sizes can be specified. WHAMO also allows the engineer to diagnose and fix operating problems in existing systems.

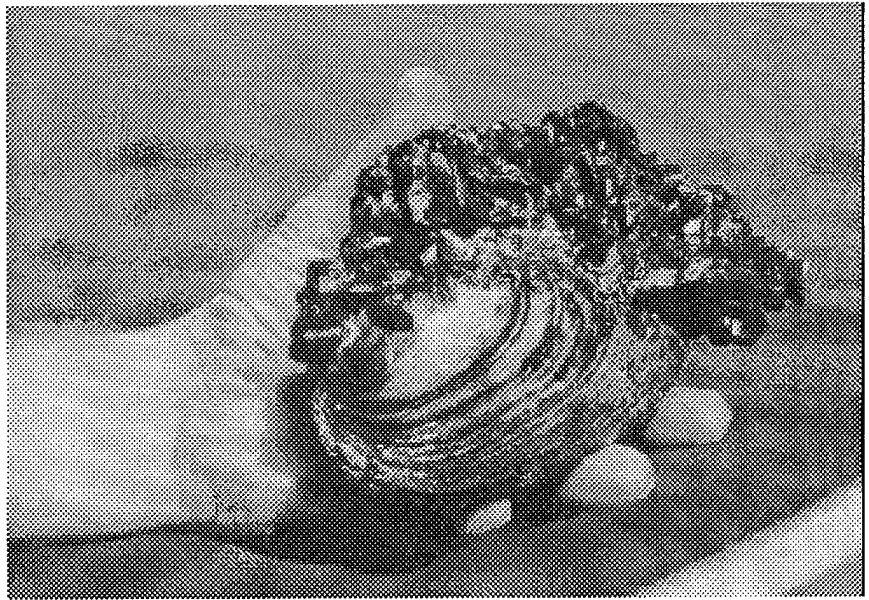
In FY97 CERL converted WHAMO to the Windows® environment; developed a flexible, easy-to-use graphics package to display program output; and developed a graphical point-and-click interface for program input.

(POC: Vicki Van Blaricum, v-vanblaricum@cecer.army.mil)

### Zebra Mussel Research

*Coatings and Materials to Control Zebra Mussels.* In FY97 CERL conducted a program to evaluate coatings and materials designed to prevent the attachment of zebra mussels (above right) to structures. *In situ* tests on a wide variety of antifouling paints, thermal-spray metallic coatings, foul-release coatings, and metallic and plastic materials were conducted at Black Rock Lock. Field tests of coatings on trash racks, dam gates, and a floating plant continued in the Buffalo, Louisville, and St. Louis Districts. The leaching rate for coatings and materials containing copper and/or zinc has been determined over a 5-year period. Research results will provide facility managers with cost-effective, environmentally sound methods for protecting components of public facilities from zebra mussel infestations. Use of these methods will help control zebra mussels while ensuring that native plants and animals are not harmed in the process.

(POC: Ellen Segan, e-segan@cecer.army.mil)



*Electrochemical Zebra Mussel Control Techniques.* Electrochemical techniques such as cathodic protection have been proposed for controlling zebra mussels on underwater structures. Such techniques do not damage the environment. They can be added to an existing system at little cost, and easily removed later. Although such systems are being marketed for control of zebra mussels, there is little understanding of the proper use or effectiveness of these systems.

CERL conducted controlled laboratory testing to determine whether and to what extent cathodic and anodic polarization affect adult zebra mussels. The investigation showed that, at levels that are not damaging to structures, such techniques have no effect on adult zebra mussels in a laboratory environment. However, questions remain about the effectiveness of cathodic protection on zebra mussels in the larval and juvenile stages of development since such a laboratory investigation is not feasible.

An FY98 workshop is scheduled for users and researchers to evaluate the state of the art in this area and to discuss the future use of such techniques in the field.

(POC: Ellen Segan, e-segan@cecer.army.mil)

## **Construction Technology Transfer Center**

A pilot project continues between CERL and Indiana State University (ISU) to develop a Construction Technology Transfer Center (CTTC). During FY97, the delivery of targeted technologies was initiated. The CTTC developed a World Wide Web site providing technical information from construction industry, Corps of Engineers, and American Society of Civil Engineers web sites. One target technology, the prototype Mechatronically Assisted Mason's Aide (MAMA), was repaired and functionally improved during the early part of FY97. The operational prototype, developed jointly by CERL and the International Masonry Institute, was publicized and demonstrated to contractors, union representatives, construction insurance companies, potential manufacturers, and labor rights organizations. Arrangements were made for a field test of MAMA at a contractor's site during the first quarter of FY98. Also, a prototype construction safety support information system based on the Corps of Engineers Safety Manual was developed on a handheld personal computer and a personal digital assistant.

(POC: Jeff Kirby, j-kirby@cecer.army.mil)

## **Land Management System (LMS)**

Managing land and water resources has become increasingly difficult in the face of new legal requirements, conflicting input from special-interest groups, and growing public demand for timely, accurate cost/benefit/consequence analysis related to any significant proposed land management action. Advanced technologies such as geographic information systems (GIS), remote sensing, landscape process modeling and simulation, etc., offer many capabilities to help land managers address these difficult demands. These tools work independently, however, and provide disconnected data that must be integrated to be fully useful to Army land managers. CERL's

LMS initiative addresses the Corps Civil Works mission by providing an integrated capability for modeling and decision support technologies for applications relevant to the management of military lands, waterways, and airspace.

In FY97 a Civil Works Demonstration Plan for LMS was completed. The Upper Mississippi River System (UMRS), including tributaries, was chosen for the initial focus. Geomorphology, hydrology, hydrodynamics, and sediment dynamics will be examined and modeled to assess future habitat conditions (both physical and chemical), and to provide recommendations for consideration in river resource management.

(POC: William Goran, w-goran@cecer.army.mil)

## **Regulatory Analysis and Management System (RAMS) II Planning Document**

The regulatory division of the Corps of Engineers processes about 13,000 water-related permits annually. The input, management, analysis, and reporting of regulatory data have traditionally been carried out with software and database designs unique to each District. The result has been high corporate costs for system development, procurement, training, and support, and a reduction of reliability in upward data reporting.

RAMS II is an updated automated corporate information system developed by CERL and tested at nine Districts with Headquarters, U.S. Army Corps of Engineers (HQUSACE). RAMS II addresses deficiencies with district-specific systems by standardizing and normalizing the database structure and porting the system to software that complies with Army Technical Architecture guidelines.

CERL has produced mandatory Life-Cycle Management of Information Systems (LCMIS) planning documents for RAMS II through the testing and evaluation phase. LCMIS documentation will allow HQUSACE to request approval for deployment of RAMS II in FY98.

(POC: Paul Loechl, p-loechl@cecer.army.mil)

## Improved O&M Budgeting Environment

Due to workforce reduction over the past few years, submitting and tracking of the O&M budget began spanning multiple organizations in the district offices. Project offices often became involved directly with inputting data into the system instead of district office personnel, and district offices became the error checkers and approvers. To accommodate this change, the budgeting environment was expanded to provide all levels simultaneous access in a multi-user network version of the Windows Automated Budget System (Win ABS). In addition to expanding user access, training tools were provided so district offices would have the means to train project managers and other personnel.

In FY97 the complete suite of support tools was offered via the Web from a Win ABS home page. It includes a manual and training tool, a page from which to download program updates, a discussion forum for users, and a problem submission questionnaire to notify the developers of system problems or desired enhancements. The Win ABS user forum has proved to be an excellent way for users to network with each other for solutions, and the implementation of the forum has decreased support calls by nearly 50%.

(POC: Laura Harmet, lharmet@cecer.army.mil)

## Repair, Evaluation, Maintenance, and Rehabilitation (REMR) Systems

REMR operations management systems are decision-support tools for determining when, where, and how to effectively allocate M&R



dollars for Civil Works structures. In FY97 CERL continued developing REMR management systems for major types of Civil Works structures maintained by the Corps.

*Coastal Structures.* In FY97 software was completed to support assessment procedures and calculate condition indexes for rubble breakwaters and jetties (above). The initial draft of assessment procedures for seven types of non-rubble breakwaters and jetties was produced and will be completed in FY98.

(POC: Don Plotkin, d-plotkin@cecer.army.mil)

*Inland Navigation.* In FY97 software was completed to support assessment procedures and calculate condition indexes for exposed gear, enclosed gear, gear rack, strut arm, and hydraulic cylinder lock operating equipment assemblies.

Software development for the remaining four assemblies (rocker arm, cable, chain, and coupling) was started and will be completed in FY98.

(POC: Dave McKay, d-mckay@cecer.army.mil)

*Flood Control.* Initial condition assessment procedures and a condition index (CI) for embankment dams were completed in FY97, with

field testing and technology transfer set for FY98. This system will enable the Corps to prioritize monitoring and instrumentation, repairs and enhancements, engineering analyses, and embankment/foundation rehabilitation. In addition to calculating the condition index, the system also uses the collected data to produce numerical priority rankings for dam components. These priority rankings are based on the condition and importance of the components, and can be used to help make decisions about specific M&R tasks based on their impact on dam performance. The overall goal is to sustain the best possible condition for embankment dam structures at any given funding level.

In FY97, the preliminary embankment dam CI procedures were applied at the John Kerr Dam, Wilmington District. A draft of the results was provided to the district and a final report will be published using modified procedures in FY98.

(POC: Stuart Foltz, s-foltz@cecer.army.mil)

## Construction Productivity Advancement Research (CPAR)

Five demonstrations were completed in FY97 under CPAR, a Civil Works-oriented R&D program conducted and cost-shared in partnership with industry and research universities.

*Blast Media for Lead-Based Paint Removal and Waste Stabilization.* The use of lead-based paint (LBP) has been broadly banned, but old LBP remains on many Civil Works structures. This creates health and environmental risks when such structures need repainting, and strict regulations control LBP removal operations to protect the surrounding air, land, and water. CERL, in partnership with the TDJ Group, Inc., modified existing chemical stabilizer/abrasive blast admixtures to enable removal of LBP from structural steel, concrete, and wood surfaces (below left).

This project produced (1) formulations for chemical stabilizers added to abrasive blast media, (2) an engineering and environmental assessment of effects on subsequent coating life, (3) methods for dust control and workspace containment during blasting, (4) tests to verify the long-term stability of the hazardous heavy-metal paint waste in a landfill, and (5) possible recycling options for the abrasive blast residue. The product, BLASTOX<sup>®</sup>, is manufactured by TDJ Group, Inc., and is available through commercial distributors.

This project has won the Federal Laboratory Consortium Award for Excellence in Technology Transfer, and the CERL researchers won a 1998 Army Research and Development Award for their work.

(POC: Vince Hock, v-hock@cecer.army.mil)





*Development and Demonstration of Advanced Design Composite Structural Components.* This CPAR project with West Virginia University (WVU) produced a lightweight composite bridge deck system, called the H-deck, that met AASHTO HS25 truck live load criteria for stringers spacing up to a maximum 9 ft span. During FY97, the West Virginia DOT in conjunction with WVU successfully constructed two short-span demonstration bridges using the H-deck system. The H-deck system is now being evaluated through the Highway Innovative Technology Evaluation Center (HITEC), and 10 additional H-deck installations are scheduled before the end of 1999.

A cost-benefit analysis indicated that the as-constructed cost of the H-deck system is only slightly higher than for traditional reinforced concrete decks. However, the composite decks should have a significant life-cycle cost advantage over conventional reinforced concrete decks by avoiding the costly corrosion damage that destroys reinforcing steel. An immediate niche market for the composite H-deck system will be short-span rehab/replacement applications where it is highly desirable to minimize the structure's

downtime. CERL's primary effort in this project was to conduct the laboratory fatigue and failure tests of the deck panels. This system can now be purchased from Creative Pultrusions, Inc. This project was one of five nominees for the CERF Charles Pankow Award for Civil Engineering Research in 1997.

**(POCs: Paul Howdyshell, p-howdyshell@cecer.army.mil;  
Jonathan Trovillion, j-trovillion@cecer.army.mil)**

*Plastic Lumber Materials for Construction Applications.* Plastic lumber products made from recycled waste plastics offer advantages of natural resistance to moisture, rot, and insect attack (*above*). Plastic lumber is fabricated in traditional dimensional-lumber sizes, but its mechanical properties differ much from those of wood. To gain wider acceptance by the engineering and construction communities, plastic lumber properties must be better understood so specifications and standards can be developed. In partnership with Rutgers University and a consortium of plastic lumber manufacturers, CERL lead an effort to develop and verify performance of plastic lumber products. As a result of this work, five new ASTM test methods for plastic lumber were

approved during FY97. Several other specifications and standards for plastic lumber materials are now in various stages of development and balloting.

This project has been recognized with a 1998 Federal Laboratory Consortium Award for Excellence in Technology Transfer.

**(POC: Richard Lampo, r-lampo@cecer.army.mil)**

*Polymer Composite Piling Systems.* Traditional piling systems are inherently unsuited for harsh waterfront environments. Timber piles are subject to attack by marine organisms, but the use of creosote or chemical-treated timbers can harm the environment and will be subject to increased restrictions. In partnership with Rutgers University, several private-sector firms, two other Corps laboratories, and the Port Authority of New York and New Jersey, CERL lead an effort to develop

and demonstrate high-performance polymer composite fender, load-bearing, and sheet pile systems.

Three types of composite fender piles were installed in an FY97 demonstration and test at Piers 7 and 9, Port Newark, NJ. CERL also provided support to the Army Waterways Experiment Station in a demonstration of composite fender piles at Lake Pontchartrain, LA. In addition, CERL helped initiate a new ASTM Task Group on Systems for Marine/Waterfront Applications to develop specifications and standards for these polymer composite-piling systems.

**(POC: Richard Lampo, r-lampo@cecer.army.mil)**

*Cavitation and Erosion Resistant Thermal Spray Coatings.* This project, conducted in partnership with the Hydroelectric Design Center at Portland District, the Tennessee Valley Author-



ity, and others, demonstrated the effectiveness of thermal spray technology for applying cavitation- and erosion-resistant metal coatings to hydroelectric utility plant turbines and pumps (opposite bottom). Of 21 thermal spray coatings tested, Stellite 6® applied by the high-velocity oxyfuel process had the lowest cavitation rate, and the field applicability of this alloy was successfully demonstrated on a hydroelectric pump/turbine. In addition, four advanced iron-based alloys were evaluated in the laboratory and demonstrated for repair of high cavitation areas on turbine impeller blades.

(POC: Ashok Kumar, a-kumar@cecer.army.mil)

## Technical and Field Support

### Digital Hardhat Field Test at Fort Worth District

In FY97 CERL partnered with UIUC to field test the Digital Hardhat system at Fort Worth District. Digital Hardhat addresses the problem of collecting and organizing multimedia project data (images, video, text, and voice) and enables real-time collaboration between team members at remote construction sites and field offices. Multimedia Facility Reporting (MFR) System (lower left) allows the field representative to save multimedia information into a project-specific database



that is accessible to others over the World Wide Web (WWW).

Project information collected using Digital Hardhat will help to document

site conditions, progress, and problems in an organized manner so the information can be easily retrieved as needed by project participants over the Internet. User support is being provided by CERL and UIUC via phone, email, and a restricted-access web page. Improvements have been made to the field-tested Digital Hardhat system, and it is ready for demonstration on live projects.

(POC: Annette Stumpf, a-stumpf@cecer.army.mil)



### Paint Testing

The CERL Paint Technology Center (above) provides various paint testing, consultation, training, and inspection services for Corps Districts as well as other government agencies on a reimbursable basis. In FY97, paint testing services were provided to 16 Army Engineer Districts. Most paints tested were those intended for use on critical navigation or waterfront structures. Paints were also tested for the General Services Administration for possible inclusion in its Qualified Products List, which is that agency's catalog of products suitable for distribution to military activities worldwide.

(POC: Alfred Beitelman, a-beitelman@cecer.army.mil)



### **Civil Works Facility Condition Assessment Inspections**

During FY97 condition inspection and assessment services were performed on lock miter gates (*above*), lock sector gates, lock and dam concrete, and lock and dam operating equipment for the Rock Island and St. Paul Districts.

(POC: David McKay, d-mckay@cecer.army.mil)

### **Flood Recovery Support for Grand Forks, North Dakota**

CERL supported the Corps of Engineers disaster recovery effort following severe flooding in Grand Forks, North Dakota. Researchers

inspected flood-damaged buildings and developed cost estimates to be used in support of recovery decisions.

(POC: James Wilcoski, j-wilcoski@cecer.army.mil)

### **Welding and Failure Analyses**

CERL provided metallurgical welding and failure analysis support to the field by analyzing a broken shaft for Little Rock District, providing welding engineering support for the fabrication of the hydraulic cylinder frame support at Huntington District, and by providing welding engineering support to the New Orleans District for de-watering needles being fabricated by a contractor.

(POC: Robert Weber, r-weber@cecer.army.mil)

## **Hazardous, Toxic, Radioactive Waste — Center of Expertise (HTRW-CX) Guidance Development Program**

CERL provided design guidance to Omaha District for Engineer Manual EM 1110-1-XXXX (Control No. EM 1804), entitled "Liquid Process Piping." This Engineer Manual provides information for the design of liquid process piping systems, including criteria for the design of component parts and assemblies. Liquid process piping systems include all pipe and appurtenances that are used to convey liquids to, from, and between pumping, storage, and treatment units and are not integral to any unit.

(POC: Vince Hock, v-hock@cecer.army.mil)

## **Lightning Protection for Network and Communications Systems**

Engineer field offices within Savannah District have been upgraded in recent years to include computers, modems, fax machines, and local area networks. Recently, dedicated high-speed communications lines have been installed at larger field sites to support connectivity for the Corps of Engineers Financial Management System (CEFMS), and standard modems have been installed at the smaller sites for dial-in access. A number of Savannah District field offices have reported lightning-induced damage to sensitive equipment during thunderstorms. Power surges imposed on the electrical system and communications circuits have caused major equipment failures and downtime. The Corps dependence on CEFMS for essential business processes and the reliance

on email for everyday business communications make it imperative to provide maximum lightning protection.

In FY97 CERL completed a lightning protection survey for Savannah District. Facility conditions, including earth-ground systems, electrical systems, data and telecommunication systems, and lightning protection systems were inspected and documented. The survey also documented the electronic devices requiring protection and existing lightning protection equipment.

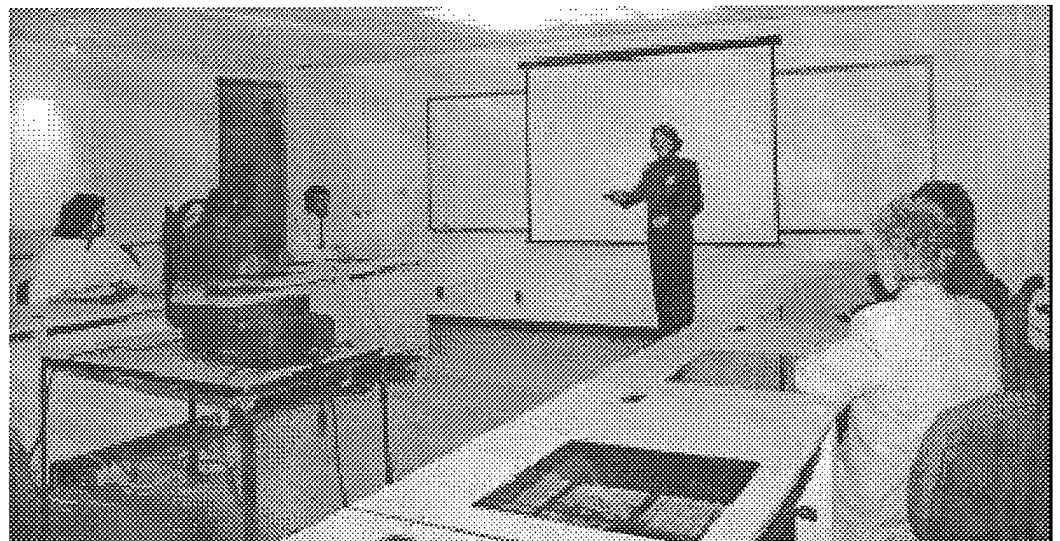
Based on survey inspection results, recommendations are now being developed.

(POC: Michael Mcinerney, m-mcinerney@cecer.army.mil)

## **Business Processes**

CERL conducted a baseline performance assessment of New York and Norfolk Districts using the latest Army Performance Improvement Criteria (APIC). Similar projects are also underway at Baltimore District, New England District, and North Atlantic Division. CERL is helping these sites develop an APIC-based strategic plan and associated action plans (below). The action plan for New York District focused on three issues:

(1) Implementation of a human resources planning process to 'take care of people.' This



process directly supports the district's strategic plan in the area of employee recruitment, retention, and performance management.

(2) Implementation of an external customer survey and an annual process for integrating the results into district business processes.

(3) A complete analysis to facilitate business process reengineering for excellence in both financial and operational performance.

(POC: Sine Farrell, s-farrell@cecer.army.mil)

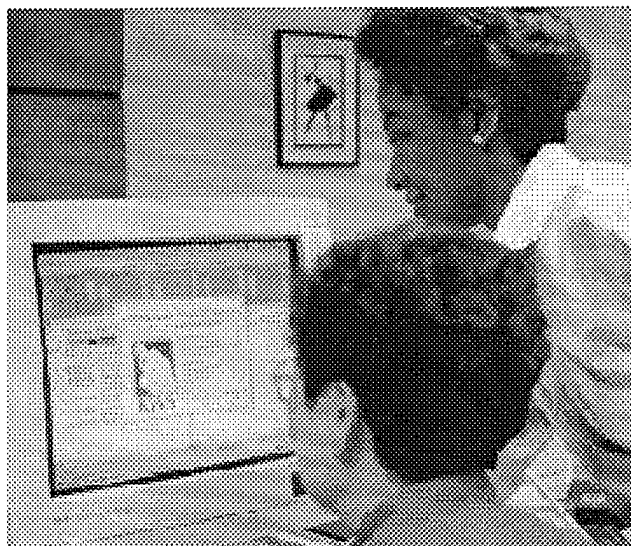
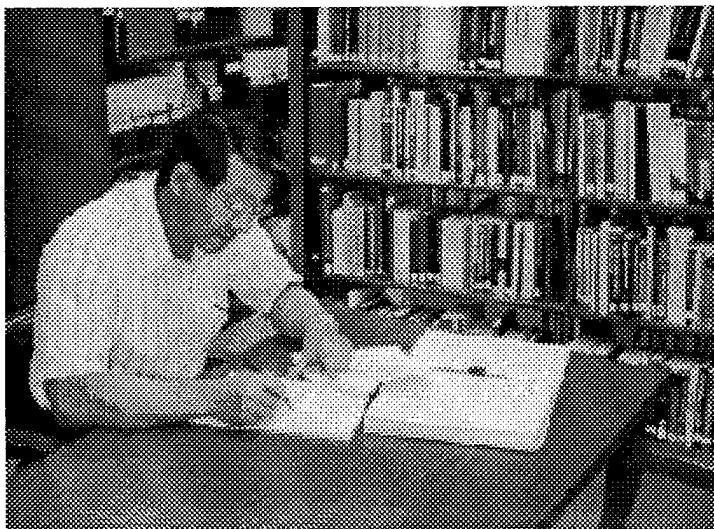
### Knowledge Worker System

A CERL-developed automated project-management tool, the Knowledge Worker System (KWS), was used to enable the New York District Strategic Planner to track progress on action plan activities noted above. KWS provides an online capability (upper right) to identify and assign specific measurable tasks to the team members; it tracks not only progress, but also the files and related information needed to perform the tasks.

(POC: Wayne Schmidt, w-schmidt@cecer.army.mil)

### Corps of Engineers Financial Management System (CEFMS) Support

During FY97 CERL facilitated the conversion to CEFMS at nine Corps of Engineers sites



(Vicksburg, Rock Island, St. Louis, Omaha, Kansas City, Japan, and Chicago districts, plus Missouri River and North Central divisions). Twenty-one site visits by CERL experts included assistance in staffing CEFMS helpdesks, providing support to resource managers, and assisting new users.

(POC: Carl Camp, c-camp@cecer.army.mil)

### Independent Review of Contractor Report for Charleston District

As a reimbursable project for the Charleston District Office, CERL conducted an independent critical review of a draft technical report (lower left) entitled "Evaluation of Radiological Source Terms and Consequences Generated by Postulated Loss of Cooling Events in SRS Waste Tanks," prepared by a contractor for the Department of Energy. The review focused on examination of the physical simulation of the postulated events, verification of governing transport equations, applicability of initial and boundary conditions, numerical accuracy of employed thermophysical properties, and validity of the conclusions. General comments were provided on the applicability of the study results and recommendations.

(POC: Chang Sohn, c-sohn@cecer.army.mil)



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