The REMR Bulletin

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

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Flow Model for Evaluation and Maintenance of High-Velocity Channels

by

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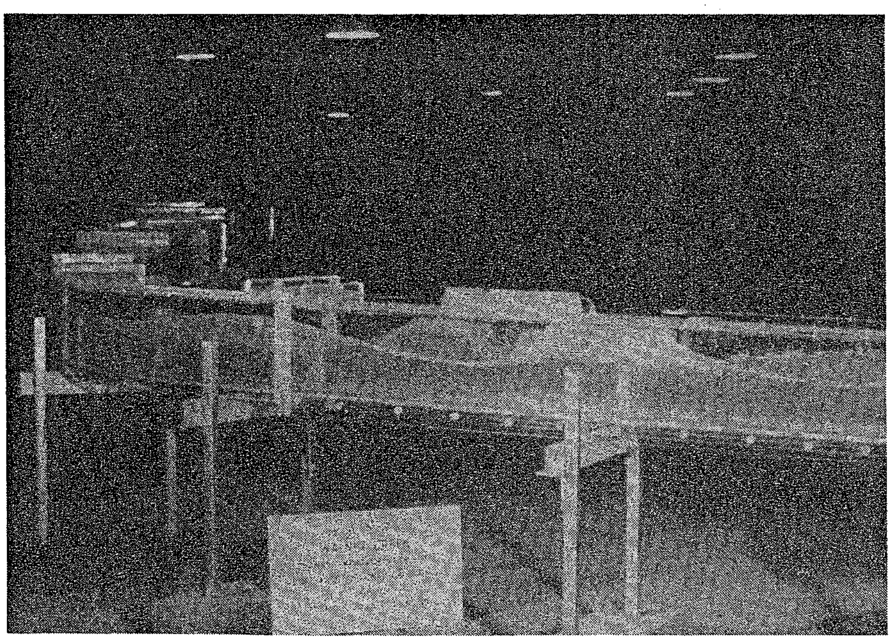
U.S. Army Engineer Waterways Experiment Station

An inexpensive tool that personnel can use in the field to evaluate evolving high-velocity channels is being developed at the Waterways Experiment Station (WES) in Vicksburg, MS. The tool is a numerical flow model that can estimate the location and strength of hydraulic jumps and standing waves in high-velocity channels. Field engineers can use this tool to help determine effective and safe operating conditions for these types of flood control channels.

The hydraulic performance of a high-velocity channel depends on maintaining a supercritical flow regime over specified portions of its length. Predicting the potential location of shocks, such as oblique standing waves and hydraulic jumps, and determining the superelevation of the water surface in channel bends are necessary to evaluate and maintain the required wall heights. Typically empirical equations or physical hydraulic models have been used to make these evaluations.



Physical model of high-velocity flow channel, Walnut Creek, Sacramento, California

Physical models were used in the original study of many existing flood-control channels, but urbanization within their drainage basins has resulted in discharges greater than those for which the channel was originally designed. Obstacles, such as debris or bridge piers, may cause the flow to jump to a subcritical state, thus resulting in flood damage. Therefore, an inexpensive and portable means for evaluating these channels is needed. A numerical model is a logical approach.

Numerical Flow Model

The model being developed at WES is a modification of a spillway model developed previously by Dr. Charlie Berger, Hydraulics Laboratory, WES. The high-velocity channel model, HIVEL2D, is a depth-averaged, two-dimensional (2-D) flow model designed specifically for flow fields that contain supercritical and subcritical regimes as well as the transitions between the regimes.

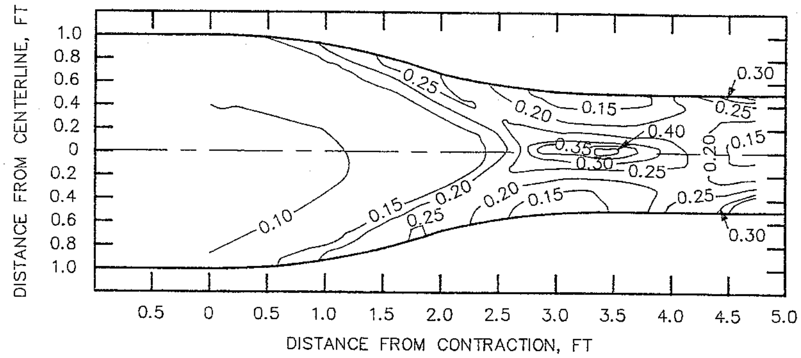
Model Applications

A series of tests, including channel contractions, confluences, curves, and expansions, has been conducted to evaluate the performance of the model. These channel configurations were chosen to match existing, good data sets from flume simulations. Future tests will include bridge piers.

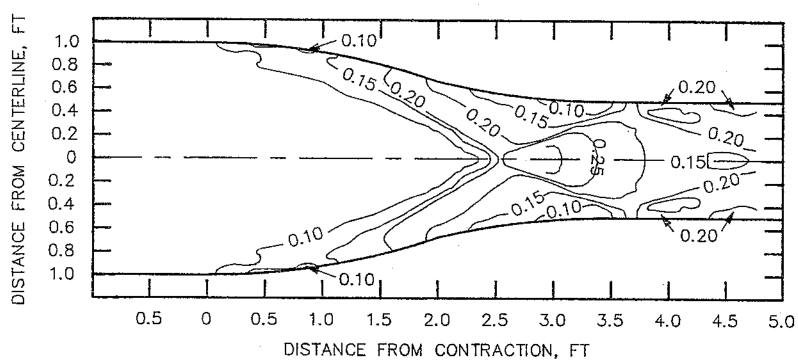
Initially, HIVEL2D was run to simulate supercritical flow in a channel contraction. Two contractions were tested, one with straight walls and one with curved walls that have geometries similar to those reported by Ippen and Dawson (1951). These cases are geometrically simple, but the results demonstrate the ability of the model to capture the supercritical shock waves caused by changes in the wall boundaries. Figure 1 shows contours of flow depth for a curved-wall section observed in the laboratory and computed by HIVEL2D. The straight-wall contraction results are presented in Figure 2. The numerical model captures the oblique standing waves produced by the contractions.

After these base cases were documented, tests were conducted to compare the results from HIVEL2D with some of those obtained in the physical model study of Rio Puerto Nuevo Flood Control Channel (Stockstill and Leech 1990). The Margarita Channel was one of three models tested for the project. The Margarita Channel consisted of two reverse curves, a width transition, and tailwater that produced a hydraulic jump upstream of the width transition.

To avoid similitude questions, HIVEL2D was run at laboratory scale. This method resulted in direct comparisons of calculations to observed quantities. HIVEL2D not only captured the hydraulic jump in the channel but also produced the asymmetric flow

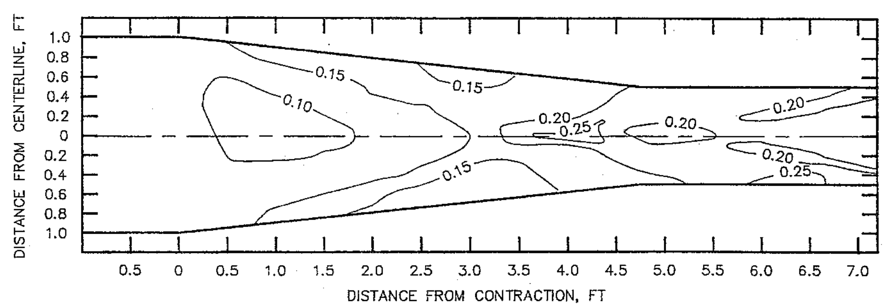


a. Laboratory flume (modified from Ippen and Dawson 1951)

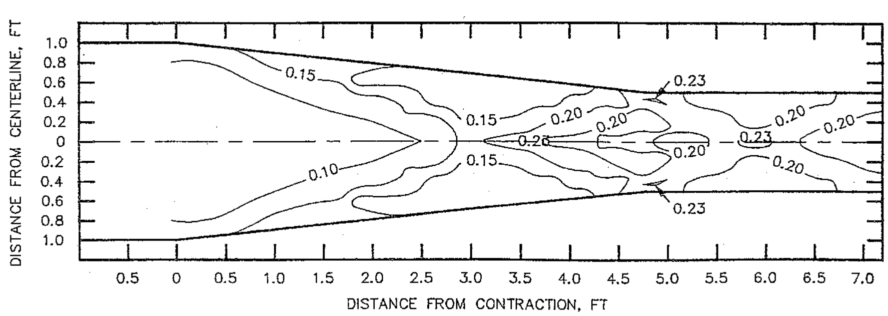


b. Numerical model (HIVEL2D)

Figure 1. Depth contours in a curved-wall contraction, Froude No. = 4.0



a. Laboratory flume (from Ippen and Dawson 1951)



b. Numerical model (HIVEL2D)

Figure 2. Depth contours in a straight-wall contraction, Froude No. = 4.0

patterns downstream of the width transition that was observed in the physical model. The short length of the transition (1 on 4) in conjunction with the asymmetric flow distribution produced by the upstream bend resulted in a large eddy in the downstream channel that produced flow concentrations along the left wall. Higher velocities (1.9 fps) existed along the left wall, whereas the flow along the right wall was essentially stagnant, as shown by the dark area in the laboratory photograph presented in Figure 3. The numerical model results shown on Figure 4 show that HIVEL2D accurately predicted the asymmetric flow patterns downstream of the expansion.

The numerical model was further tested by a comparison of computed results of the Puerto Nuevo/Guaracanal Channel confluence with those observed in the laboratory study. Figures 5 and 6 show that the HIVEL2D captured the overall features of the diamond-shaped standing wave pattern resulting from the confluence geometry. Water-surface

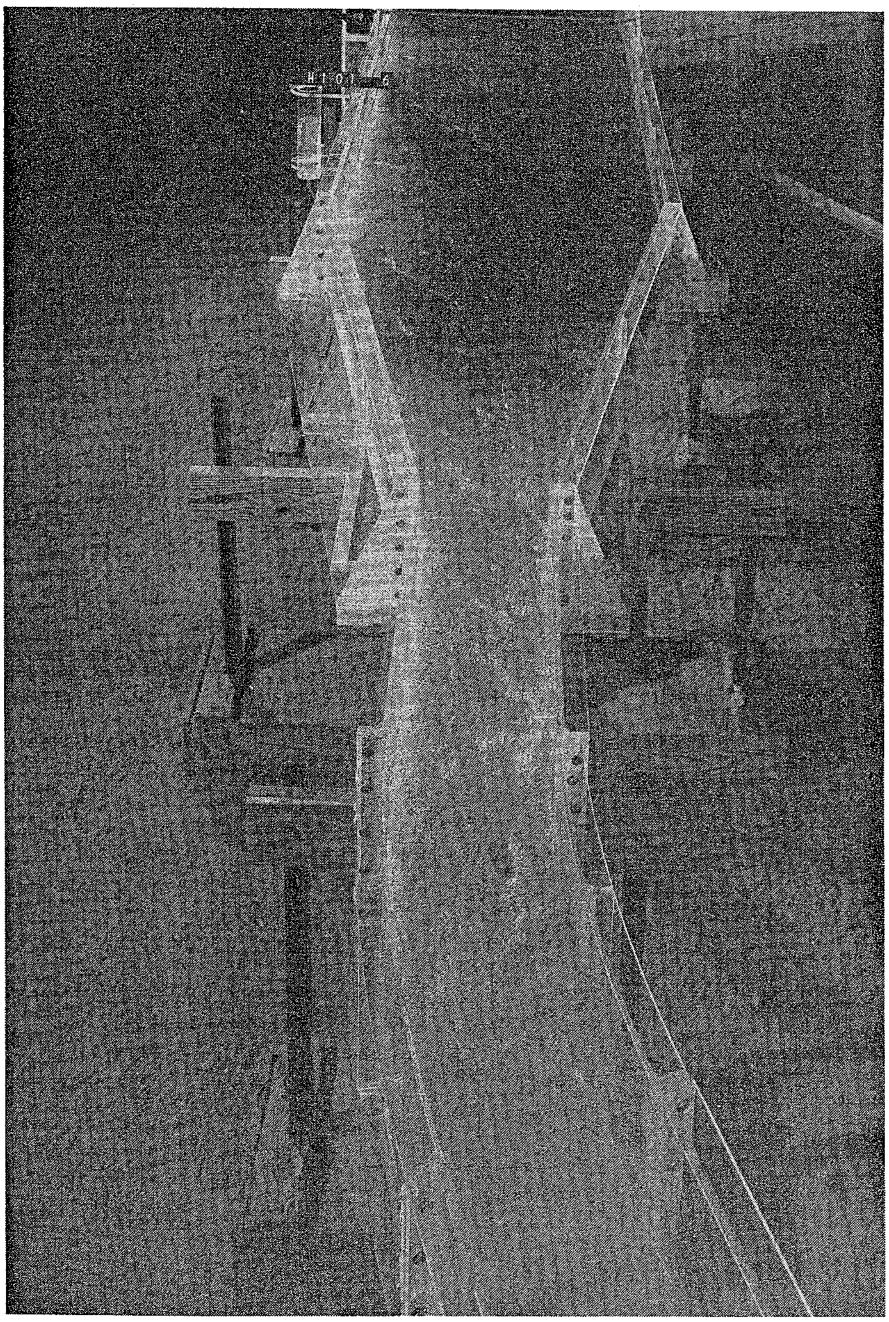


Figure 3. Margarita Channel physical model flow conditions in the vicinity of the channel expansion

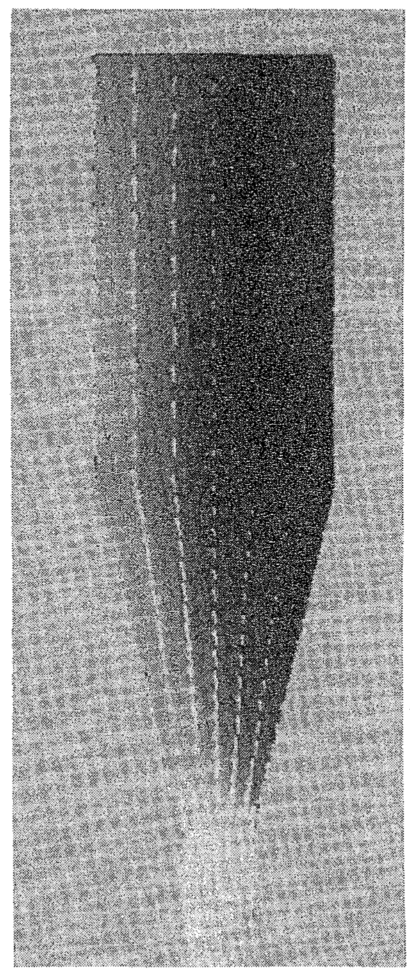
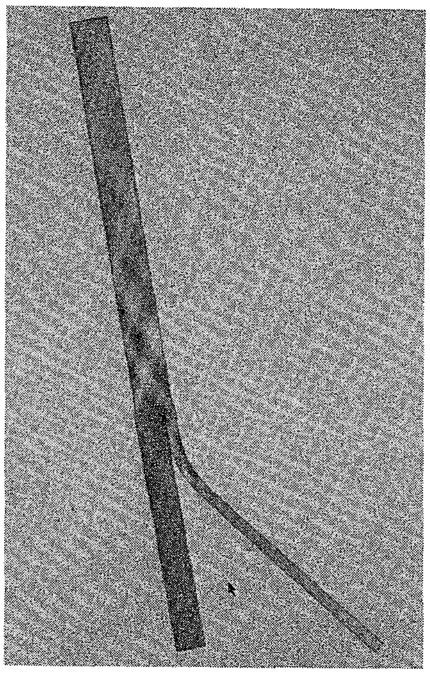
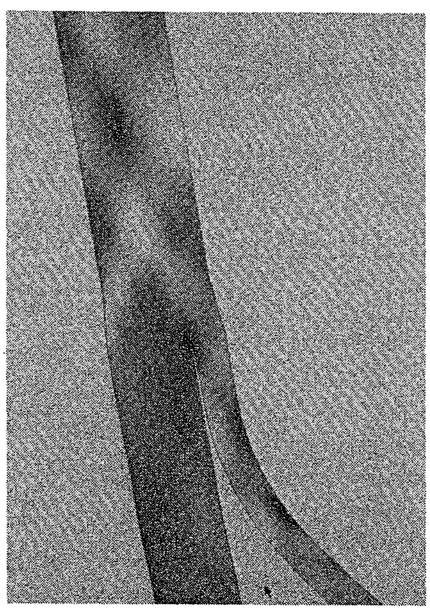


Figure 4. Velocity contours and vectors computed by HIVEL2D, downstream of the Margarita Channel expansion

profiles along the flume walls obtained with HIVEL2D and those observed in the laboratory are presented in Figure 7. The confluence is 13.9 ft downstream of the upper end of the flume. In most supercritical channels, the water surface oscillates in time even under steady boundary conditions. The recorded laboratory results are the maximum water-surface elevations observed, whereas the numerical model represents time-average water-surface elevations. HIVEL2D adequately simulated the initial shock wave crest, but the location of each subsequent wave crest is increasingly in error. This difference is the result of the shallow-water assumption used in the 2-D



a. Overall view of the channel



b. Closeup view of the channel confluence

Figure 5. Computed depth contours at the Puerto Nuevo/Guaracanal Channel confluence

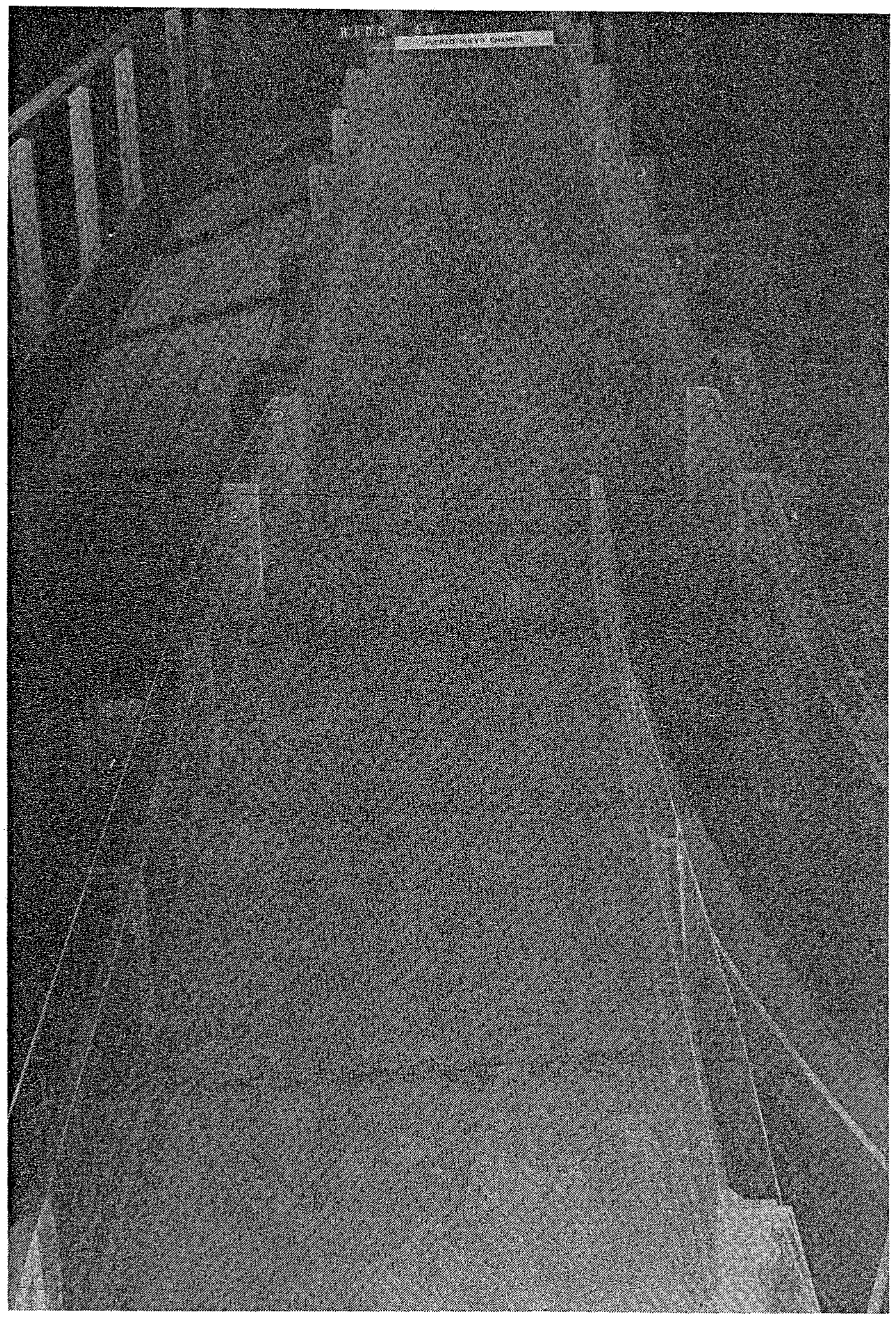


Figure 6. Physical model flow conditions at the Puerto Nuevo/Guaracanal confluence

numerical model. The shallow-water assumption results in all waves traveling with the celerity of a long wave, whereas three-dimensional (3-D) flow is actually composed of many wave speeds, the maximum of which is the long-wave celerity. The larger wave celerity means that the standing wave angles will be greater than the 3-D waves. This shallow-water equation limitation should be of little consequence, since channel wall heights are set to contain the maximum water-surface elevation plus freeboard.

Field Applicability

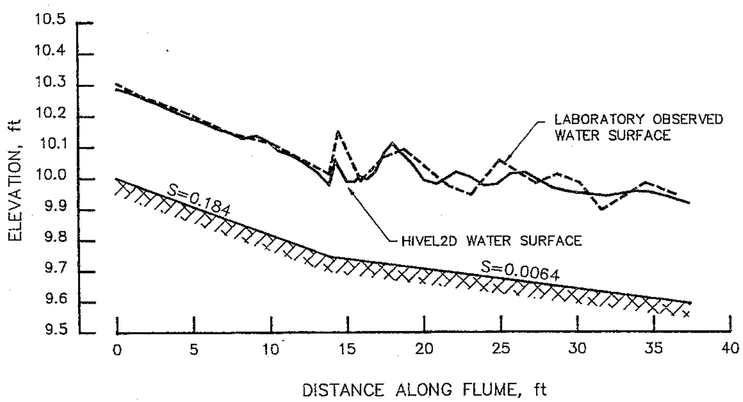
After completion of model testing, HIVEL2D will be made more user friendly, and program documentation will be prepared. HIVEL2D will then be available to field offices.

For additional information, contact Richard Stockstill at (601) 634-4251 or Charlie Berger at (601) 634-2570.

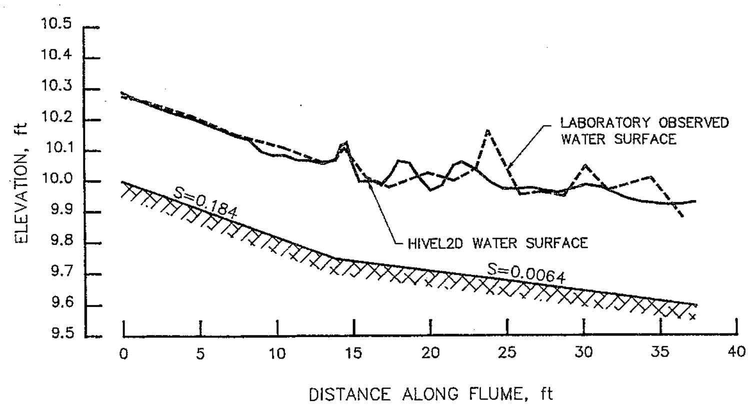
References

Ippen, A. T., and Dawson, J. H. 1951. "Design of Channel Contractions," *Transactions of the American Society of Civil Engineers*, Vol. 116, pp. 326-346.

Stockstill, R. L., and Leech, J. R. 1990. "Rio Puerto Nuevo Flood-Control Project, San Juan, Puerto Rico; Hydraulic Model Investigation," Technical Report HL-90-18, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

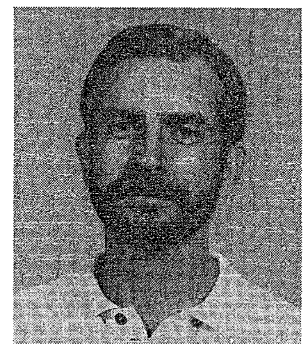


a. Right wall

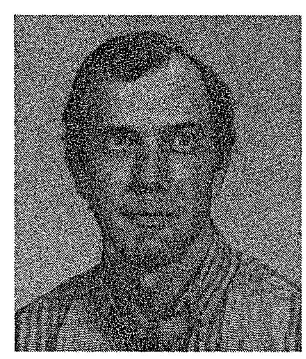


b. Left wall

Figure 7. Water-surface profiles along the Puerto Nuevo Channel walls



Richard Stockstill is a research hydraulic engineer in the Structures Division, Hydraulics Laboratory, WES. He received a B.S. degree in management, a B.S. degree in civil engineering, and an M.S. degree in civil engineering from Mississippi State University and has done advanced graduate work at the University of Washington. He is one of the Principal Investigators for REMR Work Unit 32657, "Model for Evaluation and Maintenance of High-Velocity Channels."



Charlie Berger is a Research Hydraulic Engineer in the Estuaries Division, Hydraulics Laboratory, WES. He received B.S. and M.S. degrees in civil engineering from Mississippi State University and a PhD degree in engineering mechanics from the University of Texas at Austin. He is one of the Principal Investigators for REMR Work Unit 32657, "Model for Evaluation and Maintenance of High-Velocity Channels."

Icing Problems at Corps Projects

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

The freezing temperatures of winter months can literally put the Nation's navigable waterways out of commission because of problems evolving from ice formation. Tainter gates may become frozen in place and therefore inoperable as the result of ice accumulations upstream of locks and dams (Figure 1). Roller gates cannot be operated if their chain hoist systems are buried in ice. The weight of ice on the support bracket can cause failure of a miter gate. Lock walls, mooring bitts, gate and valve machinery, even walkways can experience damage from ice formation. Each year, considerable time and effort are required to return ice-impacted machinery to normal. The problem affects about half of the United States, with varying degrees of severity, depending on location and intensity of winter weather.

Both structural and operational solutions to some of these costly ice problems have been developed at specific projects, but in many instances may not be widely known or economically feasible. For example, considerable attention has been given to lock wall icing. Hanamoto (1977) proposed several methods of alleviating this problem, including polymer coatings, high-pressure water jets, large ice saws, and pneumatic devices. Although these methods have met with varying degrees of success, they are not used extensively because they are not cost effective.

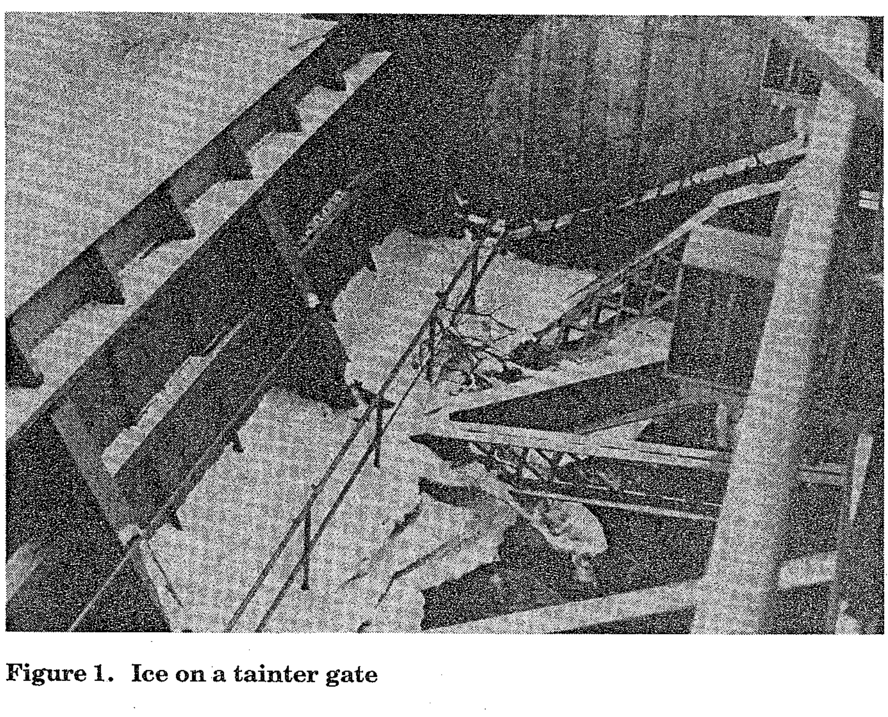


Figure 1. Ice on a tainter gate

Survey of Icing Problems

In an effort to identify existing solutions to these icing problems and to provide an avenue for sharing these alleviation methods, the Cold Regions Research and Engineering Laboratory (CRREL) sent a survey in December 1991 to all Districts and Divisions with projects affected by inclemate weather (Haynes, Haehnel, and Zabilansky, in preparation). As an offshoot of the original purpose of the survey, the investigation also helped to identify problems for which solutions are not currently known and for which additional research is needed.

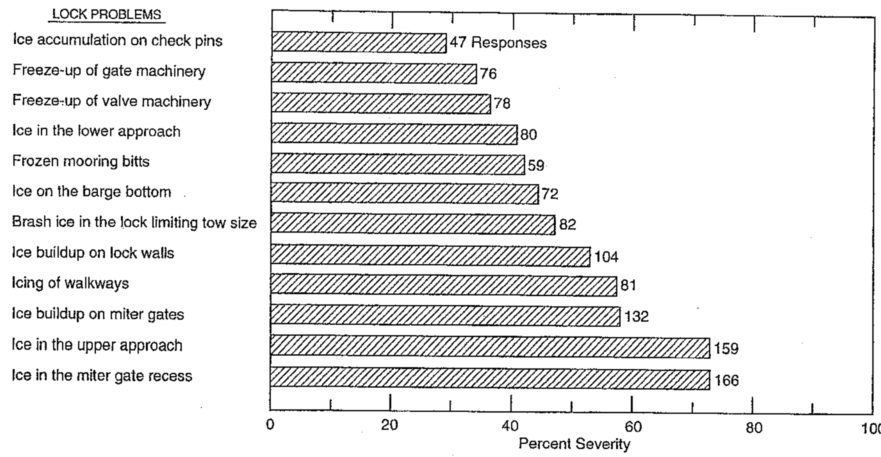
The two-page survey focused on three areas: locks, dams, and general ice problems. Known problems and alleviation methods were listed, but space was provided on the form so that respondents could add specific events occurring at their installations. Responses were requested in two columns: severity and alleviation method. The severity categories (high, medium, and low) were subjective, but an example was included to clarify interpretation of the categories: "If an icing problem causes an interruption of operations and 100 man-hours are required for normal operations to be restored, mark the category 'high' if the event happens every 5 years or less; 'medium' if it occurs every 5 to 10 years; and 'low' if it occurs every 10 years or more." Respondents were asked to name any alleviation methods they had used for a particular problem.

Response to the survey was excellent. The results were entered into a database. The severity responses were converted from "high," "medium," "low," or "none" to a percentage rating. A 100-percent severity rating indicates that an area has a serious icing problem, whereas a 0-percent rating indicates that no icing problems exist at that site (Figure 2). The percentage rating provides a basis for comparison of the impact of icing among Corps projects; also, a comparison of problems can aid in sorting out those that need the most attention. With this rating system, the severity of these problems by geographic area can be identified as well as the frequency that various solutions have been used. Thus the effectiveness of each solution can be assessed.

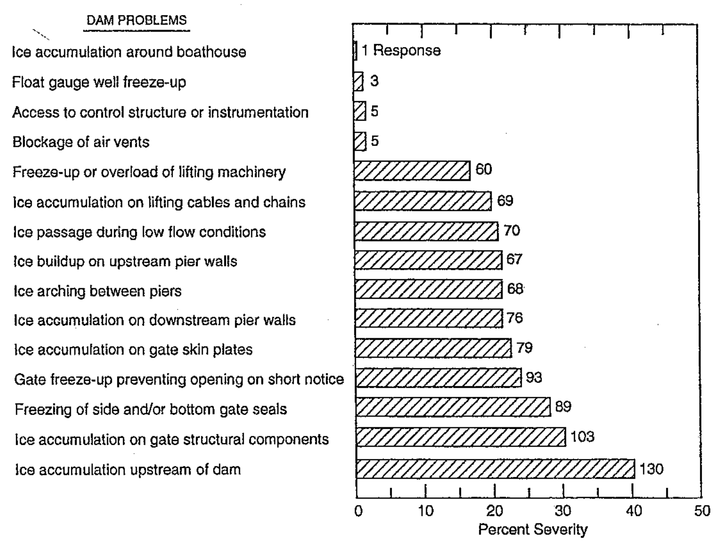
To compare the severity of icing problems at Corps projects, a percent severity was found for each problem listed. In addition to the problems listed on the survey form, other problems were identified by the respondents, such as ice damage to hand rails, damage to piezometer casings, freezing in piezometer tubes, ice formation in bypass wells, well float freeze-up, ice blockage of air vents, and well float gage freeze-up.

Solutions

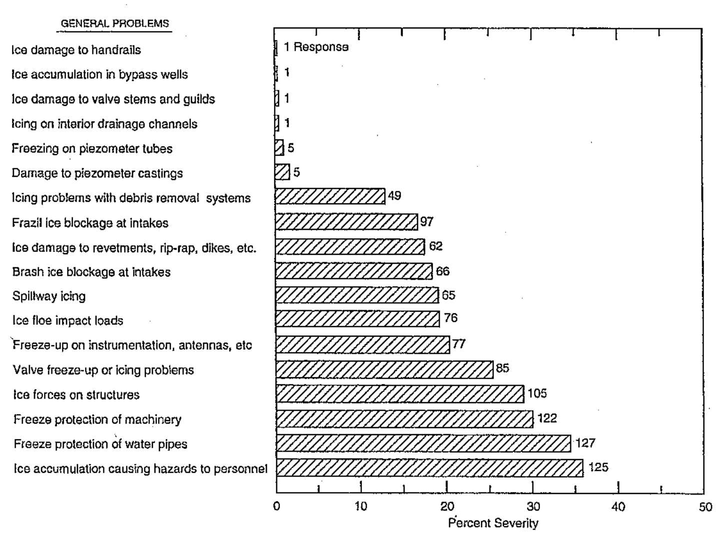
Various alleviation methods to icing problems were reported (Figure 3). These solutions can be categorized as operational, mechanical, heat, and manual. There are a few problems for which no solutions were identified, notably ice damage to revetments and riprap.



a. Locks

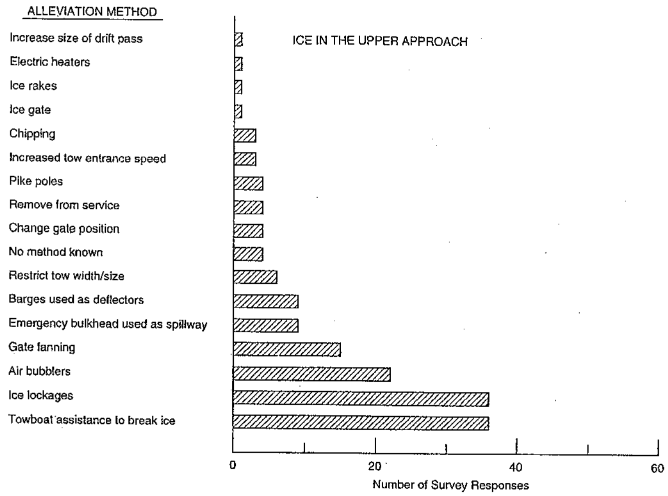


b. Dams

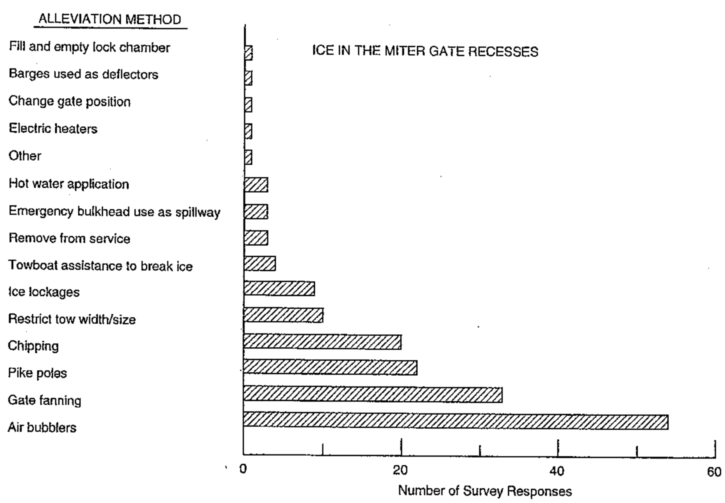


c. General ice problems

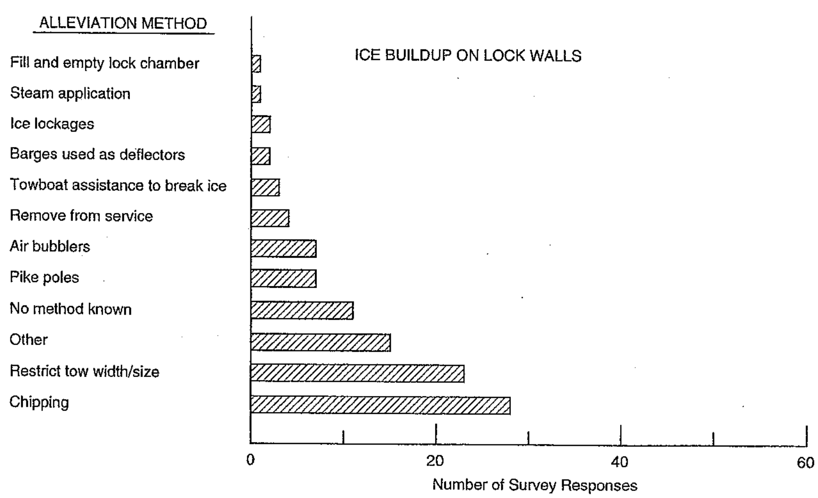
Figure 2. Severity of ice problems



a. Ice in the upper approach



b. Ice in the miter gate recesses



c. Ice buildup on lock walls

Figure 3. Alleviation methods and number of responses

Operational solutions

Operational solutions are those that do not require changes in project hardware or design but instead require changes in project operations during the winter to handle ice accumulations and icing problems. These include ice lockages; increased tow entrance speed; use of the emergency bulkhead as a spillway; use of barges as deflectors; gate fanning; restriction of tow width and size; removal from service; towboat assistance to break the ice; changing the gate position or continual movement of the gates; use of sand, salt, or other ice-melting compound; flushing water; ice coupling; filling and emptying the lock chamber; draining the water pipes; leaving water running; restricting intake flow; covering the air intake for tunnel operation; sealing leaks on dam gates; greasing mooring bitts; keeping the pool level low; maintaining the winter pool at high elevation; and towboat wheel wash.

Mechanical solutions

Mechanical solutions often involve the purchase and installation of hardware and equipment. In some cases, they may also require modifications to existing projects. However, the costs incurred by these solutions are usually offset by the huge reduction of time required to handle ice problems. These solutions include air bubblers, ice piers, water jets, intakes below ice depth, burying water pipes below the frost line, insulating water pipes, plywood covers, electric motor overload protection, use of an ice gate, and increasing the size of drift passes.

Heat solutions

The use of heat to control icing may require purchasing and installing hardware, like the mechanical installations. The operating costs will vary with the demand and should be considered in any installation. These options include steam application, electric heaters, hot water application, and gas heaters.

Manual solutions

Manual solutions are labor intensive and time consuming. The hardware involved is usually very inexpensive compared with the labor costs. These solutions include compressed air lances, pike poles, ice rakes, chipping, and saws.

Additional information about these solutions can be obtained from a project or Corps District where the remedy has been implemented. The rationale for the design or rehabilitation of a project should consider methods for preventing the formation of ice in problem areas, in contrast to the removal of ice after it has formed. Many of the manual methods of removal should be eliminated wherever possible. The survey results also showed a need to develop new solutions to many icing problems that still prevent Corps projects from operating efficiently during winter conditions.

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

References

Hanamoto, B., Editor. 1977. "Lock Wall Deicing Studies," Special Report 77-22, U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, NH.

Haynes, F. Donald, Haehnel, Robert, and Zabilansky, Leonard. "Icing Problems at Corps Projects," REMR Technical Report in preparation, U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, NH.

Donald Haynes is a mechanical engineer in the Ice Engineering Research Branch at the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL), Hanover, NH. He has a B.S. degree in mechanical engineering from the University of Arizona and an M.S. degree in mechanical engineering from Michigan Technological University. Haynes has over 20 years of experience in applied research on ice problems and is currently a Principal Investigator on a REMR research work unit on icing problems. He is a Registered Professional Engineer in the State of New Hampshire.

Robert Haehnel is a research mechanical engineer at CRREL and works in the Ice Engineering Branch. He holds a B.S. degree in engineering from Brigham Young University. Haehnel has been involved in the REMR Program for a year and has been with CRREL for 4 years. He is a member of the American Society for Mechanical Engineers.

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

Trenchless Technology Seminar

Trenchless pipeline rehabilitation, horizontal directional drilling, and microtunneling will be the focus of the Trenchless Technology Seminar to be held 26-30 January 1993 in Vicksburg, MS. This seminar is co-sponsored by the Trenchless Technology Center (TTC), Louisiana Tech University; Waterways Experiment Station (WES); and the North American Society for Trenchless Technology (NASTT).

Course chapters and case studies will be presented by industry experts. These will provide an in-depth look at trenchless design techniques for installing, rehabilitating, or replacing underground utilities. Topics on the agenda include a review of the state of the art in trenchless technology, costs and logistics, design methods and criteria, contracts and specifications, design for usability, project management, equipment selection and application, pipe and soil interaction, equipment and soil interaction, and case histories.

Table top displays will feature rehabilitation systems, microtunneling equipment, and mini-horizontal directional drilling. A tour of WES will include a visit to the Construction Productivity Advancement Research (CPAR) Microtunneling and Horizontal Directional Drilling (HDD) testing site.

This seminar is directed toward engineering staff responsible for underground infrastructure projects, technical and marketing staffs, equipment manufacturers and material suppliers, faculty members of colleges and universities, contract administrators and project managers of utility owners, and senior boring equipment operators and line supervisors.

For more information about registration and motel accommodations, contact NASTT at (312) 644-0828.

Request for Articles

We want to hear from you! The purpose of *The REMR Bulletin* is to keep you the readers informed of developments in the REMR Research Program and to provide a means for you to pass on to others your experiences in repair, evaluation, maintenance, or rehabilitation activities. Send us your draft articles, reports, photographs, notices, or news about what is going on in your area. We will help you share this information with others who can benefit from your experience. Please write to: Director, U.S. Army Engineer Waterways Experiment Station, ATTN: CEWES-SC-A/Lee Byrne (Technology Transfer Specialist), 3909 Halls Ferry Road, Vicksburg, MS 39180-6199, or call (601) 634-2587.

Fourth REMR-II Field Review Group Meeting

A major goal of the Repair, Evaluation, Maintenance, and Rehabilitation (REMR) Research Program for the upcoming year will be to close the gap between development of new technology and its application in the field. This was the consensus of the Field Review Group (FRG) attending the Fourth REMR-II FRG Meeting held September 29 and 30 at Waterways Experiment Station (WES), Vicksburg, MS.

The catch phrase during the meeting was "getting more bang for the buck," and emphasis was placed on technology transfer. All work units were reviewed to assess their productivity, cost-effectiveness, and serviceability.

Other recommendations included working closer with other programs and facilities to realize synergisms, increase the number of milestones within work units, encourage District and Division personnel to attend review meetings, and expedite technology transfer through increased publications, demonstrations of technology, and workshops.

The next FRG meeting is scheduled for July 1993 at a location to be determined. At that time, the progress on each work unit will be reviewed, and additional research needs will be assessed for new starts.

For more information about the REMR Research Program, contact the REMR Technology Transfer Specialist, Lee Byrne, at (601) 634-2587, or write Director, Waterways Experiment Station, ATTN: CEWES-SC-A/Lee Byrne, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199.

Publications

Several REMR publications will soon be ready for distribution. *DAMSEAL--An Expert System for Evaluating Dam Seepage*, Technical Report REMR-GT-19, by Roger L. King and Wendell O. Miller, documents an expert system containing the Corps' best diagnostic capabilities for seepage analysis and control at dams. The *Annotated Bibliography of REMR Technical Reports Through September 1992*, unnumbered, contains abstracts of REMR technical reports published through September 1992. *Continuous Deformation Monitoring System (CDMS)*, Technical Report REMR-CS-39, by Carl Lanigan, documents automated deformation monitoring technology developed at the U.S. Army Topographic Engineering Center; the CDMS is capable of computing structural deformation using the Global Positioning System survey technology while operating in a continuous fashion over time.

Featured in This Issue

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The REMR Bulletin is published in accordance with AR 25-30 as one of the information exchange functions of the Corps of Engineers. It is primarily intended to be a forum whereby information on repair, evaluation, maintenance, and rehabilitation work done or managed by Corps field offices can be rapidly and widely disseminated to other Corps offices, other US Government agencies, and the engineering community in general. Contribution of articles, news, reviews, notices, and other pertinent types of information are solicited from all sources and will be considered for publication so long as they are relevant to REMR activities. Special consideration will be given to reports of Corps field experience in repair and maintenance of civil works projects. In considering the application of technology described herein, the reader should note that the purpose of *The REMR Bulletin* is information exchange and not the promulgation of Corps policy; thus guidance on recommended practice in any given area should be sought through appropriate channels or in other documents. The contents of this bulletin are not to be used for advertising, or promotional purposes, nor are they to be published without proper credits. Any copyright material released to and used in *The REMR Bulletin* retains its copyright protection, and cannot be reproduced without permission of copyright holder. Citation of trade names does not constitute an official endorsement or approval of the use of such commercial products. *The REMR Bulletin* will be issued on an irregular basis as dictated by the quantity and importance of information available for dissemination. Communications are welcomed and should be made by writing US Army Engineer Waterways Experiment Station, ATTN: Lee Byrne (CEWES-SC-A), 3909 Halls Ferry Road, Vicksburg, MS 39180-6199, or calling 601-634-2587.

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