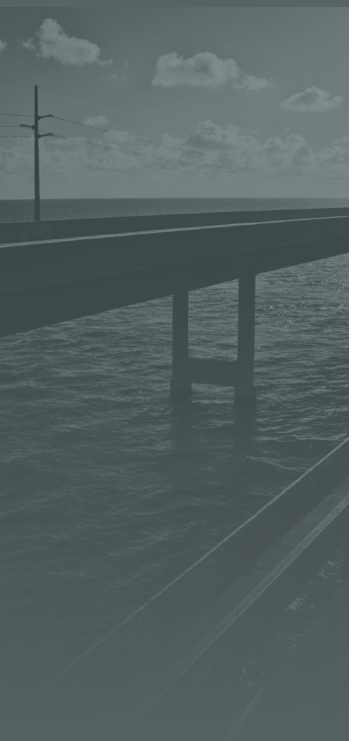

Mapping the Future of Hydraulics Research

A Strategic Plan to Protect Highway Infrastructure

NEARLY 60 PERCENT of failed bridges in recent years have succumbed to hydraulic forces. As our highway infrastructure ages and the risk of bridge and culvert failures rises, the need to predict, detect, and prevent water-related damage grows more urgent. To stimulate advanced research in this area, the Federal Highway Administration's (FHWA's) Exploratory Advanced Research (EAR) Program convened the First International Hydraulics Research Forum, gathering researchers and other stakeholders to identify research priorities.

Collaborating on a Hydraulics Research Roadmap

The Hydraulics Research Forum, held in June 2007, drew experts from government transportation agencies, universities, and industry, who reported on a broad spectrum of ongoing investigations and specific research needs. Discussion centered around three major areas of hydraulics research—coastal, inland, and environmental—and the need to establish communication, partnerships, and future direction. Two topics warranted special attention: advanced modeling capabilities (physical, numerical, and super-computing) and the implications of climate change for the field.

According to Kornel Kerenyi of FHWA's Office of Infrastructure Research and Development, "The participants emphasized the importance of collaboration to maximize scarce funding and data sharing to accelerate the progress of research. They recommended that annual or biennial hydraulics research forums be organized, a Web site be created for reporting and peer-reviewing hydraulics research, and a steering committee, working groups, and collaborative relationships be formed for planning and conducting research."

Among the high-risk topics with long-term potential raised at the forum, participants called for research into potential applications of "smart" materials, such as in integrated scour-monitoring systems. They also recommended that hydrodynamic bridge pier and deck systems be developed, as well as structures that can adapt optimally to flow conditions through the use of adaptive materials based on nanotechnology and biomimetic concepts.

For the near term, two areas of high-risk, high-payoff research were identified: development of smart particles for monitoring of hydraulic hazards and the development of scour countermeasures using advanced materials based on nanotechnology.

EAR Support for Hydraulics Research

Two EAR-sponsored investigations are underway that address hydraulics research needs. A joint study is exploring new ways to measure and understand the complex flow fields and boundary pressure fields that are associated with bridge pier scour. Led by FHWA's Hydraulics Research Laboratory in collaboration with experts from the National Aeronautics and Space Administration's Jet Propulsion Laboratory, this project is pursuing an integrated, flexible, sensing system that can measure changes in shear stress and pressure when a scour hole forms. Such a system would significantly aid small-scale experiments in bridge scour problems.

A second project is working toward an advanced optical system to allow three-dimensional measurement of the entire instantaneous flow field around bridge pier models. The high-resolution volumetric

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particle image velocimetry system will be able to capture and quantify complex, unsteady flow fields in experimental bridge scour research. Also led by the Hydraulics Research Laboratory at Turner–Fairbank Highway Research Center, this joint study with the U.S. Department of Energy's Argonne National Laboratory will enable hydraulic researchers to develop more precise models for predicting scour.

At the Cutting Edge—Smart Sensor Networks

Following on the Hydraulics Research Forum's recommendation for the development of intelligent piers, the EAR Program convened a market research meeting in June 2009 to explore the potential of wireless, "smart particle" sensor networks for hydraulics research and monitoring. Such sensors would be capable of transmitting data on position, velocity, pressure, and other variables under a wide range of environmental conditions. At the 1-day conference, five research laboratories presented their ideas, and a government review panel developed recommendations for moving forward. The panel comprised experts from the U.S. Army Corps of Engineers, National Institute of Standards and Technology, U.S. Geological Survey, U.S. Naval Academy, and Oak Ridge National Laboratory.

The panel recommended that a problem statement and a performance standard be developed as the basis for a full feasibility analysis. They identified a number of challenges—concept validation, data accuracy, cost–benefit considerations, reproducibility, scope of application, and potential environmental impacts—and suggested that a research roadmap be developed as well. The panel also called for a follow-up meeting that would include a broader array of university and industry researchers.

Future Efforts

The EAR Program continues to seek promising, high-risk, high-payoff projects in transportation-related hydraulics research, guided by the multiyear strategic plan formulated at the Hydraulics Research Forum. "Future research," Kerenyi predicts, "will lead to progress in many areas: computational fluid dynamics modeling, environmental highway hydraulics, hydrodynamic bridge structures, and shear stress and turbulence measurement. Many researchers will also focus on how climate change will impact hydrology and hydraulics."

What Is the Exploratory Advanced Research Program?

FHWA's Exploratory Advanced Research (EAR) Program focuses on long-term, high-risk research with a high payoff potential. The program addresses underlying gaps faced by applied highway research programs, anticipates emerging issues with national implications, and reflects broad transportation industry goals and objectives.

To learn more about the EAR Program, visit the Exploratory Advanced Research Web site at www.fhwa.dot.gov/advancedresearch. The site features information on research solicitations, updates on ongoing research, links to published materials, summaries of past EAR Program events, and details on upcoming events. For additional information, contact David Kuehn at FHWA, 202-493-3414 (email: david.kuehn@fhwa.dot.gov), or Terry Halkyard at FHWA, 202-493-3467 (email: terry.halkyard@fhwa.dot.gov).

Learn More

For more information or to discuss potential advanced hydraulics research topics, contact Kornel Kerenyi, FHWA Office of Infrastructure Research and Development, at 202-493-3142 (email: kornel.kerenyi@dot.gov).

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