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Storm surge and wave modeling for the protection gates in new orleans

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STORM SURGE AND WAVE MOD PROTECTION GATES IN NEW OR

BY DAVID SCHOWALTER AND PETER GRANT

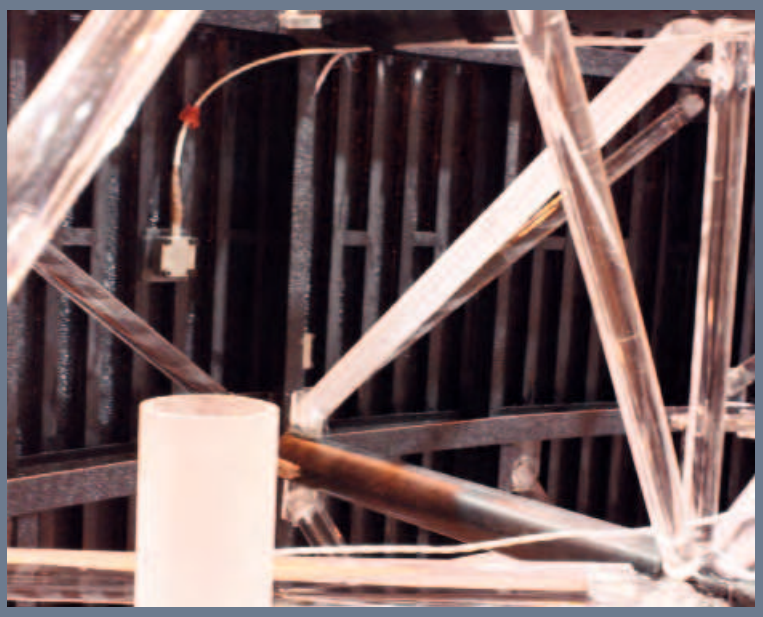
In August of 2012, Alden Research Laboratory, Inc. (Alden), headquartered in Holden, Massachusetts, U.S.A., acquired AECOM's hydraulic engineering and modeling laboratory in Redmond, Washington, and hired the associated staff. By combining the modeling talents and fisheries knowledge of Alden staff with the hydraulic modeling and fisheries engineering experience of the AECOM hydraulic engineering and modeling operation, Alden has created the largest commercial hydraulic engineering laboratory system in North America.

The AECOM laboratory was formerly known as the "ENSR hydraulics lab." and became part of AECOM in 2005 when AECOM acquired ENSR. Charles "Chick" Sweeney, P.E., started the independent hydraulic modeling laboratory in 1978. The hydraulics lab. has been a leader in the optimization of hydraulic structures and fish passage systems associated with hydroelectric power generation, working especially closely with federal agencies and hydroelectric power utilities in the Pacific Northwest. Additionally, the group has helped municipal utilities to ensure proper performance of pump stations and water conveyance systems. Capabilities include physical hydraulic modeling, 1-D and 2-D numerical modeling, 3-D computational fluid dynamics (CFD) modeling, fisheries and hydraulic engineering design, and associated field services.

Alden has been expanding geographically in recent years, having opened up an office in Fort Collins, Colorado, in 2009, and establishing a presence in Portland, Oregon, in 2011. This addition is a major milestone in an ongoing effort to better serve clients in the U.S. and internationally. It establishes Alden's presence on both coasts and enables the company to better serve the growing hydraulic design and flow modeling market. The two units have similar corporate cultures and have not been competing directly on projects in recent years.That translates into the ability to offer more resources and more talent to the customers of both facilities. A continued collaboration with AECOM is also expected.

Complementary Experience

While the groups centered in Holden and Redmond have similar physical and computational hydraulic modeling experience, some subtle and strategic differences exist. For example, the Redmond team has had a special focus on fish passage hydraulics and habitat protection in the U.S. Pacific Northwest and federal agency work, whereas the Holden operation was more focused on fish passage and protection in the Midwest and East Coast,



Hydroelastically Scaled Sector Gates

Storm Surge and Waves Testing

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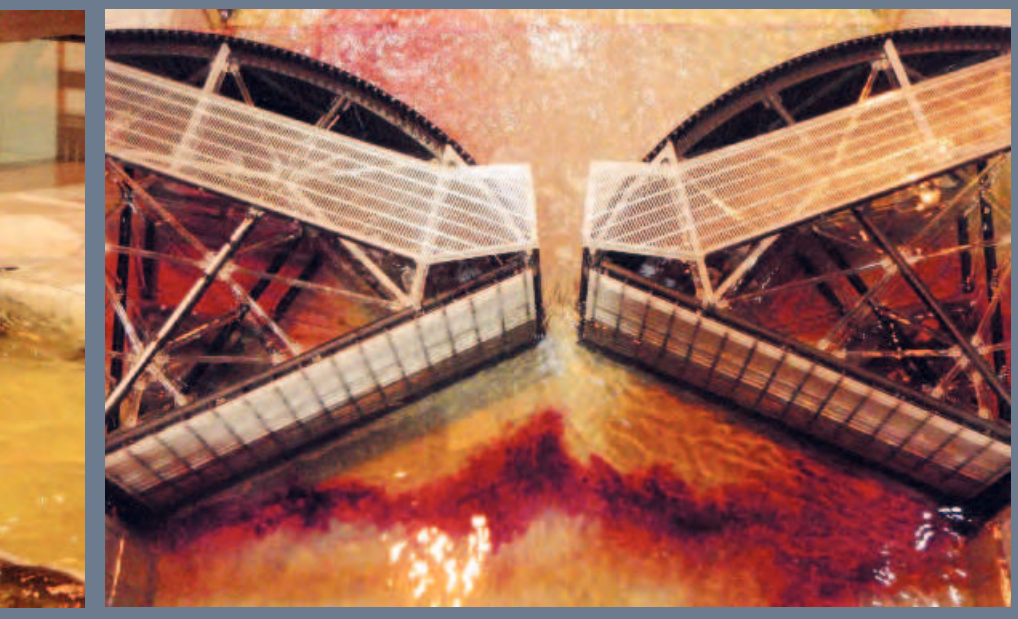
with very unique facilities for using live fish in testing flumes. The Holden operation is also very well known for flow meter and flow control equipment testing and calibration, has a long history of working with the U.S. nuclear power industry on safety system hydraulics, and services the fossil power industry with gas flow modeling, especially in the area of air quality control system optimization.

While both groups have developed physical models of coastal structures in recent years, the Redmond operation's work in this area has been more extensive. The following case study provides an example of Alden's new capabilities through the Redmond acquisition. With rising sea levels and increased awareness of storm surge flooding dangers, Alden anticipates providing more of this type of infrastructure support in the coming years.

Case Study: Storm Surge and Wave Modeling

In 2009, the Redmond laboratory developed a 3-D hydroelastic 1:20 scale physical model study of the neutrally buoyant sector gates that are part of the 3 km long Inner Harbor Navigational Canal (IHNC) storm surge barrier in New Orleans. This modeling effort was commissioned by the United States Army Corps of Engineers (USACE) in response to destruction brought by Hurricane Katrina. The IHNC surge barrier is the first line of defense against storm surge and is designed to allow some waves to overtop the structure. A polder (an area of low land) behind the surge barrier can accumulate up to 1.5 ft of additional water surface elevation during a 1 percent chance hurricane. The system's sector gates then become a large flood-relief valve and are required to open to let the accumulated water back out to sea. The study was performed to affirm the design loads under storm surge and wave conditions, and to determine loads under reverse head conditions caused by storm surge receedance.

Besides being geometrically similar at a one-twentieth scale, the model components were individually designed to bend and vibrate at a scalable frequency recorded by accelerometers placed on the gate, exhibiting the effects of model generated waves with size and frequency spectrum similar to Hurricane Katrina. This



Reverse Head Test

Peter Grant **is a Senior Engineer in Alden's Hydraulic Engineering and Modeling group. He is a graduate in mechanical engineering from Purdue University, where he obtained his B.S.M.E. and M.S. in Fluid Dynamics. His experience includes all aspects of design-build projects from physical modeling of hydraulic systems and design of automated machinery, through quality inspections and plant start-ups of fish collection systems and other automated equipment. Mr. Grant is a registered professional engineer and a member of ASCE and ASME.**

David Schowalter **is currently Principal Engineer and Director of Business Development for Alden. Dr. Schowalter received his Bachelor's degree at Cornell University and his M.S. and Ph.D. degrees at the University of California, San Diego. He spent three years as a Visiting Assistant Professor at North Carolina State University. He joined Fluent Inc. in 1997 and was involved in technical support, consulting, sales, and business development with a focus in the energy industry through the ANSYS acquisition in 2006. He joined Alden in 2008, and manages strategic business initiatives, as well as some specific technical activities, particularly those associated with Computational Fluid Dynamics applications.**

scaling technique is not often utilized for coastal structures like surge barriers and breakwaters but is more common for the investigation of gate vibration in a dam's floodgates. The IHNC sector gates, which are similar to radial Tainter gates turned on their side, have significantly more structural members, forming three truss layers that resist the roughly 6 m storm surge corresponding to a 1 percent chance hurricane.

The gates incorporated two buoyancy tanks per gate leaf. A large buoyancy tank near the front of the gate helps to ease gate movement by reducing the force placed on the bottom seal. A smaller buoyancy tank near the gate's axle allowed these large, 25.6 m radial sector gates to be floated in place for final assembly. The innovative use of these tanks in the sector gate design was necessary to ease the operability of the gates and to reduce operations and maintenance costs. However, this also presented the designers with challenging questions regarding the forces experienced by the gates and the plausibility of exciting resonant vibrations.

Key findings from the experiments showed that waves directly in front of the sector gates were reduced by the channel's deeper waters and the long approach walls in front of the structure. Although these waves were reduced in total height, the curvature of the sector gates tended to focus wave energy where the gates meet, occasionally creating wave pressures acting on an overhanging portion of the gate that were twice the horizontal design pressure. Vibrations, however, were only observed during overtopping events; the frequency of which were far from dangerously resonant conditions.

Confirming the magnitude of wave pressures and forces during large wave impacts helped designers make final selections for structural members and the casting design of the main bearing supporting the weight of the sector gate.

For reverse head tests (simulating the release of flood waters from the polder behind the surge barrier after a storm's passing), the gates were instrumented to monitor vibration and the 1-D forces on the gates' actuating cylinders. During these tests, it was found that the hydraulic torque curve was considerably different than that for sector gates without buoyancy tanks (the only source of design data available up to that point). The test results created new hydraulic torque curves for sector gates with buoyancy tanks that the designers used for their selection of an appropriately sized gate opening and closing actuator.

A Common Future

The merging of AECOM's former Redmond hydraulic laboratory and Alden's legacy staff has resulted in a very rapid but smooth transition, owing to the similar culture and common technical work scope of the units. The coming years will be a building experience as the two groups work together on joint projects that combine the coastal and large hydropower facility experience in Redmond with the fisheries biology expertise in Holden.

For more information, please visit www.aldenlab.com.