*Ice formation in a wave environment within the Flume*

**The Flume**

The IEF Flume is the perfect device for testing river processes, particularly those related to frazil ice. It is 120 feet long and 2 feet by 4 feet in cross section. It can be tilted from 2 degrees normal slope to 1 degree adverse slope, and with two pumps it has a flow capacity of 14 cubic feet per second.

The bottom is refrigerated to facilitate studies of the variable roughness of the underside of a natural ice cover, since in effect the ice sheet is turned upside down. The Flume room operates at temperatures between 65°F and -20°F.

The wide variety of applications for the Flume include the study of an ice cover accelerating the sediment transport and scouring around bridge piers due to an ice cover. The glass sides of the Flume reveals how water erodes banks or the bed when an ice jam is present. Unique ice control techniques can be studied, and devices such as ice booms are easily evaluated and calibrated. The concept for a frazil ice collector screen has been developed and modeled in the Flume.

**Ancillary Areas**

The IEF shop and storage areas are used to setup experiments and store necessary materials. Large truck doors allow passage directly into each of the coldrooms, and an overhead monorail crane runs into each coldroom to facilitate the movement of heavy loads. A smaller coldroom is used for storage and analysis of ice samples from various tests.

The staff frequently conducts both expedient and long-term field studies of ice jam sites, usually including measurements of ice thickness, channel geometry and water temperatures. Our other field activities include supervision and installation of devices for ice control, on-site demonstrations of ice control structures, and consultation with other Corps engineers, local government officials, contractors, or other private entities.

**What Can We Do For You?**

CRREL is a federal installation so we often work with federal agencies. The lab is also mandated to transfer technology, and we're receptive to projects from other government agencies or the private sector. The facility is very versatile and we are interested in conducting research of any kind that will further the field of cold regions studies.

In the last couple of years, we have conducted tests for the U.S. Army, U.S. Air Force, Federal Aviation Administration, Homeland Security, oil companies, several other federal agencies, and non-government organizations.

Our capabilities and facilities are available to assist you in addressing and solving any problem related to applied engineering in cold regions.

The Ice Engineering Facility and CRREL are a national resource and an asset to the Army, the nation and the public.

Facility point of contact:
Leonard Zabilansky
(603) 646-4319
Leonard.J.Zabilansky@usace.army.mil

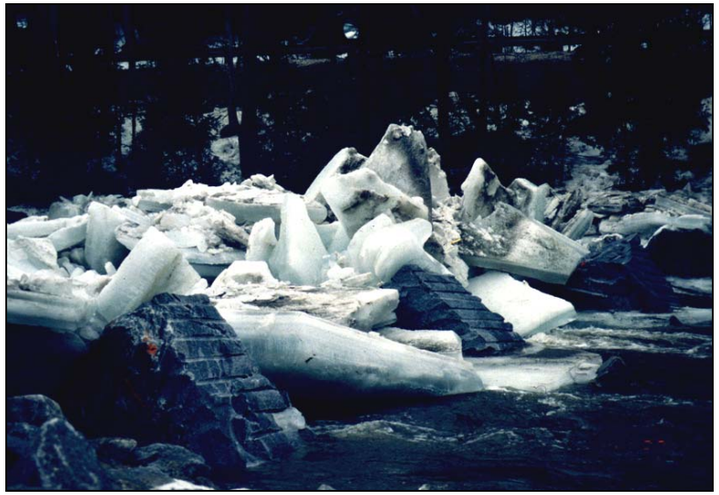
U.S. Army Engineer Research & Development Center
Cold Regions Research & Engineering Laboratory
72 Lyme Road, Hanover, New Hampshire 03755-1290
(603) 646-4100 www.crrel.usace.army.mil

US Army Corps of Engineers®
Engineer Research and Development Center

Cold Regions Research & Engineering Laboratory

# Ice Engineering Facility

*Model testing of the Barrow, Alaska, shore protection system within the facility's Test Basin*



*A CRREL designed ice control structure in place and working in Hardwick, Vermont*

Ice Engineering is a field of study that seeks to provide technical analyses and designs for solving ice problems -- that is, any situation where the effects of ice increase operational or maintenance requirements, reduce reliability, or impair man's activities around bodies of water in the world's cold environments. These problems can range widely, from ice jam flooding in Ohio to ice buildup at water intakes of a power plant in New Jersey to using ice covers for expedient river crossings or runways in Minnesota, and from winter navigation problems on the Inland Waterways, designing systems that withstand the destructive forces of moving ice on shoreline or offshore structures in the freshwater of the Great Lakes or the saltwater of the Arctic Ocean.

**Ice Engineering at CRREL**

The Cold Regions Research and Engineering Laboratory of the U.S. Army Corps of Engineers is a federal laboratory with the special mission of understanding the characteristics of the cold regions of the world and applying this knowledge to find better ways to live and work there.

The Ice Engineering Facility of CRREL was built to research, analyze, and solve ice problems on bodies of water using physical modeling. The extensive capabilities of our technical and support staff and our in-depth research, numerical modeling and field work combined with physical models make CRREL's unique Ice Engineering Facility the most flexible ice engineering organization in the world.

The IEF is a special purpose building on the grounds of CRREL in Hanover, New Hampshire. It is constructed as a flexible facility to be used with applied engineering to resolve engineering problems in cold regions river systems, navigation, mobility and equipment. There are offices, shop areas, and instrumentation rooms, but the IEF is known best for its three refrigerated research and refrigerated laboratory spaces -- the Test Basin, the Research Area, and the Flume.

**Test Basin**

Offshore structures are severely affected by ice formation and movement. The IEF Test Basin was designed primarily for large-scale study of the effects of ice forces on such structures as drilling platforms, shore protection systems, bridge piers, and for model studies of icebreaking vessels. Researchers with the IEF have assisted several organizations in designing offshore structures that are cost-effective, stable, and strong enough to stand up to the forces created by floating, mobile ice.

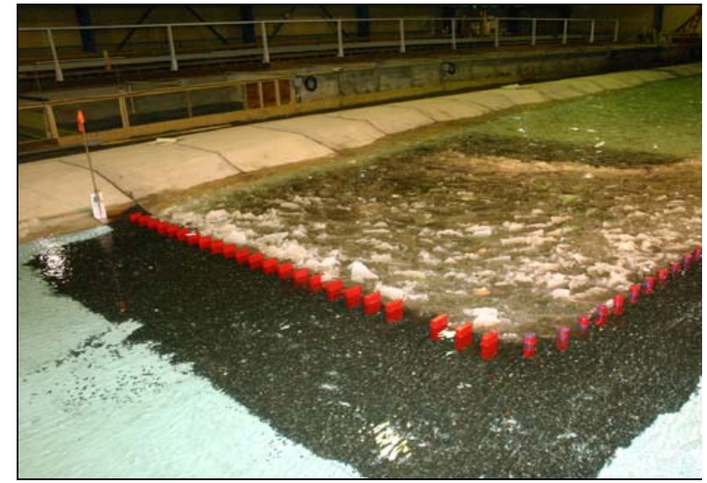
The Test Basin lets us duplicate conditions to test and monitor ice forces. Models of offshore structures can be built and tested. A carriage moves the model through ice-covered water, simulating ice impacting or passing the structure. Force and pressure transducers and accelerometers measure the model’s responses to ice forces. We can also analyze the ice failure modes of various structure configurations using video documentation. The controlled environment of the basin is large enough to be used to evaluate oil spill detection and mitigation techniques at the meso-scale. (The Test Basin is the featured cover photo.)

The Test Basin is 30 feet wide, 8 feet deep and 120 feet long. The room operates at any temperature between 65 and -20°F with even temperature distribution to ensure uniform ice thickness. Water with 1% urea by weight is used to freeze model ice with engineering characteristic proportional to model being tested. Models are pushed through the ice using the main carriage that spans the tank that is designed for 1000 lb load on all axes at speeds up to 7 ft/sec. The main carriage is parked in a heated space or preparation tank that is separated from the main tank by a thermal door to keep instrumentation warm while an ice sheet is grown. The main carriage is used to push the broken ice sheet into the melt tank at the opposite end from the preparation tank at the conclusion of the test to providing a quick turn around between ice sheets. A second carriage provides access to the ice sheet for measuring the engineering properties to insure the correct ice strength prior to testing.

The Test Basin is also used to study the forces of ice on locks and dams, ice control and management techniques, vessel dynamics in ice, brash-ice refreezing phenomena, the formation of ice pressure ridges, vertical uplift forces, ice-sheet bearing capacities, and fracture toughness crack propagation in ice.

**Research Area**

The Research Area is a large (80- by 160-foot clear span) refrigerated room where large-scale physical models of sections of rivers and lakes can be constructed and used to characterize an icing problem and evaluate remedial measures.



*Model study of an ice control structure within the Research Area*

There are few limits to the range of physical modeling activities that can be conducted in the IEF Research Area. In addition to modeling unique or generic river elements such as bends, changes in slope, and manmade features, IEF engineers can set up wave studies, duplicate frozen soil masses for various purposes, and create special trafficability environments. Models of small reaches of rivers can be constructed to test ways to alleviate ice jams through channel modification or control structures. The Research Area can also be used to test the bearing capacity of large ice sheets, testing mobility on snow or to cold-test vehicles and other equipment to be used in cold regions prior to deployment.

The temperature range of the Research Area is from 65 to -20°F. Four pumps are capable of providing flows up to 15 cubic feet per second. A cold glycol loop is available for secondary cooling to -10°F. The floor holds loads up to 400 pounds per square foot. The size of the room lends itself to testing snow mobility and cold testing of equipment.