CRREL Conducts Physical Model Tests for Barrow Coastal Protection

By Marie Darling, ERDC PAO

The ice-inundated Barrow coastline during an ice shoving or "ivu" event. Photo courtesy Alaska District.

Researchers with the Cold Regions Research and Engineering Laboratory (CRREL) are providing assistance to a very remote region of the world. A region so unique that months of darkness are followed by months of sunlight and the daily minimum temperature is below freezing for more than 300 days of the year. The area of interest is in Barrow, Alaska, the northernmost community in North America located on the Chukchi Sea coast, Barrow is approximately 10 miles south of Point Barrow, from which it takes its name.

The approximately 4,500 residents (most of them Inupiat Eskimos) are suffering the impacts of climate change – a thinning and shrinking ice sheet. This ice sheet traditionally provides a platform from which they hunt and fish. The changes in sea ice have resulted in increased erosion to the coastline; both by wave erosion during fall storms when ice is not present and by shoving large ice sheets or "ivus" into the shore during winter storms. Shore erosion not only results in loss of land, but also threatens critical infrastructure as well as valuable historical sites.

CRREL engineers are working with the Alaska District and engineers at the ERDC Coastal and Hydraulics Laboratory (CHL) to provide a solution for the eroding shoreline with a uniquely designed riprap shore protection system that protects the beach from wave action, but is robust enough to survive ice shoving.

The Test Basin within CRREL's Ice Engineering Research Facility is a tank that measures 120-feet-long by 30-feet-wide and eight-feet-deep. It is housed in a coldroom that can be operated at temperatures to minus 20 degrees Fahrenheit.

The Barrow model shown here prior to testing is a 1:20-scale model of the proposed shoreline protection structure. Photo by L. Zabilansky,

Traditionally, the Test Basin has been used to conduct large-scale studies of ice forces on structures such as bridge piers, ships, riprap structures and offshore platforms. With the knowledge and expertise gained from these previous studies, the Barrow coastal shore protection model testing will be well addressed.

The Barrow model tests will consider engineering designs for shoreline protection structures to reduce coastal erosion due to changes in sea ice presence and the timing and intensity of fall and winter storm events. The barrier was designed to prevent damage from waves and ice floes impacting the shoreline at Barrow.

“A series of model tests will be conducted in the Test Basin to simulate the impact of ice shoves from the Arctic Ocean onto the proposed coastal protection structures. The results of the tests will guide Alaska District engineers in the final design and construction at Barrow,” said Dr. Jon Zufelt, CRREL research engineer.

The model (shown here during testing) is pushed through the ice cover. The left hand side of the model uses special placement of the riprap material (individual stone placement); while right hand side is randomly placed. The special placement provides greater resistance to ice ride-up action. Photo by L. Zabilansky, CRREL.

An “ice shove” is a term developed by early CRREL sea ice researchers Drs. Devinder Sodhi and Austin Kovacs to describe the movement of sea or lake ice onto shore by the environmental forces of wind and/or water current. According to these researchers, ice shoves are not predictable and are often associated with storm events. In the Arctic Ocean, ice shoves can result in a variety of ice types reaching the shore, but large, thick first-year or multi-year ice sheets appear to penetrate the most inland, forcing piles of broken-up pieces or rubble ice to ride-up the beach, resulting in shoreline gouging and damage to infrastructure.

The first test considered whether a traditional boulder breakwater construction with a design based on the expected wave energy would be effective against moving sea ice. This testing indicated that the ice forces were much higher, resulting in the ice riding up and over the barrier, effectively destroying it by bulldozing and removing the rock from which it is constructed.

“In most areas of the country, including parts of Alaska, the wave climate determines the size of boulder required for successful shore protection structures. In some areas of Arctic Alaska, such as Barrow, the ice forces are much more severe than the wave climate,” said Zufelt.