U.S. Army
Corps of Engineers

Great Lakes Coastal Infrastructure: Critical Protection at Risk

This paper provides an overview of the vital role that coastal infrastructure plays in protecting urban waterfronts from storm surges, waves, and ice. It presents a strategy to prioritize limited federal funding and to begin a dialogue with local and state officials regarding potential options for non-federal interests to assume fiscal responsibility for these structures in the long-term.

The Great Lakes coastal shoreline includes some of the most beautiful, valuable, and vulnerable property in the Midwest and Northeast. Cities and towns in eight States have flourished along the shores of the Great Lakes because of their natural beauty and the value they bring to commerce, navigation, and recreation. Most of these coastal cities were established as ports, taking advantage of the Great Lakes as their primary mode of transporting goods, material, and people.

Over 130 coastal cities and towns around the Great Lakes have federal navigation projects that include channels for navigation and structures like breakwaters and piers. Although authorized to safeguard navigation activities in the federal harbors from waves and ice, these navigation structures also provide critical flood and storm protection for buildings, roads, and facilities that developed in their shadow along the urban waterfront. In some cases, urban waterfront development includes critical infrastructure for power generation, water supply, and wastewater treatment.

Federal funding for the maintenance of federal harbors is prioritized based on the national economic benefits of the harbor related to commercial navigation. Harbors that lack significant commercial navigation are not currently a high funding priority. Consequently, maintenance of recreational harbors and harbors with limited commercial traffic has been deferred.

Great Lakes Navigation System

The Great Lakes navigation system is a network of harbors, channels, locks, and dams that provides for interstate and international transportation of goods and materials (180 million tons of cargo in 2004).

The United States Great Lakes navigation system includes over 130 federal navigation projects with 610 miles of channels, 117 harbors, 104 miles of breakwaters, 20 dredged material disposal facilities, and the locks at Sault Sainte Marie, Michigan; Chicago, Illinois; and Buffalo, New York.

Most of the federal harbors in the Great Lakes were constructed between 1860 and 1940. At some of these harbors, commercial navigation has declined or ceased completely over the past 50 years. Recreation has become the major industry at many Great Lakes harbors, in some cases completely displacing industries that relied on commercial shipping. Currently, only 63 federal navigation projects on the Great Lakes support commercial navigation.

Coastal Forces

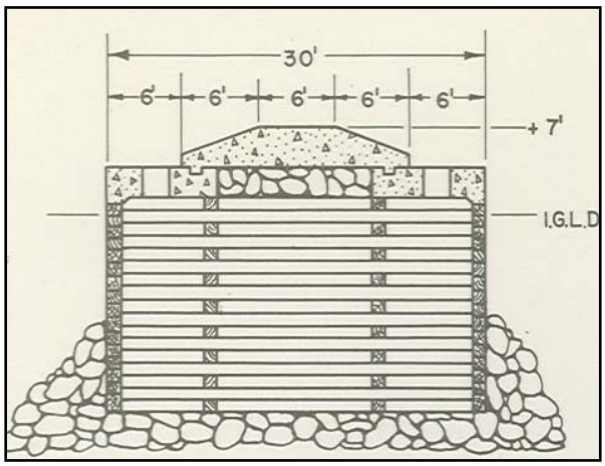
The Great Lakes are truly inland seas, with over 10,000 miles of coastline that is subjected to harsh, rapid changes in weather and wave conditions. Waves 10 to 24 feet in height, created by strong winds blowing over the lake surface, can deliver a powerful force capable of moving large stones weighing many tons each. Often, large waves combine with up to eight feet of storm surge, creating a substantial rise in water level.

The combination of storm surge and large waves, especially when accompanied by ice, generates powerful forces on harbor structures. Structures can be exposed to these forces many times each year, which can weaken a deteriorated structure with every event.

The photo above (*Duluth-Superior Harbor*) depicts large waves at a harbor entrance. In addition, massive ice floes can literally engulf breakwaters (*below - Buffalo Harbor, NY*). The top of the breakwater is barely visible in the ice. Coastal structures constantly exposed to these forces year after year gradually weaken, which can eventually lead to partial or total failure of the structure if adequate maintenance is not performed.

Harbor Structures

Great Lakes harbor construction began in the 1800s when demand for commerce prompted the nation to deepen coastal rivers and bays and to construct jetties or piers perpendicular to the shore. Jetties and piers help keep channels open for navigation. Later offshore breakwaters were constructed to provide safe entry into the harbors, especially during storms.



Several types of breakwaters have been constructed in the Great Lakes. The oldest and largest group used timber crib core sections. Timber cribs are wooden frames that were constructed on shore, floated into position, and filled with rocks to sink them into place. Most timber cribs had a concrete or stone superstructure added later, and some have added steel sheetpile reinforcement.

Other structures are constructed with laid-up stone, tightly placed cut stone blocks stacked into a pile around a core section that was often a timber crib. Newer breakwater structures are typically steel sheetpile or stone rubble mound. The latter structure type consists of large irregular boulders placed tightly together.

Over half of the coastal structures on the Great Lakes were built before World War I and over 80% are older than the typical 50-year design life. Deterioration is most extreme in breakwaters built with timber cribs, since wood decays rapidly when exposed to the air during low lake levels. Lake levels have been relatively low over the last several years, especially in Lake Michigan and Lake Huron, which has accelerated deterioration

Petoskey Harbor

Petoskey Harbor is located on the shore of Lake Michigan's Little Traverse Bay on the west coast of Michigan. The Federal harbor was constructed in 1908 with a timber crib and a concrete cap.

Petoskey is a recreational harbor and the main harbor of refuge for boaters traveling between Charlevoix and Mackinaw City. The breakwater protects several municipal buildings, a park, and a marina. The typical storm wave (the 2-year offshore wave) at this harbor is 12.5 feet, and the maximum recorded wave height was 16.4 feet.

After years of decay, a section of the breakwater collapsed in November 2005. In March of 2006, the concrete cap was pushed away by ice leaving a 50-foot gap in the breakwater as shown above. City buildings and the marina are at risk if further deterioration occurs.

Cleveland Harbor

Cleveland Harbor, located on Lake Erie, supports the transport of more than 15 million tons of commercial cargo for the steel, auto, and construction industries. Estimated annual business revenues of approximately $280 million dollars support nearly 4,000 jobs.

Harbor infrastructure includes more than five miles of breakwater and pier, built between 1875 and 1915. In addition to providing safe navigation for lake freighters, the system protects extensive waterfront development, including the Rock-n-Roll Hall of Fame, Cleveland Browns Stadium, the Great Lakes Science Center, eight cargo docks, two tour boat operations, three marinas, berthing for a maritime museum, and a U.S. Coast Guard station. The typical storm wave in this harbor is 11.5 feet, while the maximum recorded wave height was 13.8 feet. Underfunded breakwater maintenance, combined with cumulative storm damage has left significant portions in poor condition.

Michigan City Harbor

Michigan City is a city of 33,000 located in Indiana on the southern shore of Lake Michigan, 60 miles southeast of Chicago. Once an active commercial harbor, Michigan City is now almost entirely recreational.

Harbor infrastructure includes 5,400 feet of breakwater, piers, and revetment structures built between 1884 and 1948. It protects a recreational boat marina, a U.S. Coast Guard Station, and a NIPSCo coal-fired power plant. The typical storm wave at this harbor is 15.1 feet, and the maximum recorded wave height was 19.0 feet.

Milwaukee Harbor

Milwaukee Harbor supports commercial shipping that transported 3.8 million tons of cargo in 2005. The harbor is home to a new terminal for cruise ships and a high-speed ferry. The port generates revenues of $80 million annually and directly supports over 1,000 jobs.

The Lake Michigan waterfront is the focal point of the City of Milwaukee, Wisconsin. The 3.7-mile-long harbor breakwater was built in the 1890s. It protects a major commercial navigation port, municipal and private marinas, the regional wastewater treatment facility, the art museum, and recreational facilities.

High Lake Michigan water levels in the mid 1980s combined with storm surge from an intense storm caused significant flooding of the Jones Island wastewater treatment plant. The typical storm wave at this location is 16.4 feet and the maximum recorded wave height was 21.3 feet.

Summary

Federal harbor infrastructure that protects waterfronts in many Great Lakes coastal cities and towns requires regular maintenance and repair. However, harbor infrastructure maintenance is no longer a federal budget priority, which has produced a serious situation of continuing deterioration. In addition, recent low water levels have accelerated deterioration in many harbor structures.

Approximately 80 percent of the Great Lakes harbor structures are older than their 50-year design life and many are more than 100 years old. With the current federal funding situation, the majority of harbor structures are not likely to be repaired in the foreseeable future. Over one-half of the federal harbors are no longer considered a budget priority because of the lack of commercial use.

With the lack of adequate maintenance, harbor structures will continue to deteriorate and put critical city infrastructure at risk. Reduced maintenance could increase shipping costs and also reduce protection of coastal assets and infrastructure currently sheltered by the harbor structures. Substantial damage to urban areas could result, with damages and replacement costs of harbor infrastructure being far greater than the investment required to maintain harbor infrastructure.

The Way Ahead

The Corps of Engineers is initiating an effort to collaborate with state and local officials to develop a strategy to ensure the continued protection of critical coastal infrastructure. The first step will focus on prioritizing limited funding to critical commercial harbor infrastructure using risk-based methodology. The second step approach will determine the best strategy for protecting vital harbor infrastructure that is no longer a budget priority.

A team of experts has been established to develop consistent methods to assess harbor infrastructure condition and determine the risks associated with the potential failure of structures. This information will be used to prioritize limited federal funding in a manner that reduces risk to the Great Lakes navigation system.

For structures that are no longer a federal budget priority, the Corps is initiating a dialogue with state and local officials to inform them of the current condition of the infrastructure, the projected risks posed by deferred maintenance, and the resource requirements for maintenance and repair. Together we can investigate options that would allow non-federal entities to assume maintenance responsibility for these structures if state or local officials want to preserve the navigation, recreation, and flood damage reduction benefits they provide.

Although the challenges posed by limited funding for harbor structure maintenance are very serious, our best opportunity for protecting our valuable Great Lakes coastal resources lies in working collaboratively on a local, state, and federal level to prioritize limited resources and develop innovative and effective solutions.

For information about the coastal infrastructure at any of the federal harbors in the Great Lakes, contact the following U. S. Army Corps of Engineers offices:

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