VISUAL AID
Tsunami Sea Walls

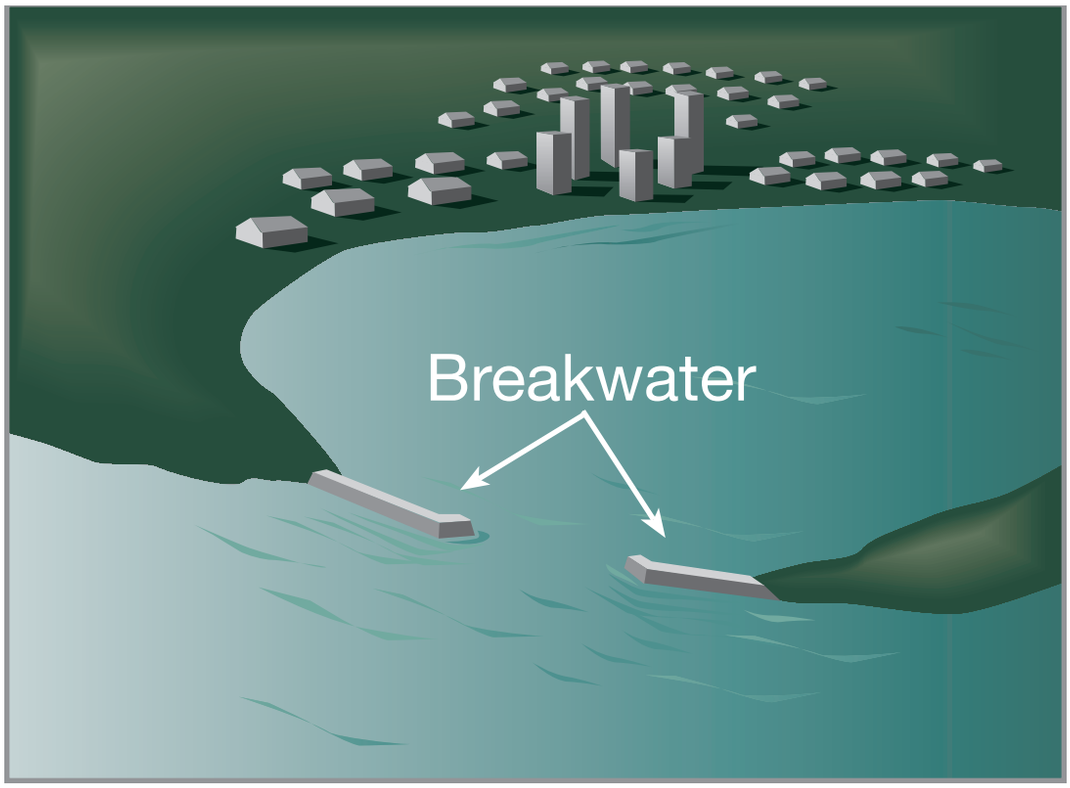
Sea wall with stairway evacuation route used to protect a coastal town against tsunami inundation in Japan. Photo courtesy of River Bureau, Ministry of Land, Infrastructure and Transport, Japan.

Sea walls are curved coastal barriers that block waves from inundating coastal areas and redirect wave energy back towards the sea. Sea wall construction can be expensive. Poorly built sea walls require high maintenance costs and are subject to scouring (erosion) at the base.

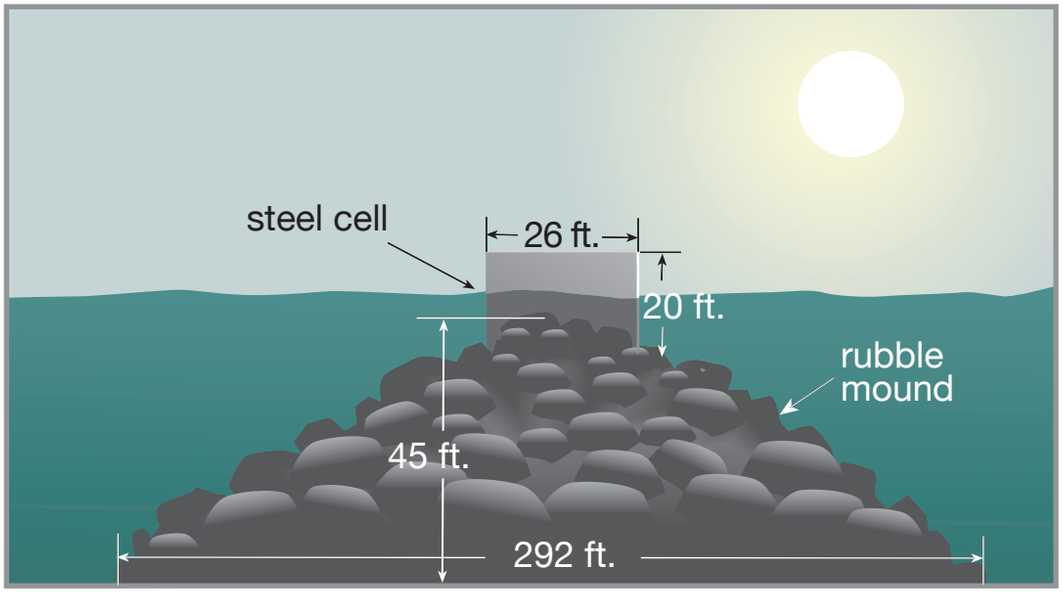
On Okushiri Island in Japan, a seawall about 4.5 meters high was built to protect the Aonae peninsula. However, this wall was overtopped by a tsunami in 1993 and more than 185 people were killed. Since then the wisdom of the wall has been debated. It is now so high that it obstructs the view of the sea and was extremely expensive to build.

VISUAL AID
Tsunami Breakwaters

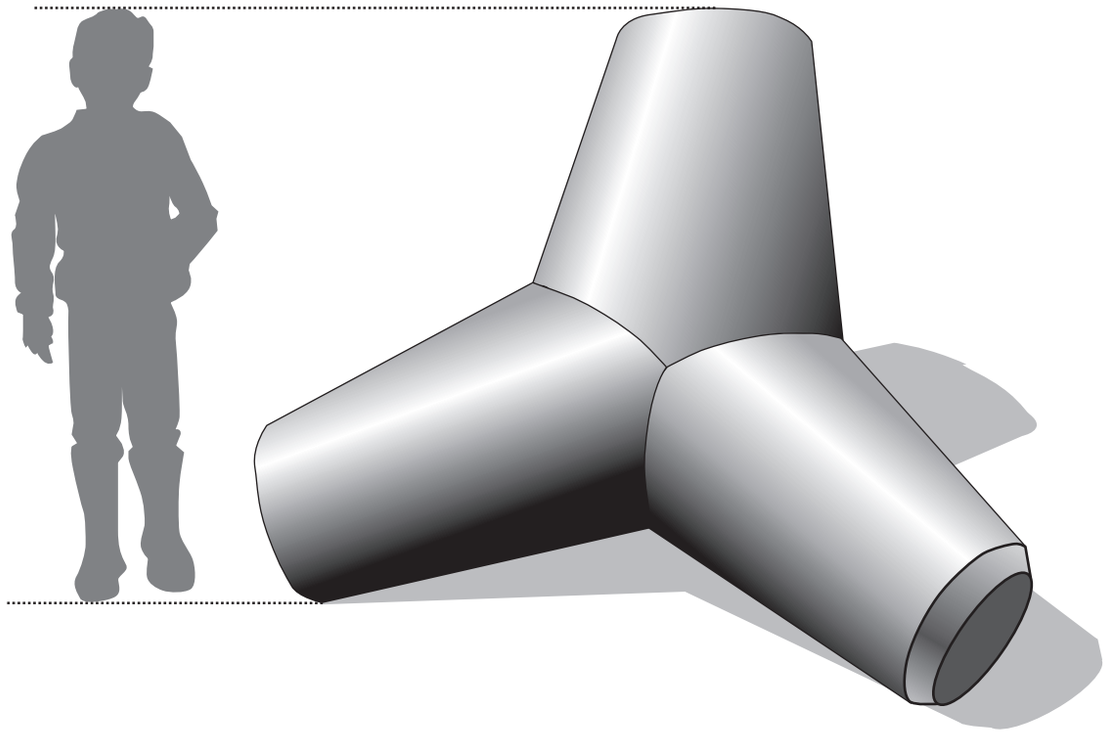
Tsunami breakwaters are offshore structures that restrict the inflow of tsunami and storm waves into a harbor by narrowing the entrance. Such a breakwater can be found in Ofunato Bay on Japan's Sanriku Coast and can be viewed on Google Earth.



Breakwaters are built as underwater berms and topped with an armor unit that dissipates incoming wave energy. Breakwaters are subject to scouring (erosion) at the base of the structure. They also have the potential to change a bay's environment by decreasing water circulation.



VISUAL AID
Tetrapod

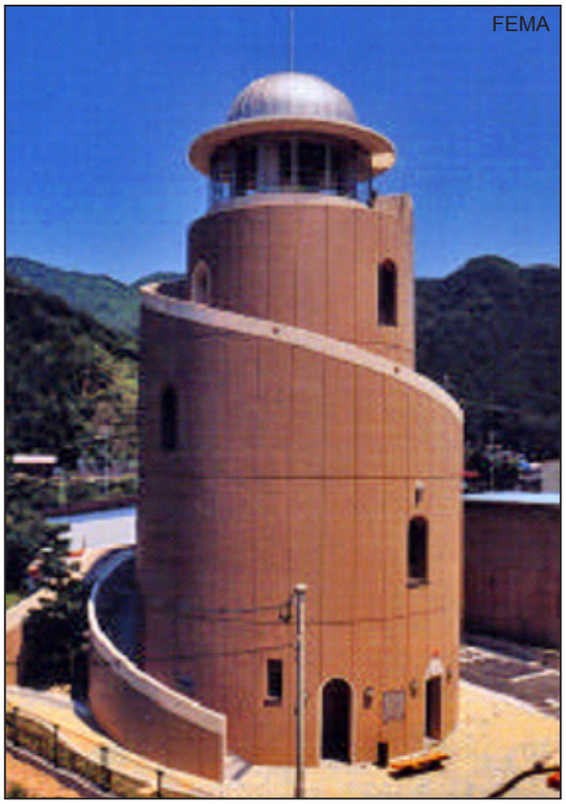


Tetrapods are one type of concrete armor unit with four legs. Tetrapods are also used along the breakwater of Crescent City, California, a city with a strong history of tsunamis. It is important to note that some tsunami waves are powerful enough to transport tetrapods.

VISUAL AID
Shirahama Elevated Shelter

This elevated shelter was built at a beach resort in Shirahama, Tokushima Prefecture, Japan. It can hold up to 700 people in an area of 7,535 square feet. Earthquake considerations include pipe piles driven about 66 feet deep into bedrock because of the potential for soil liquefaction. The elevation of this building is 11.5 meters tall. This is four meters higher than the design elevation of 7.5 meters based on the historic earthquake and tsunami that struck the area in 1854.

VISUAL AID
Nishiki Tower



The Nishiki Tower is in the town of Nishiki, Mie Prefecture, Japan. This tsunami refuge is five stories tall and was constructed using reinforced concrete. In tsunami-free times the first floor is used for public toilet and storage space for fire equipment; the second floor for a meeting room; and the third floor for an archival library for natural disasters. The fourth and fifth floors have 786 square feet for evacuees. Nishiki Tower is designed to withstand a high intensity earthquake. The foundation consists of a 13 -foot deep sand and gravel layer with concrete piles extending 20 feet deep. Tsunami design includes a 6 meter evacuation elevation based on historic data and the building is designed to withstand the impact of a 10-ton ship at a velocity of 10 meters per second.

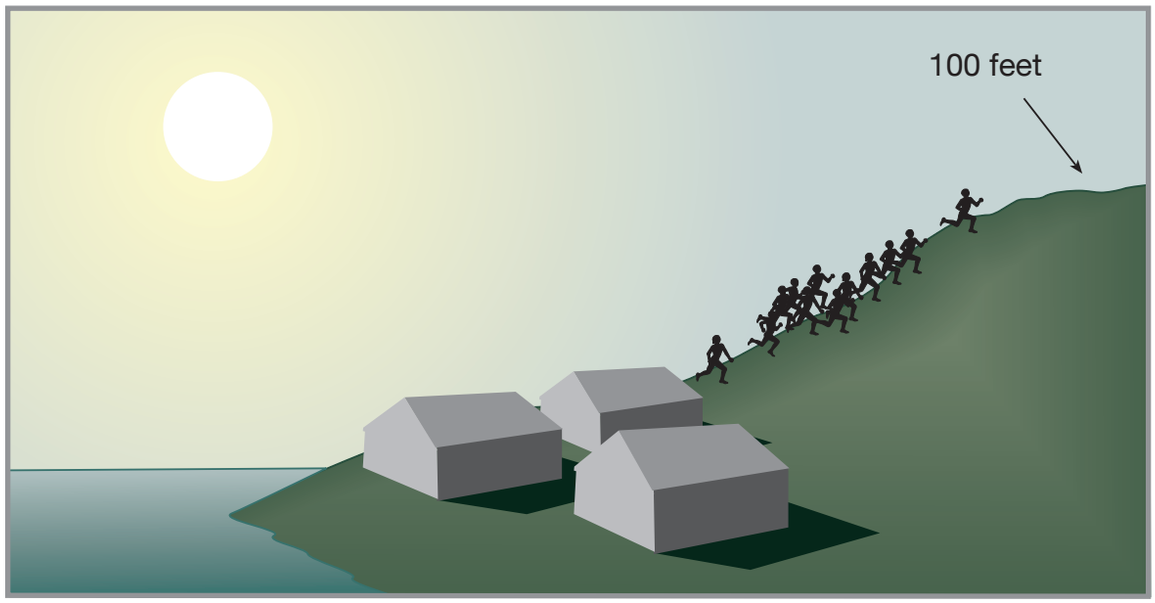
VISUAL AID
Water Gate on Okushiri Island

This water gate is used to protect against tsunami waves on Okushiri Island, Japan. The gate begins to automatically close within seconds after earthquake shaking triggers its seismic sensors.

VISUAL AID
Elevated Platform on Okushiri Island

This elevated platform serves as a tsunami evacuation site on Okushiri Island in Japan. In tsunami-free times it also serves as a scenic view point.

VISUAL AID
Existing High Ground



Naturally occurring high ground may be used or modified for vertical tsunami evacuation. Large open areas on high ground offer easy access for large numbers of people with the added advantage of avoiding the possible anxiety of entering a building after an earthquake. Existing high ground should be evaluated for the potential of wave runup or erosion.

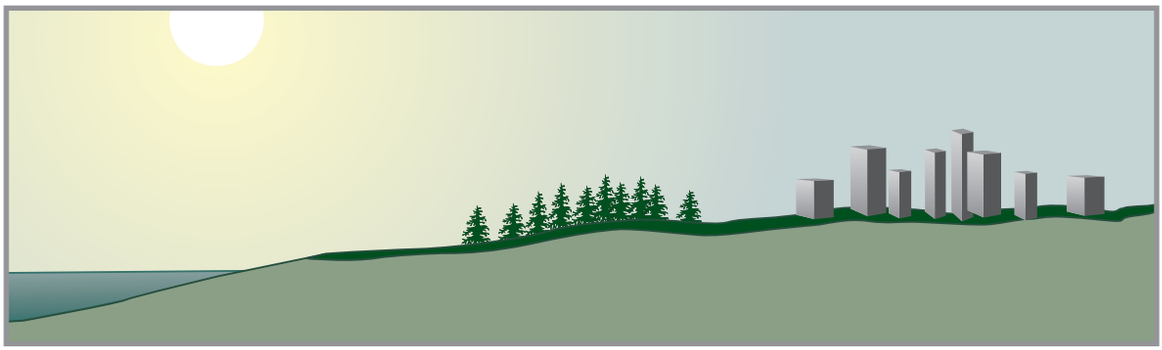
VISUAL AID
Tasukaru Tower

Fujiwara Industries Company, Limited, of Japan developed the Tasukaru Tower. This economical structure can hold 50 people at an elevation of 5.8 meters. The span between the supporting posts is about 18 feet.

VISUAL AID
Berm

A berm is artificial high ground. This berm was built in Aonae on Okushiri Island in Japan.

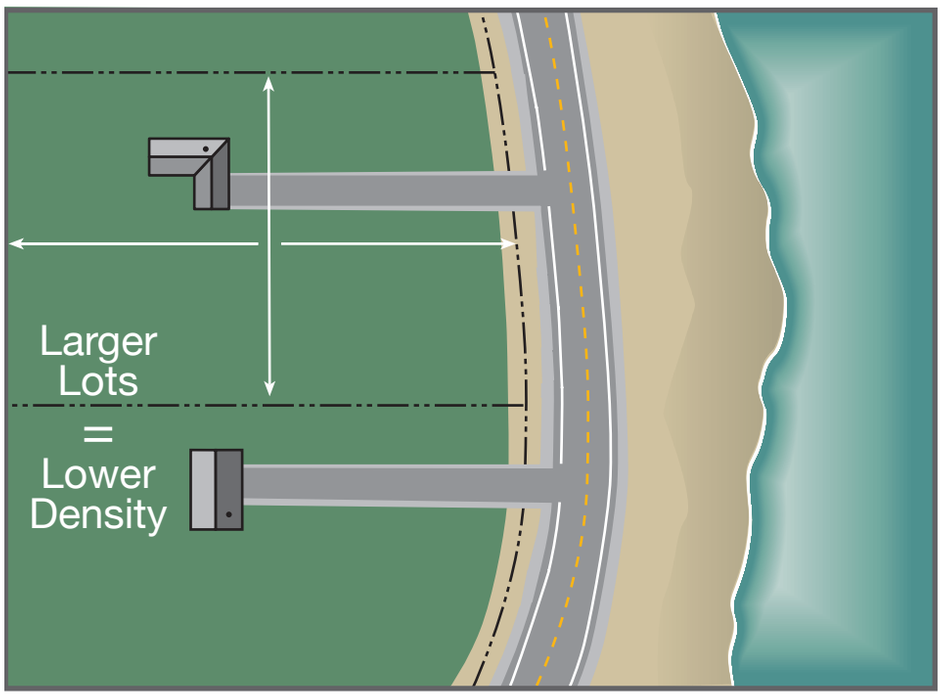
VISUAL AID
Tsunami Control Forest



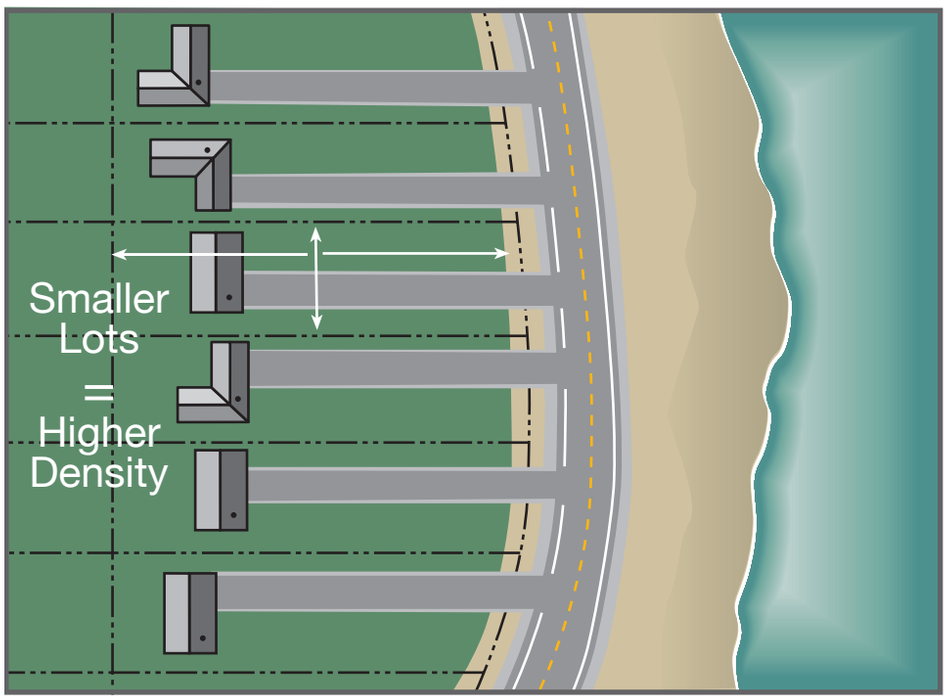
Cities and towns can plan for tsunami control forests between the shore and the developed part of town. The trees of the forest act as a buffer, helping to dissipate the wave energy as it washes ashore and filters out large ocean debris. Along the Sanriku Coast of Japan, the spruce tree is favored for their counter-tsunami groves. Coastal reefs are also protected for their potential to decrease the devastating effects of tsunamis.

VISUAL AID
Zoning

Cities can zone low-lying high-risk tsunami areas for open space use or if necessary, for large lots. This may decrease the amount of people in a high-risk area and/or decrease the amount of potential damage or floating debris from a tsunami.



Large lot zoning creates a lower density of land use in high risk areas.



In low risk areas, sites can be closer together.