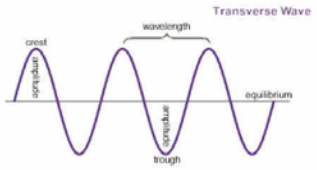
Student 6: High Not Achieved

NZQA Intended for teacher use only

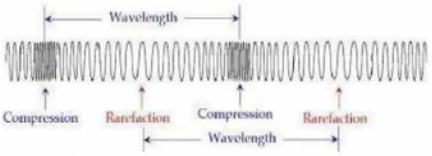
Waves - The interference of waves: Tsunamis

Types of wave: Waves are important because they carry energy without any transfer of matter from place to place. There are two types of wave motion.



Transverse wave: "For transverse waves the displacement of the medium is perpendicular to the direction of the propagation of the wave. A ripple on a pond and a wave on a string are easily visualised transverse waves."[1]

Longitudinal wave: "In longitudinal waves the displacement of the medium is parallel to the propagation of the wave. A wave in a "slinky" is a good visualisation. Sound waves in air are longitudinal waves."[2]

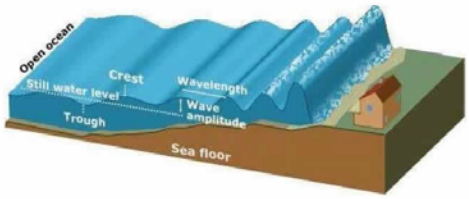


For both transverse and longitudinal waves:

Wavelength, (λ), is the distance between any two corresponding parts of the wave
Amplitude, (A), is the maximum distance the medium moves from the equilibrium position

What wave is a tsunami?

A vertical displacement in the water column at sea creates waves that become tsunamis, such as an earthquake where one tectonic plate slides under another creating a vertical displacement. While at sea these transverse waves have a VERY large wavelength (approximately 500 kilometres), but their overall amplitude is very small (about a meter). Because of the very large wavelength, the wave loses very little energy as it moves along the ocean, thus allowing tsunamis to inflict damage hundreds of km's away. As these waves approach the shore, they start to behave differently and their wavelength becomes smaller and the amplitude becomes much taller. Shallow water compresses the energy as the tsunami moves towards the beach. The wave is moving slow but has tall height, as v and λ decrease, A increases.



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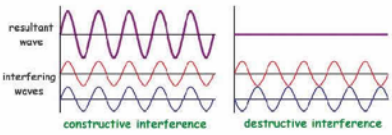
Interference: Combining waves

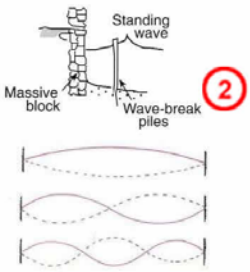
"When two or more waves pass through each other, the displacements of the medium caused by each individual wave combine to create a resultant wave. This is known as interference."[3] If a crest from one wave happens to line up with the trough of another, they cancel each other out. The particles of the medium have opposite phase and the displacements subtract to give zero displacement, this is called **destructive interference**. If two waves line up crest to crest or trough to trough, they add up. The particles of the medium are in phase and their displacements add to give a crest of double the individual amplitude, this is called **constructive interference**. This is why waves at the beach are all different sizes as well as why tsunamis come as different sizes (But tsunamis size are mainly dependent on the vertical displacement from within the ocean floor). There are lots of different wave groups coming in, and they're interfering with each other in different ways.



Phase: Property of waves definition

If we think of a wave as having peaks and valleys with a zero-crossing between them, the phase of the wave is defined as the distance between the first zero-crossing and the point in space defined as the origin. Two waves with the same frequency are "in phase" if they have the same phase and therefore line up everywhere. Waves with the same frequency but different phases are "out of phase." [4]

Standing waves result when two equal waves are going in opposite direction and in this case you get the usual up/down motion of the water surface but the waves don't progress. These are common in coastal areas where waves reflect off seawalls. In this case this can happen when a small tsunami hits seawalls. At least 43 percent of Japan's 29,751 kilometre[5] coastline is lined with concrete seawalls or other structures designed to protect the country against high waves, typhoons or even tsunamis. Vertical seawalls are built in particularly exposed situations, like Japan. These reflect wave energy. Under storm conditions or tsunamis a non-breaking standing wave pattern can form, resulting in a stationary wave which moves up and down but does not travel horizontally.



Waves Hitting Things

When a tsunami hits a hard vertical surface (such as a seawall) it is reflected. In other words, the wall pushes the water back just as hard as it got pushed, and sets up waves in the other direction. With constructive interference, you end up with bigger and therefore stronger waves. This is why, in the long run, solid seawalls are not good for saving property from the ocean. You end up creating stronger waves that cause even more erosion. However, seawalls have come under controversy in Japan as their seawalls were overcome by the tsunami's power in 2011. "There is simply no guarantee that seawalls will stop every single tsunami," Nobuo Shuto, an engineer at Tohoku University, told The Economist back in 2014."[6]

Conclusion

A Tsunami is a natural occurring event, there is nothing in our man power to stop a tsunami or to predict one. It is too physically strong. However, there are ways that we can prevent damage from accumulating like it has done before. The use of seawalls to create a standing wave or to prevent the height of a tsunami is one way possible. Different designs of man-made tsunami barriers include building reefs and forests to above-ground and submerged seawalls. In 2005, India began planting casurina and coconut saplings on its coast as a natural barrier against future tsunamis like the 2004 Indian Ocean earthquake. Studies have found that an offshore tsunami wall could reduce tsunami wave heights by up to 83%[7]. Japan formerly had protective walls, many of which were built in the 1930s following a large tsunami. One of these stood up reasonably well against the 2011 tsunami. Most, however, did not. The Economist explains: "*...the evidence for their effectiveness is flimsy. True, Fudai, a village sheltering behind a giant concrete shield, escaped unscathed in 2011. But in the city of Kamaishi a $1.6 billion breakwater, listed in the* 'Guinness Book of Records' *as the world's largest, crumbled on impact. Nearly 90 percent of existing seawalls along the northeast coast suffered a similar fate.*"[8] There is not much we can do but to accept the fact that tsunamis are a wave of mass destruction.

1 http://hyperphysics.phy-astr.gsu.edu/hbase/sound/tralon.html
2 http://hyperphysics.phy-astr.gsu.edu/hbase/sound/tralon.html
3 ESA Study Guide Physics Level 3, page 52
4 https://www.learner.org/courses/physics/glossary/definition.html?invariant=phase
5 https://www.cia.gov/library/publications/the-world-factbook/geos/ja.html
6 http://www.sciencealert.com/japan-is-building-a-400-km-sea-wall-to-protect-against-tsunamis
7 http://www.news24.com/World/Archives/TsunamiDisaster/India-builds-tsunami-barrier-20050114
8 http://www.sciencealert.com/japan-is-building-a-400-km-sea-wall-to-protect-against-tsunamis