appeared on 3rd Jsn 2005

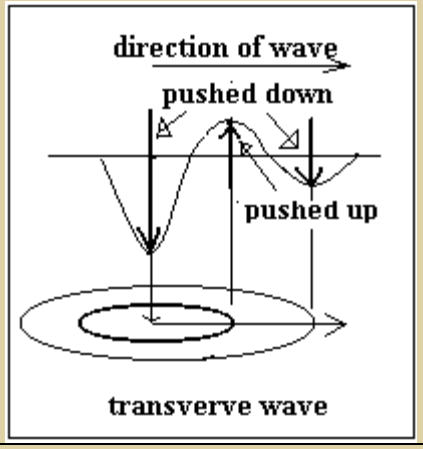
Waves, sound waves and Tsunamis

The Tsunami is not all wave, it is even like a hammer and chisel, says S.Ananthanarayanan.

Simple waves are the ripples that radiate when a pebble is thrown into a pond. The place where the stone landed gets depressed and the water the pebble has displaced flows around the pebble to rise and form a circular mound. Now this mound falls in and raises another circular mound around itself, which falls and raises the water in a larger circle and so on. It looks like a circle spreading out.

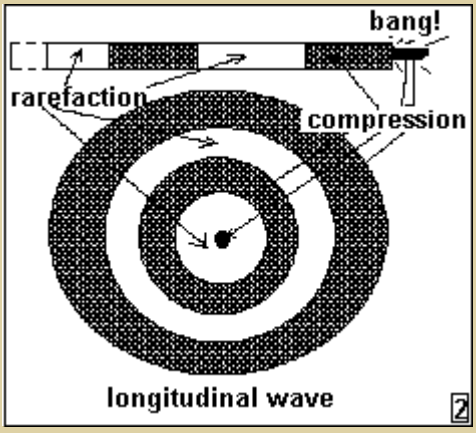
Ripples and sound waves

The form of ripples depends on the density, viscosity and surface tension of water and the ripples have the same wavelength once they get even a short distance away from the center.



Ripples are rather like the way a violin string undulates when it is plucked or the skin of a drum when struck.
There are no great pressure changes in the direction of the wave, which is transverse, which is to say the motion of the water particles is perpendicular to the wave. (see pic). The dimensions of the waves are also small compared to the depth of the water, so that the waves are really only at the surface. Huge ocean waves, which are caused by winds, are similar, while they are in the high seas.

Sound waves that pass through water are different. Here, mechanical vibrations at the frequency of the sound wave are being transmitted as longitudinal, not transverse waves (second pic). As water is practically incompressible, each compression transmits like a piston, over a long distance before the slight compression expresses itself as expansion. The result is that the speed of sound in water is much higher than that of ripples, and even many times greater than the speed of sound in air.



Even in the air, the nature of sound waves is that of a longitudinal wave and in both cases, or in any medium, the speed depends on the density and elastic properties of the medium and is fixed for the medium.

Shock waves

While what has been said is about sound waves, of the waves of mechanical disturbance in the medium, a physical object can move in the medium at any speed. And along with the movement of the object, there would also be disturbance of the medium, like the waves that spread from the bow of a boat moving in water, that would move in the medium at the speed of such disturbance in that medium, But if the object were itself moving at the speed of sound in that medium, then the object would find itself always at the very place where the wave that it had just created had reached! This creates huge build-up of energy and causes the celebrated 'sonic boom' as an aircraft crosses the sound barrier. This is also the reason for 'explosion' when a cracker goes off, with particles crossing the sound barrier. But shock waves are just mechanical, sound waves and move like sounds in the medium.

The Tsunami

This is a different genus of animal altogether. The main thing that makes it happen is physical dimension – the disturbance has to be large – many times the size of waves - and violent – with energy to move huge quantities of water.

When there is a violent event, like an undersea volcano erupting or many acres of the sea-floor shifting a hundred meters in a second (or two), millions of tonnes of water get displaced. A hundred square kilometers of water around the place may rise and then sink. The dimensions are too large for waves. The sinking water mass transmits the pressure like through a rigid piston, through the deep ocean body, but spread in all directions, and affecting the whole mass of water, to cause a rising of the water a hundred kilometers away. That water then sinks, to set off a rising another hundred kilometers away. Because of the spread, the energy disperses with reduction when it is further away, like sound waves in water, but much faster than waves, as the incompressible water mass is being used like a piston.

The result is wave-like movement, up and down, of millions of tonnes of water, which transmits at a speed of hundreds of kilometers an hour, a speed that depends upon how deep the ocean is. As the action is of transmission of pressure at high speed, the wavelength is on scores of kilometers. Hence, unlike waves of ordinary wavelength, the tsunami hardly notices little obstacles. The result is practically no loss due to 'scattering' an effect that can dampen even large wave system caused by winds. As the energy is distributed over such quantities of water, the physical distortion, or size of waves at the surface is hardly noticeable.

Shallow water

But the Tsunami shows itself when it comes to shallow water, near land. Now the depth of water involved is much less. The pressure towards the land mass, pushing right down till the ocean depth, must now express itself in a wedge rising to the surface. As the depth reduces, speed of the wave slows down, but the pressure transmitted is not reduced. With falling speed, the energy must show somewhere. It shows as a rising column of water. And a wall, ten to thirty metres high, many kilometers thick, rams the ill-fated land mass that came in its way.