Theory of Tsunami Multi Drawback and Inundation on the Coastline

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SUMMARY:
There has been found during Asian tsunami 2004 many tsunami water drawbacks (maximum 1300 metre and depth 6 metre) at African coast instead of normal one drawback during Japan tsunami 2011 on the Pacific coast. Generally the third tsunami wave has been the biggest one. Traditional wavelength, wave amplitude and frequency theory for homogenous seawater could not explain above mentioned detected coastline phenomenon.
According to authors tsunami multi drawback theory it is easy to explain detected water drawback phenomenon. Theory has been based on reflecting pressure wave ray theory and underwater acoustic channel theory. According to theory tsunami wave pressure energy will change first to seawater potential energy and then kinetic energy damaging coastline societies and structures. In underwater acoustic according to theory sound of the submarine will be detected thousands of kilometres trough channels. Similar way tsunami wave groups will propagate long distances having strongest third pressure wave group.
Keywords: Tsunami, Propagation, Inundation, Drawback

1. INTRODUCTION

During Asian tsunami 2004 it has been found on the African coast at Xaafuun peninsula four tsunami drawback: "At first, a 100 m drawback was noticed followed first flooding the beach. Next, the water withdraw again by 900 m before the second wave flooding the town. Finally, the water withdrew again by 1300 m offshore before the third and most powerful wave washed through the town. These drawbacks correspond to 0.5 m, 4 m and 6 m depths. Four powerful waves were observed, with an estimated wave period of 12 minutes". During 2011 tsunami on the Japan Pasific coast only one drawback has been seen. How to explain this difference?

Traditional tsunami theory based on wave length, wave amplitude and wave frequency could not explain above mentioned phenomenon, specially biggest third tsunami wave problem. 1300 meter drawback with 6 meter depth in Xaafuun Peninsula is too long and too big for traditional theory when the wave enters shallow water.

Multi drawback theory and inundation theory will explain simple, how this will happen. Theory starts from the pressure shock wave propagation in layered see water after ocean bottom earthquake and illustrates, what different phenomenon – energy type changes - happens near coastline. This theory will radically change our vision, how tsunami enters from deep to shallow water, flooding and run up on the shore.

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2. FROM DEEP WATER TO SHALLOW WATER

As the deep ocean tsunami approaches the coast, propagating pressure wave will reflect from the rising bottom. If rising angle of the bottom is 45^{o}, horizontal pressure wave will reflect directly upwards. With lower angles pressure wave will reflect little forwards according the normal reflection rules.

When reflected pressure wave reaches the surface of seawater, pressure will increase seawater surface level (Fig 1.) depending how high pressure is and how long pressure shocks will influence. Increase of seawater level could be from centimetres to meters depending on energy level of the tsunami wave. Tsunami pressure wave energy will change to potential energy on the surface of ocean.

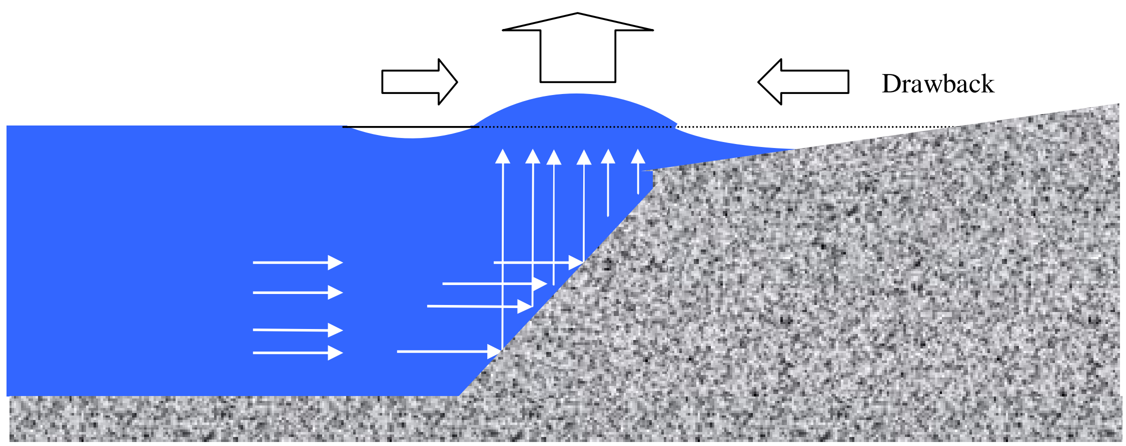

Figure 1. Reflected pressure, seawater increase and water sucking from both sides

3. DRAWBACK

When seawater surface increases, it will need more water and it starts to suck water from shallow water and open ocean side. If water depth on the shallow side is only some few meters, seabed will be seen because we don’t have water enough to supply to increasing area. This phenomenon has been named and drawback (Fig 1.). On the open ocean side there is nearly no lowering of seawater surface level, because there is seawater enough to supply increasing seawater hill.

4. HOW POTENTIAL ENERGY CHANGES TO KINETIC ENERGY?.

When tsunami pressure wave shocking stops in some minutes, high seawater surface level area will fall down to the normal surface level (Fig. 2). We will have huge seawater flow to the shoreline and to the remarkable less flow to open ocean depending about drawback phenomenon.

For example, if we have height of increased seawater 10 meter and depth of drawback 5 meter, we will have 15 meter potential energy to change kinetic energy. One can approximately calculate based on Bernoulli fluid mechanics law, wave velocity will be over 40 km/h. On the open ocean side there is nearly no drawback, so there is potential energy less.

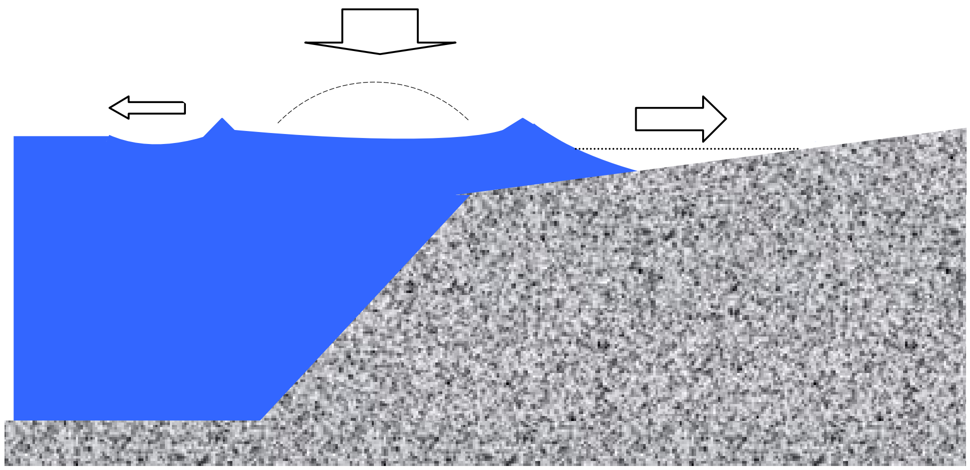

Figure 2. Seawater hill fall and flow to both directions

Potential energy changes with above mentioned way to kinetic energy and seawater flows faster than human can spring to shoreline and run up to ground. Very high tsunami water levels we have, when we have triangle bay, where the seawater flows narrower section area. It could happen tsunami water height is ten of percents higher than straight shore.

5. MULTI DRAWBACK

After earthquake in ocean bottom follows big see water movements causing long effecting pressure wave shock in horizontal direction. This pressure shock wave behaves in see water like sound, which is also pressure fluctuation. The speed of sound in seawater increases with increasing hydrostatic pressure, temperature and salinity. In equatorial seawater sound speed is high near warm surface, lowest in depth of hundred meters due to decreasing temperature and in again higher in the deepness because of increasing hydrostatic pressure down to bottom of the ocean. Sound speed varies approximately 1480 m/s – 1540 m/s.

This phenomenon is very well known in underwater acoustics and it is possible find three separate layer for sound velocity. Surface layer is down to about 100 meter, middle layer from 100 meter to 1,000 meter and bottom layer below 1,000 meter. Sound speed difference with different layers could be tens or meter per second, which means minutes in hours propagation.

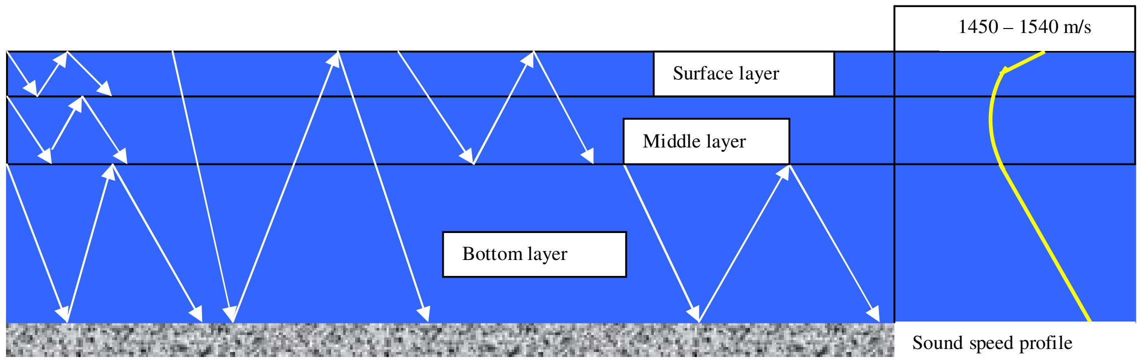

Figure 3. Reflection between different sound speed layers in seawater and sound speed profile

Sound will reflect between surface, upper middle layer, lower middle layer and bottom. Sound energy losses will be remarkable on the seawater surface and on the bottom depending ground quality. Losses are minimal in middle layer reflection and one can detect underwater sound propagation thousands of kilometres.

In underwater acoustics in detection of submarines this channel has been named "Deep sound channel", earlier named SOFAR (sound fixing and ranging) channel.

Mathematically multi-layer theory has been analysed effects of adjacent layers in reference: "Governing equations for three layered tsunami waves were developed transforming Navier-Stoke equations using proper boundary conditions and long wave approximation".

Similar pressure wave shocks propagate in different layer. Pressure wave propagation will be in middle layer slower than surface and bottom layers. In addition to main inside layer reflections, there is three types reflection between surface, bottom, upper and lower middle layer. All together one can find six total reflection types.

Due to different speed of pressure wave layers, we have pressure shock groups propagating with different speed. During Asian tsunami 2004 it took five hours for tsunami to reach African coast Four different layer pressure wave groups come one after one during 12 minutes.

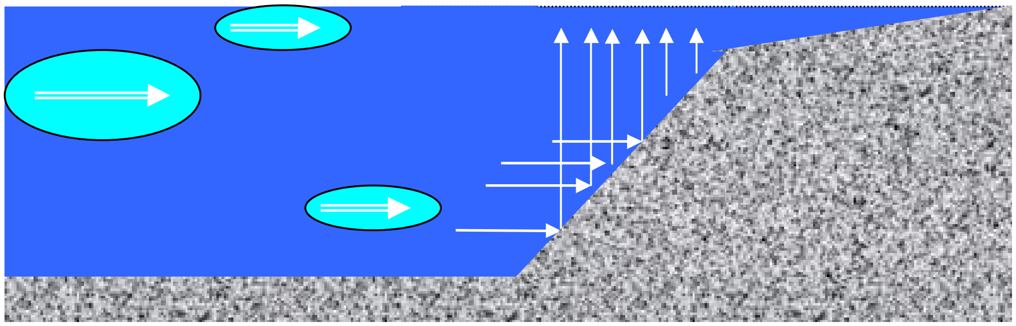

Figure 4. Pressure wave group propagation in different layer

During Japan tsunami coast was so near tectonic earthquake area, there was no time for wave pressure group separation and that is the reason for one drawback.

Third wave and drawback was biggest. We can estimate, third strongest wave comes from middle layer, where the pressure wave reflection loses are at the minimum.

Ocean bottom trenches, ridges, underwater volcanoes and in the beginning seabed movements could happen in many steps, which will cause irregularities in reflection of pressure waves to the surface and clear figure, what happens, is difficult to see in practice.

6. CONCLUSIONS

Shallow coast having seawater depths down to 5-6 meter in the distance of one to two kilometres on the edge of kilometres deep ocean will strengthen remarkable the tsunami wave damages.

Coasts of deep ocean, which are some hundred kilometre from earthquake centre, are dangerous, because one pressure shock after another shock will increase once seawater level up to extremely high potential energy level. This happens during 2011 tsunami on the Japan Pacific coast.

Above bottom earthquake centre seawater will rise very high causing water waves, which will damp very quickly because on the larger area energy density will decrease and because of the viscosity of seawater.

On the open ocean having bottom with underwater steep ridges or volcanoes will cause during tsunami increase of seawater level, which is much higher than surrounding. These places are good for tsunami warning buoys because instead of measuring millimetre seawater level increase you can measure metres in serious tsunamis.

The most important in the future is to understand theory of the tsunami more detailed and with the help of better theory save people of total catastrophe of the coming tsunamis.

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