Controlling Tsunamis
-Reducing The Damage of Tsunamis by Its Characteristic-

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Abstract

The shallower the water depth is, the slower a tsunami flows. We considered we might be able to prevent all parts of the tsunami from reaching the shore by using objects to make a difference in the level of the seabed. We placed objects in our model and generated waves. We saw the speed change, but it contradicted our hypothesis. We succeeded in reducing the damage caused by the waves.

1. Introduction

Many earthquakes occur in Japan, and tsunamis may occur along with the earthquakes because Japan is surrounded by the sea. Of course, huge earthquakes creating large tsunamis do not occur very often. However, within the next 30 years, there is a 70-80% possibility of a huge earthquake accompanied by a large tsunami. This has come to be known as the “Nankai Trough Giant Earthquake”. If an effective means of dampening the tsunami is found, the damage caused by this earthquake can be reduced.

It is already known that the shallower the water depth of a tsunami is, the slower the speed of the wave is. If we define v as the speed of the wave, g as the gravitational acceleration and h as the depth of water, then $v=gh$ is true. We considered using this unique characteristic to try attenuating the tsunami. If the hypothetical method shown below is used in combination with a conventional method such as constructing an embankment, a greater effect can be expected in reducing tsunami damage.

Keeping in mind the characteristic shown above, we will add cuboid objects on the seabed, making a difference in level and in water depth. We know tsunamis above the objects will be shallower, and we estimated they will flow slower than other parts of tsunamis. Therefore, the tsunami’s speed would change, the tsunami would spread out and we can weaken the tsunami’s power. This is our hypothesis.

To confirm this hypothesis, we built an experimental device to reproduce tsunamis. Using our device, which imitated the distance of the earthquake center to the coast, we measured the amount of water that overflowed from the coastal part of the device and investigated the changes occurring due to different conditions.

2. Explanation of the device

We made a device to generate waves. It is illustrated in Figure No.1. It is made from wood and acrylic sheets, and it is 1.5m long. We initially set the slope at 30 degrees. We filled this device with water to a depth of 15cm. Then we attached wooden poles to the

acrylic sheets to prevent them from flexing due to water pressure. We also filled the gaps of the device with glue to prevent water leakage. At the front of the device there is a small acrylic sheet attached by hinges, and the sheet is connected to a piece of string. We pulled this string manually to lift the acrylic sheet and generated waves. Then we checked the mass of the water that flowed into a box at the back of the device to quantify the tsunami damage. We looked at how the damage changed depending on the objects we placed on the artificial seabed.

3. Method 1

Next, we will explain the specific method of the experiment. We conducted two types of experiments. First, we will explain experiment 1. As mentioned above, we pulled the string manually to lift the acrylic sheet and generated waves. When we set objects down, we placed them like in Figure No.1. The objects are stone and they are 15cm long, 10cm wide, and 5cm high. We conducted the experiment by changing the number of objects from zero to three. Then we took pictures of the waves with our smartphones and observed the changes in the speed of the waves.

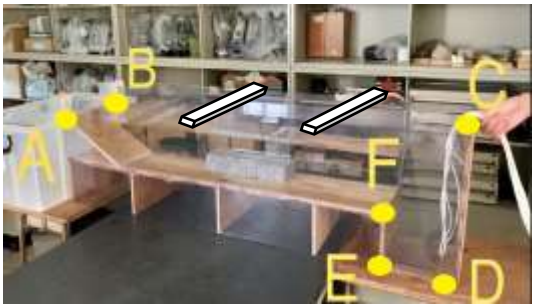
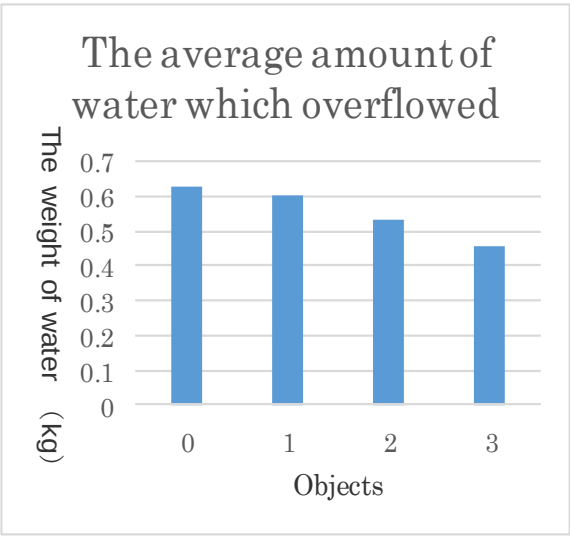


Figure No.1

4. Result 1

The amount of water that flowed into the box at the back of the device decreased due to the addition of objects. The more objects we added, the less water flowed into the box. We observed that the wave above the objects flowed faster than the wave around the objects. This contradicts our hypothesis. Before we conducted experiments with stone objects, we used wooden objects, but they were moved by the waves.



5. Consideration 1

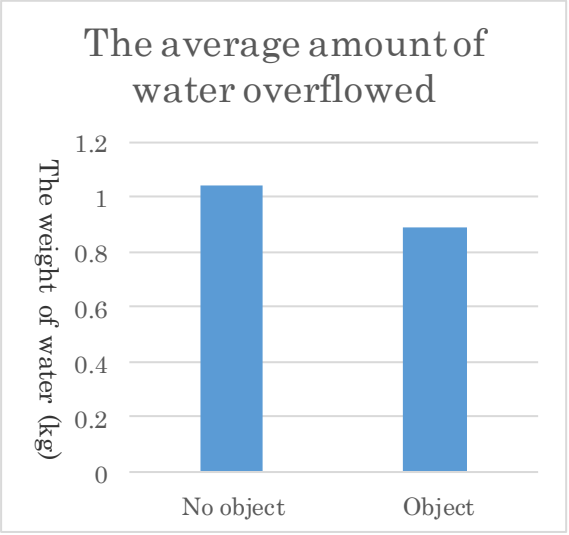
Judging from our observations, we thought that the waves didn't have a tsunami's characteristics. We also thought that objects got energy in exchange for the energy the waves lost.

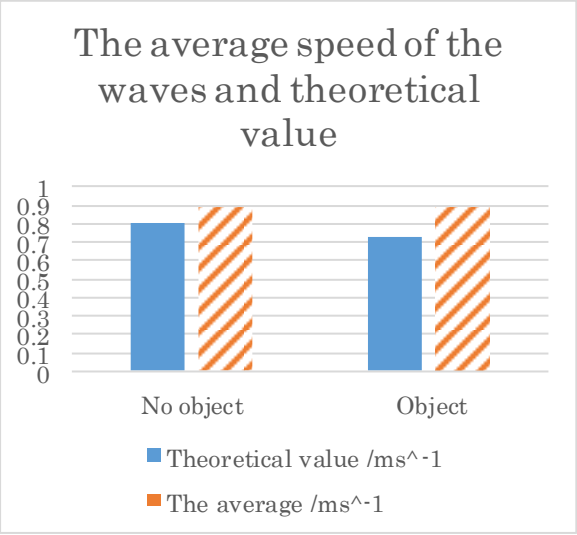
6. Method 2

Second we will explain experiment 2. We later changed the slope to 10 degrees to more closely imitate the actual slope of seabed. Then we also changed the water depth to 6.6cm to match the new angle. We used wooden objects and they are 40cm long, 15cm wide, and 1cm high. We held them down by using nails. We dropped a bag with four 2-liter plastic bottles to pull the string. We did this to keep our experiments consistent. Besides these changes we conducted the experiment in the same manner as before. We measured the time for the water to flow 30cm.

7. Result 2

We calculated the theoretical values by defining g as 9.8ms^-2 and h as 6.6×10^-2m without objects and g as 9.8ms^-2 and h as 5.4×10^-2m with objects. Like in experiment 1, the amount of water that flowed into the box at the back of the device decreased as a result of adding objects. However, the wave above the objects flowed faster than the wave around the objects. This contradicts our hypothesis.





8. Consideration 2

The faster wave above the objects spread sideways, so the part of the wave flowed in different directions from the original direction. We reduced the amount of water in the device when we added the objects, so we think that had an effect on the amount of water that flowed into the box. In experiment 1, we observed that the wave above the objects flowed faster than the wave around the objects. But in experiment 2, the speed of the wave generated when we did not add the objects was almost the same as the speed of the wave above the objects. Therefore, the wave around the objects flowed slower than the wave generated when we did not add the objects. The speed of the wave did not change

whether we added objects or not, so we think that the wave was different from tsunamis.

９．Conclusion

By adding objects and making a difference in depth of the device, we could decrease the amount of overflowed water as in our hypothesis. Therefore, we thought the difference in depth decreased the energy of tsunamis and reduced damage from them. According to result 1 and result 2, the larger the difference in depth we made, the greater the difference in speed. The depth of the sea is great, so if we place objects that are the right size for the depth, they will have a great influence on real tsunamis.

１０．References

[1]Osamu Sandanbata, et al. Equipment of Miniature Instruments to Measure Tsunami Waves in an Experimental Tank. Technical Research Report, Earthquake Research Institute, the University of Tokyo, No.24, pp.29-34, 2018.
http://www.eri.u-tokyo.ac.jp/GIHOU/archive/24_029-034.pdf (2020-11-16)
[2]Kazuhiro Nakamura. “Izu Oshima Kishotokoutu-oshimanokishonohanashi” 3, Uminonami.
http://www13.plala.or.jp/oosimakisyou/3nami.html (2020-11-16)
[3]Koudokeisansaito Keisan-CASIO
https://keisan.casio.jp/exec/system/134620503 (2021-2-3)

１１．Key words

Tsunamis　Objects　Speed