A model to represent the damage from earthquakes in developed land

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There are many kinds of effects from earthquakes. This time, we focused on the collapse of buildings. From previous research, it is clear that the damage in embankments is more severe than that in cutting soil and the borders of the two areas. In addition, it is known that depth of embankment and the damage are correlated to each other. Based on those researches, we conducted demonstrations to create a model which behaves like actual ground on the time that an earthquake occurs. The model was made of clay and gardening sponges. Eventually, the model we made and modified finally can show actual character in only the border between cutting soil and embankment. However, we guess that we can improve the model easily by reforming it and we would complete the exact correct model.

1 Background

Japan is a country with many earthquakes. And there are various types of damage such as tsunamis, fires, and landslides. In this research, we focused on collapse of buildings. The collapse of building was seen in various areas of Miyagi at the Great East Japan Earthquake. By conducting research about this, we thought that we could reduce the damage from the earthquake.

Building collapse can occur anywhere, but it often occurs in residential areas. The cause is that residential areas is made from two types of land. Cutting soils and embankment. Cutting soils is a part where cut the slope and flattened, and it is strong. On the other hand, embankment is a part where brought the soil from outside to fill the valley or slope, and it tend to be fragile. A survey at a Nankodai after the Great East Japan Earthquake found that the rate of earthquake damage on embankment was about 25times higher than cutting soils. In the survey, the rate of earthquake damage was also higher at the boundary between cutting soils and embankment.

The purpose of this research is to create a model which reproduces actual ground and evaluate the earthquake damage more quantitatively. Of course, there are a lot of factors which affect earthquake damage. But we thought that it is difficult to express and control them. So we focused on the depth of embankment and researched how it affects the scale of earthquake damage. In this experiments, we aimed to reproduce the following two outcomes.

(1) The damage at the embankment and the boundary is large.

(2) There is a proportional relationship between the depth of the embankment and the damage.

2 Model 1 and the way of measuring

We used two materials to make the ground model. It is oil clay and gardening sponge. These materials have large strength differences and are so soft thus we think it is the best. We used clay as a cutting and use sponge as a banking. We put it in a crea case. We made the cutting soil about 20° .

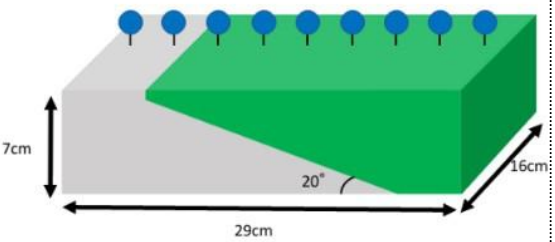

Figure 1

A way to sting pins are not exactly.

We shook the case to inspect if model 1 is right. We put masking pins on the ground. The pins are separated from each other 2cm. Besides we filled the pin 0.8cm. We use shake

machine. It is often used at economics . And it can produce constant shaking. We shook it only left and right. Thus our experiment's shake is roll. Shake is three step 100rpm, 150rpm and 200rpm. (revolutions per minute) The shaking time is 30s and 60s each two times total twenty-four. As the rpm increases, the swing width does not change, but the swing speed increases.

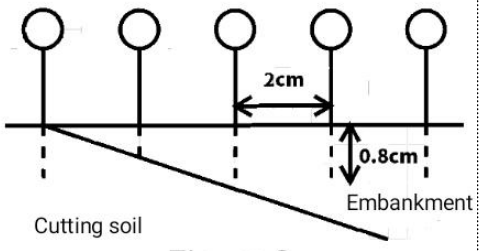

Figure 2

In common, pillar reaches at hard ground but this time we stung pins the same depth.

The evaluation of this experiment was conducted with following the process below.

(1) Take a picture from above at the same position and height, before and after the experiment

(2) Overlay the two pictures

(3) Measure how much the pins moved before and after the experiment.

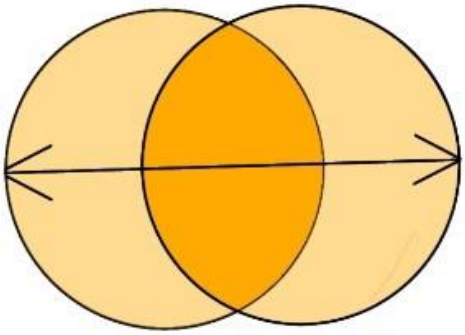

Figure 3

This arrow shows the length we measure.

3 The result and evaluation for model 1

The result is shown at figure 4. Over the cutting soil, regardless of the distance from the border, pins hardly leaned. On the other hand, the deeper the embankment is, the stronger the effect is over the embankment. As for the correlation coefficient on only the embankment, it was measured 0.905 and this model has a strong correlation. However, the lean on the border is almost the same as the cutting soil and we can say that only the embankment reproduces actual ground conditions.

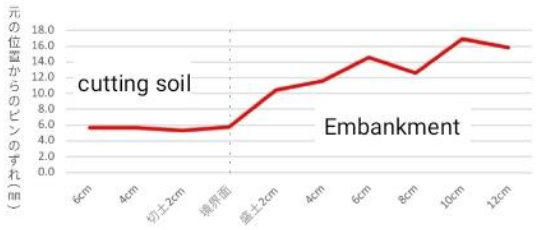

Figure 4

These numeric shows the average on each point.

As for the reason why the damage didn't emerge on the border, we guessed that clay is too tough and sponges are too weak. Soils for embankments are often brought from the place where cutting soils are made, so it is common that the strength between embankment and cutting soil is almost the same. In spite of this, there are large differences between them in terms of mass, mutability, and liquidity. We considered this difference affects the result and decided to change materials again.

4 Preliminary experiment

To search for appropriate material, We measured N-value of the material which we used in the experiment. N-value is the value of strength of ground. In the actual measurement, a weight of 63.5±0.5 kg was dropped from a height of 75 cm, and the number of blows required to penetrate the 30 cm into the sample soil was counted. The number of blows is the N value.

In our experiment, we measured the pseudo N value and looked for the combinations of cutting and embankment that have gap of N value. We dropped a ball from a height of 25.5cm and measured the number of times that

the material sank by 1 cm. As a reference, the N value of Sendai Sanko is 40~50 for the embankment part and 2~21 for the cutting part. There are a large gap between embankment and cutting in actual geological conditions and the upper limit of N-values is 50, we didn't check the accuracy to make sure it matched the real value in our first experiment. As a result of the experiment, we found a large gap of N value when we compared a sponge its uncrushed to a sponge that had been crushed and compressed the volume seven-tenths.

5 Model 2 and the way of measuring

Based on the results of the preliminary experiments, model 2 was created with the uncrushed sponge as the material to represent the cutting and the crushed sponge as the material to represent the embankment. The outer part painted light green is the uncrushed sponge and the inner part painted dark green is the crushed sponge. Unlike model 1, it is a valley-filling type model. In this experiment we did not stick pins into the cutting, but prepared five rows of pins, one at the boundary and four in the embankment. The total number of experiments was 30, so the number of data was 150. The way of sticking the pins, the way of measuring, and the way of the shaking machine were the same as in the first experiment.

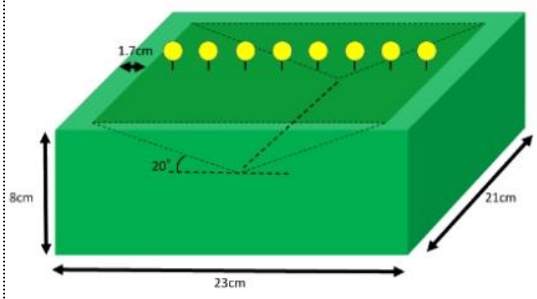

Figure 5

Broken line shows a border of valley.

6 The result of the second experiment

Look at the diagram No. 7. The three lines show a difference of shaking.
According to the result. There are two features. First, on the border, the average of damage was not affected by shaking. And the damage was the most. And then, there are not relationship between the damage and the depth of the embankment. As for the first feature, we might be able to interpret model 2 can represent (2). To go over if this feature is realistic, We compared it with previous research.

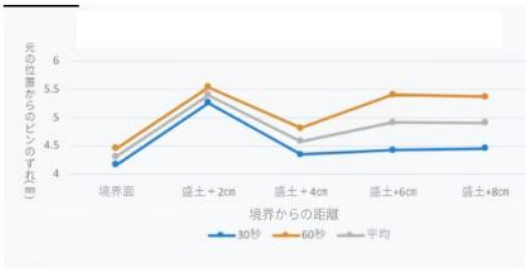

Figure 6

The pins on the cutting soil aren't measured.

Figure 7 shows the buildings which were damaged from the great east japan earthquake(reference 1). The warmer color gets, the deeper the embankment is. In contrast, The colder the color gets, the longer the length from the border is. Figure 8 represents the number of partly collapsed buildings in area 2 and colors between figure 7 and figure 8 are almost the same.

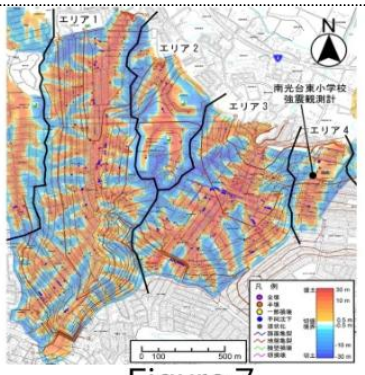

Figure 7

Warm color shows the depth of embankment and cold color shows the distance from border.

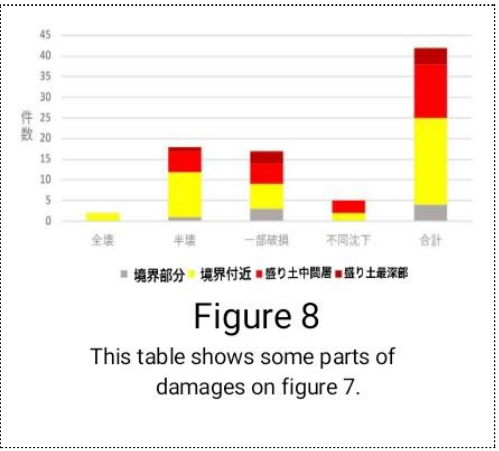

Figure 8

This table shows some parts of damages on figure 7.

From these data, we understand many collapsed buildings were collected in yellow areas.

7 Result

As a result there are some features. First, model No.1 has a relationship between depth of embankment and damage of earthquake.

Second, model No.2 is similar to the data of the diagram No.8.

In our conclusion the model No.1 is suitable to represent damage of the earthquake on the embankment.

And then, model No.2 is suitable to represent shaking on the embankment.

In the future, we have to solve 3 things. First, why isn't proportion in the experiment1 and 2.

Next, how to evaluate the damage of the earthquake. Our purpose of the research is to make a formula about the relationship between damage of the earthquake and depth of the embankment.

Finally, how to make the hazard map from our experiment. From the experiment, the danger of the places which are near the border are apparent .

8 Reference

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