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LANDSLIDE MITIGATION DEVICE USING CRISS-CROSSED BOTTLES

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ABSTRACT

The study focused on an alternative device for landslide mitigation which is the use of criss-crossed plastic bottles. Two phases of test was done with the study, first test was simulation of rainfall in the tilting soil bed without criss-crossed bottles and second with the criss-crossed bottles. Further, the angles of inclination for the tilting soil bed were 30 degrees and 35 degrees for the two phases of test. Rainfall was simulated on the bed for 15 minutes, and every 5 minutes soil and water collected through a basin was measured and recorded.

The study showed the capability of criss-crossed bottles in handling soil erosion by use of tilting soil bed. The data gathered from the tests showed that the criss-crossed bottles are more effective at 30 degrees inclination. The device helps in capturing water and soil that flows through it during rainfall which is proven by the difference of volume of water runoff with and without bottles.

Key words: landslide, landslide mitigation, criss-crossed bottles, rainfall simulation

INTRODUCTION

Landslide is the slipping of a mass of land from a higher to a lower level. Landslide is one of the most widespread natural hazards on earth, responsible for thousands of deaths and billions of dollars in property damage every year [1]. Majority of landslides, heavy rainfall and earthquakes are main triggers [2]. Sustained rainfall may also trigger landslide [3,4,5] stated that lithogy, topography, climatic conditions and human conditions are main causes of landslide. From the many factors causing landslide, heavy rainfall are the main causes of landslide here in the Philippines, landslides are one of the main problems in terms of environmental casualties. Detecting landslides and monitoring their activity is therefore of great relevance for disaster prevention, preparedness and mitigation [6]. Determination of the sliding surface is most important consideration in mitigating landslide [7]. Identifying the angle of inclination of the slope is very important in assessing whether a slope is susceptible to landslide [8]. According to Lee [9] average slope of landslide susceptibility is 33^0 angle of inclination. Shuichi [10] suggested that landslide is prone when it is on slopes with a 30^0 angle of inclination. Ellen et al [11] suggested also that 28^0-38^0 slopes are susceptible to landslide. Evans et al [12] suggested 30^0-45^0, James et al [13] and Dai F.C. [14] suggested 20^0-40^0 are prone to landslide. Due to lack of knowledge regarding the characteristics of landslide many lives have been wasted.

On February 17, 2006, an avalanche of boulders and mud rushed down a mountain side in the province of Southern Leyte, Philippines and buried the Guinsaogon Village. The area had endured ten days of torrential rain and it was heavier than normal rain, amounting to over 79 inches. The rainfall loosened the soil on the surrounding mountains. Other factors like badly broken rocks on the mountains, steep slopes and lack of dense vegetation triggered the deadly landslide (www.suite101.com). The devastating landslide killed at least 1800 people and left thousands of people homeless (www.chinadaily.com). In relation to this, landslide mitigation is already a priority to the places prone to landslide. Many landslide mitigation devices have been developed to answer the problems on landslide.

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Examples of commonly used mitigation devices are safety nets and rockfall nets. The safety nets (landslide-gib.blogspot.com) were developed to minimize the risk from landslides caused by monsoons, which are common on unstable terrains, instead of constructing retaining walls it is cheaper to use safety nets as a protection guard. Rock fall nets are also used to withstand the high impact of falling rocks. They are also designed to intercept rock or lessen the energy of the debris formed due to the falling (www.edema.com).

The mitigation devices mentioned above corresponds to the solution to the problems raised by landslides. These are the easy ways to minimize the occurrence or to lessen the possibilities of landslide. In relation to the existing solutions on landslide mitigation, this study will provide another solution needed in the mitigation of landslide. This study focuses on the use of criss-crossed bottles as another solution on landslide mitigation.

Plastic bottles are commonly used worldwide and piles up in landfills. Based from studies, each year we throw away 65 million plastic bottles (warrensurg.k12.mo.us/trees/students/students/katiel/index.html). The use of plastic bottles has increased exponentially but the recycling rate of it is extremely low, but the demand from the recyclers is actually quite high (www.msn.com). This research then intends to contribute in the recycling of plastic bottles by turning it into a landslide mitigation device, the criss-crossed bottles.

It is along this line that the study aims to determine the capability of the criss-crossed bottles in handling soil erosion by the use of a tilting soil bed. To determine if on what inclination shall the criss-crossed bottles be most effective.

METHODS

The researchers used 1.5L Coke plastic bottles because it is commonly used and easy to acquire. Used plastic bottles can be bought from junk shops or collected from stores or picked up in trash. In this study, the plastic bottles will be bought from junk shops for the sake of time and its availability.

After acquiring the plastic bottles, the researchers cleaned the inside and outside of the bottles to get rid of unwanted substances then set aside to dry. The nails were heated by coal so that punching of holes with a diameter of 3-5 mm will be easier; these holes will help in capturing soil that will run through the bottles. A #16 steel wire was used to put together the bottles and a string wire was used to secure the intersection points or joints of the criss-crossed bottles. The #16 steel wires were also heated so that it will be easier to connect the bottles together, this can be done by piercing the bottom of the bottles and then the cap of the bottles.

Forty five (45) plastic bottles were used in this study. There were 7 rows and 4 columns of the criss-crossed design, the rows consist of 3 bottles and the columns have 6 bottles.

Figure 2. *The criss-crossed bottles*

A tilting soil bed similar to the one which was made by the Soil Erosion Research Laboratory, with 4ft. x 7ft. dimensions was used as the testing equipment for this study. This device was established in response to the need for consistent and qualitative soil erosion control [15] Using this we can test the effectiveness of the criss-crossed bottles as an alternative device for landslide mitigation. The water used in simulating rainfall came from the National Water and Sewage Authority here in Cagayan. The water was delivered to the tilting soil bed via a hose with a sprinkler head.

After finishing the criss-crossed bottles the tilting soil bed was be prepared for testing. The tilting soil bed was raised and tilted to an angle of 30 degrees. Then soil was compacted to the bed with a depth of 1.5 ft, the bed should be tilted first before

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the soil is compacted to so that it will not be difficult to raise and tilt.

Figure 1. *The Research Paradigm*

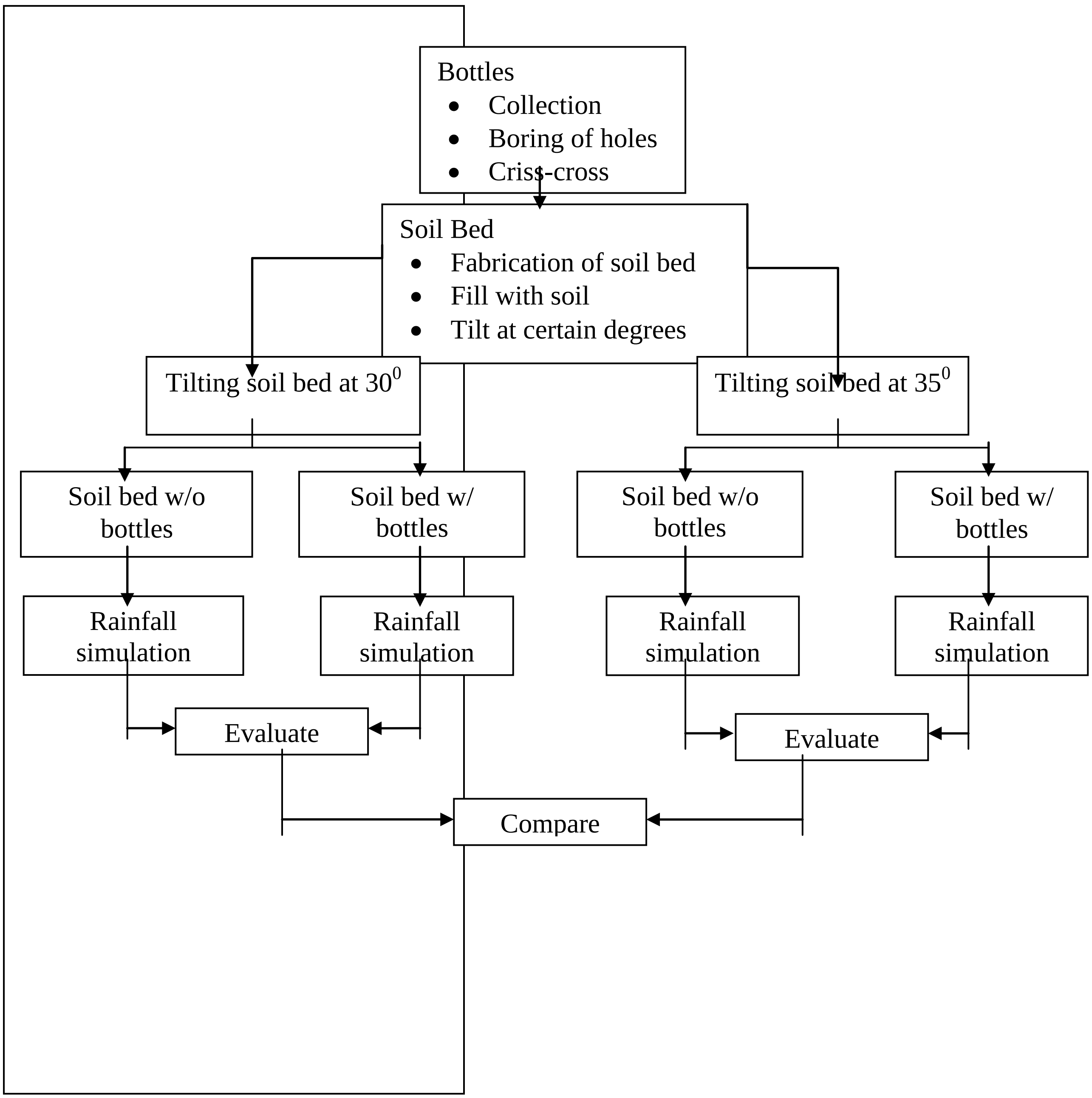

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Figure 3. *The soil bed with criss-crossed bottles*

There were 2 phases of the test; first test was without the criss-crossed bottles and second with the criss-crossed bottles.

When the angle of inclination has been set to 30 degrees, and soil is compacted, first phase of the test shall commence. The researchers simulated rainfall on the bed for 15 minutes, and every 5 minutes they measured how much soil and water had been collected.

Before continuing to the second phase, the soil should be compacted again because it has lost soil and it is wet already from the first phase. Then, the criss-crossed bottles were placed to the bed, embedding each bottle to the soil till half of the bottles' diameter were under the soil and two barbecue sticks for each bottle were stacked on it for stabilization purposes. For the second phase, just like phase 1, the duration of rainfall will be 15 minutes and every 5 minutes recording will be done.

After finishing the 2 phases on the 30 degrees angle of inclination, the inclination of the bed was raised to 35 degrees and the 2 phases were also repeated.

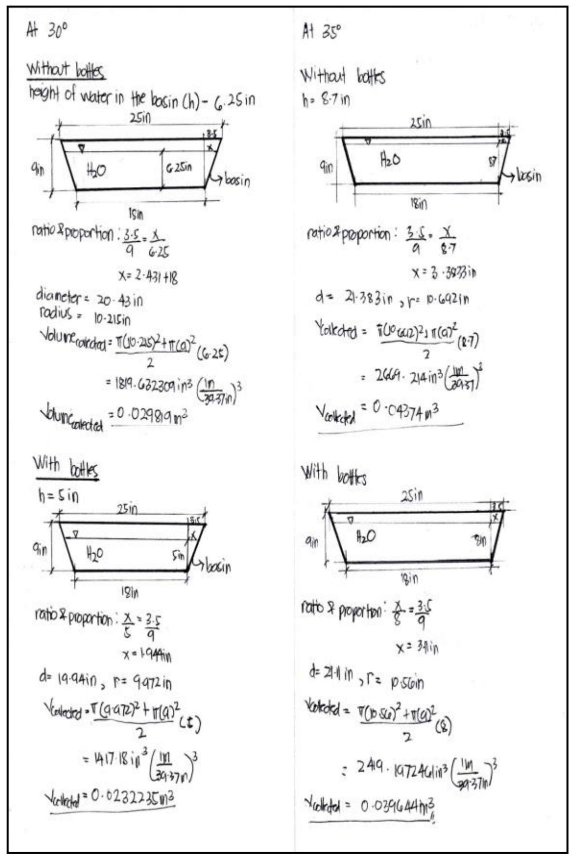
When enough data was gathered, evaluations of the result followed and see if the criss-crossed bottles are an effective landslide mitigation device.

RESULTS AND DISCUSSION

The researchers used a basin in order to collect the water that runoff through the soil bed. The researchers then measured the height of the water level, the diameter of the basin in order to calculate its volume of the water collected.

In the first phase, the 1st test without criss-crossed bottles having 30 degrees inclination and 15 minutes of rainfall simulation, the height of the water in the basin was measured so that its volume can be calculated, the calculated volume is 0.029817 cubic meter. On the 2nd test with criss-crossed bottles having 30 degrees inclination and 15 minutes of rainfall simulation, the calculated volume is 0.0232235 cubic meter. Comparing the two volumes

Figure 4: *Volume computation of collected water*



from the tests on phase1, it shows that the volume from first test is considerably higher than the second one.

In the second phase, the 3rd test without criss-crossed bottles having 35 degrees inclination, the volume of water collected is 0.04374 cubic meter. While in the 4th test with criss-crossed bottles having 35 degrees inclination, the volume is 0.039644 cubic

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meter. Comparing the two volumes again it shows that the criss-crossed bottles reduced the volume of water collected in each of the test.

Figure 4 shows the computation of the volume of the collected water from the experiment done and the data is presented in Table 1.

Table 1: *Volumes of collected water*

DATA RECORDED			
30^0			
	Duration	Volume of water used	Volume of water collected
Without bottles	15 minutes	1.85 cu. m.	0.029819 cu. m.
With bottles	15 minutes	1.86 cu. m.	0.0232235 cu. m.
35^0			
	Duration	Volume of water used	Volume of water collected
Without bottles	15 minutes	1.89 cu. m.	0.04374 cu. m.
With bottles	15 minutes	1.87 cu. m.	0.03964 cu. m.

The data showed that the criss-crossed bottles are effective in lessening soil erosion. The data also showed that the criss-crossed bottles are more effective at 30 degrees inclination.

CONCLUSION

In recent times landslides have both increased in frequency and intensity and have assumed catastrophic and disastrous proportions, causing extensive damage to life and property and posing great problems and serious challenges to man. This study looked into an alternative solution that will help decrease the effect of landslide. The study determined the capability of criss-crossed bottles in handling soil erosion by use of a tilting soil bed and comparing the volumes of water collected in the basin from the series of tests done. It was proven when the data was evaluated and analyzed that the criss-crossed bottles are an effective tool to prevent landslide by lessening soil erosion. The device helps in capturing water and soil that flows through it during rainfall. The device can be an effective tool in mitigating landslide especially with 30 degrees of inclination.

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