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Implementation of Sheet Pile as Land Slide Hazard Mitigation Method

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Abstract - *Landslide refers to several forms of mass wasting or the rapid movement of earth materials downslope under the force of gravity that include a wide range of ground movements, such as rock falls, deep-seated slope failures, mudflows, and debris flows. Landslides occur in a variety of environments, characterized by either steep or gentle slope gradients, from mountain ranges to coastal cliffs. Sheet piles are sections of sheet materials with interlocking edges that are driven into the ground to provide earth retention and excavation support. The purpose of this project is to find the effectiveness of sheet pile as a landslide mitigation measure. An experimental laboratory setup is introduced in order to artificially produce landslide. Various parameters like embedment depth of sheet pile, different types of sheet pile material such as aluminum, stainless steel and GI sheet, different thickness and shape (Z, U Straight) of sheet pile are considered. An impact load using a gate mechanism, filled with sand and pebble mixture is provided as a triggering force for landslide. It is expected to provide a suitable remedy for unexpected landslides in land slide prone area during small scale earth quake and human induced landslides and during rainy season, especially in current condition of rain induced landslides in Kerala, India.*

Key Words: Landslide, sheet pile, slope stability, hazard mitigation, rainfall induced landslide

1. INTRODUCTION

A hazard is any object, situation, or behavior that has the potential to cause injury, ill health, or damage to property or the environment. Hazards can be both natural and human induced. Sometimes natural hazards such as floods and drought can be caused by human activity. We need to put more emphasis on pre-disaster action rather than remaining content with post-disaster reaction. We must mobilize scientific knowledge and technological know-how to assess natural hazards and to strengthen disaster mitigation measures. We must promote and enforce sound scientific, engineering and construction principles.

1.1 Land Slide

Landslide, also called landslip, is the movement of a mass of rock, debris, earth, or soil, a mixture of earth and debris down a slope due to gravity. Landslides pose considerable risks to people's livelihoods and to the environment. When soil, rock, and other earth debris can no longer hold it together and gives way to gravity, landslides happen. Landslides can be triggered by earthquakes, volcanic activity, changes in groundwater, a disturbance or change of slope also by human activities, such as road and railway construction, mining, and development in urban and mountain areas.

Landslides cause billions of moneys in damages and thousands of deaths and injuries each year. The severity of landslide can be understood from the landslide we have faced just months ago in Kerala, India. There have been 24 landslides in just 24 hours with 22 deaths on August 9th, 2019. With a total death of 121 people in 2019 and nearly 22,165 people were shifted to relief camps.

1.2 Sheet Pile

Sheet piles are sections of sheet materials with interlocking edges that are driven into the ground to provide earth retention and excavation support. They are usually driven into the soil with vibratory or impact hammers. Sheet pile walls have been used to support excavations for below-grade parking structures, basements, pump houses, and foundations, to construct cofferdams, and to construct seawalls and bulkheads. Permanent steel sheet piles are designed to provide a long service life.

A sheet pile wall is a flexible wall having negligible weight and weight has no control over the wall stability. The stability is entirely due to the passive resistance developed between the wall and the soil. Steel sheet piles are available in market in several forms. Sheet pile segments with indented profiles (troughs) interlock to form a wall with alternating indents and outdents. The troughs increase resistance to bending. The cold formed steel sheet pile is formed by continuously cold-bending deformation of the steel strip to form a Z shaped, U shaped or other shaped cross sections, which can be connected to each other through an interlock.

Nowadays the number of occurrences of landslide increases. Need of a preventive or mitigation method is important and a must in current situation. A simple way to

reduce the consequences of hazard is by sheet piling. In this study, the effectiveness of application of sheet pile as a landslide hazard mitigation method is investigated. Using different types and arrangement of sheet pile material, the least deflecting and Stable condition of sheet pile can be determined. By changing arrangement and types of sheet piles, we can meet the required stability and safety from landslide. This is considered as an economical work considering the amount of disaster that can occur. Rather than that, it is an eco-friendly method which will allow application of vegetation in order to take out excess ground water as well as providing structural stability.

Use of sheet pile is an immediate mitigation method, which lasts up to 120 years but it can permanently save us from landslide by helping the soil to stay in place until the fixation of root of vegetation occurs (afforestation). They can be driven in to the ground without causing too much vibration and noise. This method can be used to reduce the hazardous effects of landslide in landside prone areas.

2. OBJECTIVE AND SCOPE OF THE STUDY

The scope of this study is limited to rain fall induced landslides, small earth quake and human induced landslide areas in practical case. The best sheet piling arrangement is found using sand medium. The landslide is provided in dry condition. The landslide load is provided in 30&60% of cobble sand mixture. Embedment depth of sheet pile up to 5, 10, 15 and 20 cm is considered. The Sheet pile shape provided are straight, Z and U types based on shapes, Aluminum, GI and Stainless steel based on material and 1,0.5- and 0.2-mm types based on thickness.

3. MATERIALS USED

1.1 Sand

The sand chosen for the study was a river sand obtained from Kadalundi river side near Nooradi, Malappuram. The sand was air dried for conducting all the laboratory tests.

Fig -1: River sand and pebbles used

1.2 Pebbles

Pebbles are used in this study to mimic the heavy rock particles that cause more damages in a landslide. Pebbles of size 80-300 mm is taken for the study.

1.3 Sheet Pile Types

Stainless steel, GI, and aluminum sheets are used for the research. The sheets were cut and shaped in to straight, Z and U shape sheet piles. Figure 2 shows straight sheet pile made of stainless steel, GI and aluminum.

Fig -2: Straight sheet pile made of stain less steel(left) and GI sheet (Centre) Aluminium sheet pile(right)

The following figure 3shows 2 Z and 2 U sheet pile attached together. Total length or sheet pile used is 50 cm and with a thickness of 0.5 mm for both

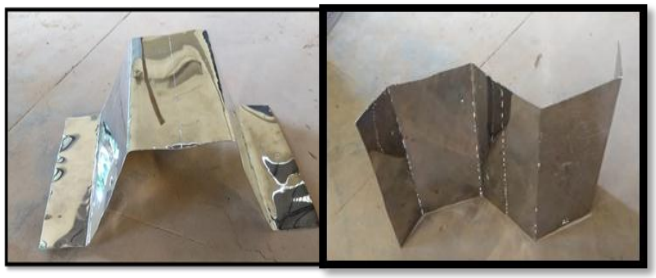

Fig -3: Z type sheet pile(left) U sheet pile(right)

4. EXPERIMENTAL PROCEDURE

A small-scale landslide lab setup is generated with setting up of 3 tanks in which, the first tank (30x30x40 cm) is provided with debris load, and second tank (50x40x40 cm) with bed rock medium as slope and the third tank (30x40x40 cm) for plain area which represents the habituated area. Best arrangement of sheet pile is determined by conducting artificial landslide impact load test in the tank filled with sand. And the most effective sheet pile arrangement is adopted to generate a solution for site condition. Figure 4 shows lab setup.

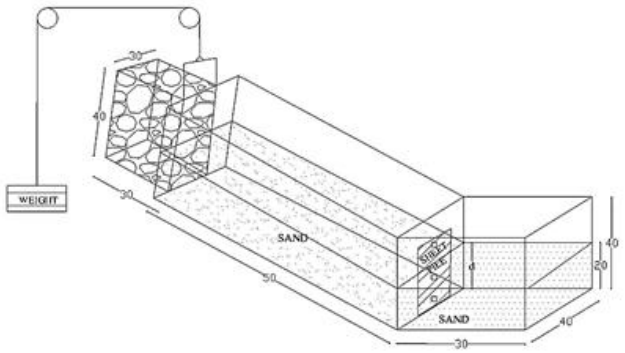

Fig -4: Lab setup

The first step of the project includes collection of materials such as, cobbles (80-300 mm size) and sand (passing through 4.75 mm). The basic properties of sand is determined. Then fill the plane and sloped tank up to 20 cm with sand (Tests of sudden land sliding on sheet pile is done with sand in dry condition for better yielding of procedure). The bottom 10 cm is compacted and top 10 cm of soil fill by pluviation method. Then fill the debris tank (30x30x40cm) with debris of different percentage of cobbles (30& 50%) with sand. The bed rock part, made of steel in order to make frictionless surface as in site condition. The combination of 3 tank is as shown in figure 5.

Fig -5: Constructed Tank Setup

Slope angle is determined on the basis of critical angle from the stability chart. Connect the sliding door of debris tank with a pully in order to open it in same time without lag using a weight. When sudden weight is applied to the loading pad, the trap door which closed the debris tank will open up, which in turn causes land slide Sand is filled prior to the test, and test is conducted in sand to find the best method of sheet pile type.

5. RESULTS AND DISCUSSION

5.1 Basic Properties of Sand

Table -1: Properties of Sand

Soil Properties	Values
Specific Gravity	2.66
Coefficient of uniformity	2.851
Coefficient of curvature	0.787
Relative Density	1.783 g/cc
Permeability	7.13x10-4 cm/s
Direct shear test: c	0
φ	32.5

The soil is confirmed as was well graded soil (SW).

5.2 Land Slide Test on Sheet Pile

The test is mainly conducted on 3 different conditions. They are mainly based on the embedment depth of sheet pile, material used and the thickness used. In each condition, the deflection of sheet pile along the depth of the sheet pile is measured using strain gauges attached on the surface of the sheet pile. A diagram is produced with depth and deformation of the sheet pile when it is introduced with sudden landslide load.

A) Test with different material used: The sheet piles made up of GI (Galvanized iron) are found superior in resisting landslide than sheet pile made of stainless steel and aluminum sheet

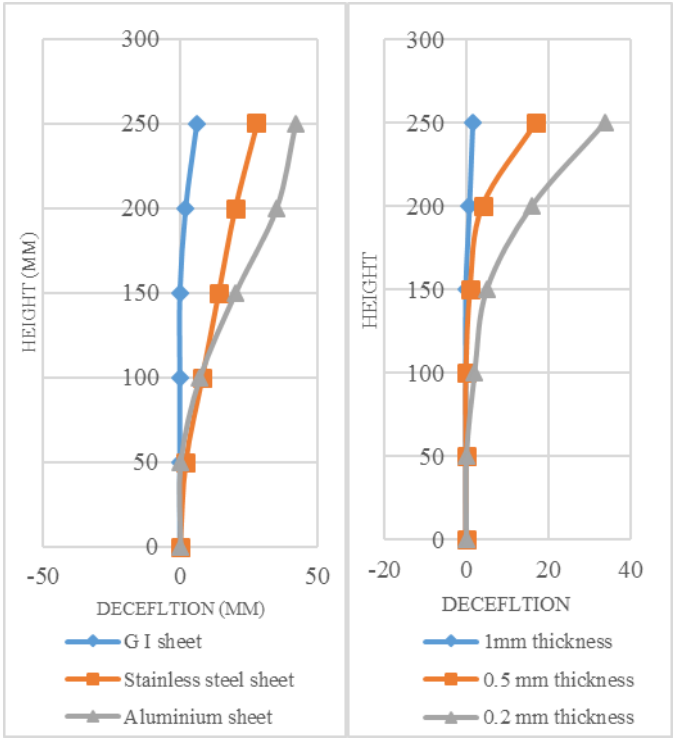

Chart -1: Height – deflection graph when different material (left) used and different thickness used (right)

B) Test with different thickness of sheet pile: Sheet pile with 1 mm thickness, which is with their greater thickness than 0.5- and 0.2-mm thick sheet.

C) Test with different embedment depth: The best results are obtained when fully embedded sheet piles are used instead of partially embedded sheet piles. When the filling in flat side of slope increases, the strength of sheet pile also

increases. The resulting deformation is very less than the deformation occurred when filling is very low in one side of the sheet pile. It is observed that least embedded sheet pile in the soil had failed easily when landslide force is struck on the sheet pile.

D) Test with different shape of sheet pile: Sheet piles with shape of Z, U and straight interconnected have been tested.50% pebbles are used in order to increase higher loading condition, since straight sheet pile in fully embedded condition could resist the land sliding well in 30% pebble condition. Among these sheet piles, Z sheet pile gave best results than straight and U.

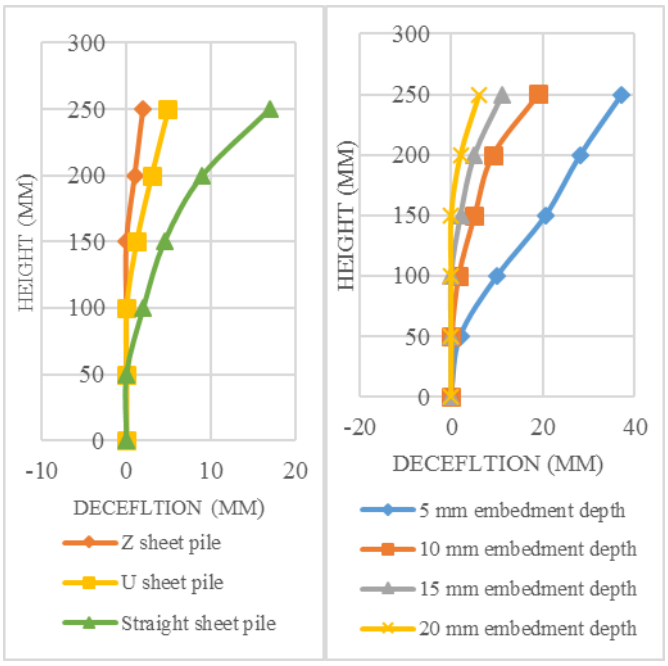

Chart -2: Height – deflection graph when different shape(left) used and different embedment (right)

U sheet pile were better than straight sheet piles but since their area of influence in soil resistance is less than that of Z sheet piles when they are in inter connected form Z sheet piles have more soil resistance capacity. This enables nearly nil deflection in sheet pile when load is applied. Z and U sheet piles segments with indented profiles (troughs) interlock to form a wall with alternating indents and outdents. The troughs increase resistance to bending.

6. CONCLUSIONS

Provision of sheet pile helps to reduce the effect of hazardous land slide. Sheet pile act as a slope stabilization method as well as a retaining wall.

- Sheet pile with more thickness gives greater strength
- Sheet piles made of GI are found superior in resisting landslide than made of stainless steel and aluminum.
- The best results are obtained when fully embedded sheet piles are used instead of partially embedded sheet piles.
- Z shaped sheet piles have best soil resisting shape and capacity than U shaped sheet piles and straight sheet piles. This is because of their bending resistance provided by the particular shape.

As a site condition recommendation, the excess water due to heavy raining can be removed if stepped landscaping is provided while using sheet pile. Sheet pile can be used as eco-friendlier way by allowing growth of vegetation in that area, it could improve retaining of soil by anchoring. Also, transpiration pull of vegetation can take out excess water from soil, without causing hazardous situation. Use of weep holes in sheet pile can be used to remove excess water.

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