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Vetiver walls mixed with banana fiber bags to rehabilitate areas piloting around park under the cycle in Ngororero and landslide prone areas

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Abstract
In rain period, the transport and commercial activities keep not being operational, this paper intention was to assess the problem and provide some solutions. To achieve the target, site investigations in area affected was conducted and samples of soil have been taken in laboratory tests and results have been analyzed, the results in Soil lab indicated that liquid limit, plastic limit, and plastic index are 27.6%, 11.1% and 16.5% respectively (sample is medium plasticity), sieve analysis test indicates that the sample is clayed soil as 85.764% have been passed through sieve size of 0.075mm, direct shear test in Gakenke District indicates that Cohesion and angle of internal friction are 25.08 and 34.67. It is observed that using vetiver walls mixed with banana fiber bags is suitable method to uproot the prevailed landslide in the affected area as it worked in other countries and the Vetiver walls are better to reduce or eliminate natural disasters such as landslides or mudslides and erosion.

Keywords: land landslide, fiber bags, direct shear test, soil laboratory test, erosion, bio-engineering

Introduction

The concerned area is located in Western province where landslide is a problem from the 10 years ago. The region has been affected by natural calamities such as heavy rains and erosion, some measures have been taken to mitigate the hazarders such as constructing retaining walls unfortunately, the applied method failed and the serious overturning occurred and caused a loss of people as well as fortune. For almost 10 years from 2000, heavy rains and landslides left more than 108 people dead and the volume of debris from landslides was 110 million m3, mostly in North and Western provinces (Bizimana and Hussein, 2015) [1]. Landslide is one of worldwide natural disasters since more than 200 years till nowadays (Jotisankasa and Tapparnich, 2010), debris flows and flash flooding in the Muong Lay district caused death and damages (Dien Bien province, 1996). The use of vegetation as a bio-engineering tool for erosion control and slope stabilization has been implemented for centuries but its popularity has increased in the last decades (Truong, 2003) [18]. This is partly due to the low costs of bio-engineering techniques, and partly due to the fact that more knowledge and information on vegetation are now available for application in engineering designs (Hengchaovanich, 1999). Landslide can be caused by deforestation not only removal of trees but also root structures that hold the soil (Donal Nixon D'Souza, 2016) [2]. Thomas, 2012 [17] defines landslide as a downhill movement of rock, soil, or debris. Montalvo, 2011defines a landslide as a geological phenomenon which includes a wide range of ground movement, such as rock falls, deep failure of slopes and shallow debris flows, which can occur in offshore, coastal and onshore environments. Varnes, 1984 [19] describes a landslide as a wide variety of processes that result in the downward and outward movement of slope-forming materials by falling, toppling, sliding, spreading, or flowing. Kumari M. Weerasinghe, 2006 [10] said a landslide occurs when part of a natural slope is unable to support its own weight. TRUONG, 2008 defines Vetiver grass as particularly effective in natural disaster reduction (flood, landslide, road batter failure, river bank, irrigation canal and coastal erosion, water retaining structure instability. Banana fiber bags have long been used for creating strong, protective barriers and for flood control. Since the walls are so substantial, they can resist all kinds of severe weather and also stand up to natural calamities such as earthquakes and floods. They can be erected simply and quickly with readily available components and simple hand tools, for very little money (Kreh, 2003) [4].

Materials and Methodology

Geographical situation in RWANDA

Rwanda is located at only two degrees south of the Equator; Rwanda has a temperate tropical highland climate, with lower temperatures that are typical for equatorial countries due to its high elevation. There are some temperature variations across the country; the mountainous West and North are generally cooler than the lower-lying East the average daily temperature is near Lake Kivu; at an altitude of 4,800 feet (1,463 m) is 73 °F (22.8 °C). There are four noticeable seasons, the long rainy season, the long dry season, the short rainy season and the short dry season. Rainfall is generally heavier in the western and northwestern mountains than in the Eastern savannas (Terry L. Smith, Rwanda, 2008) [16].

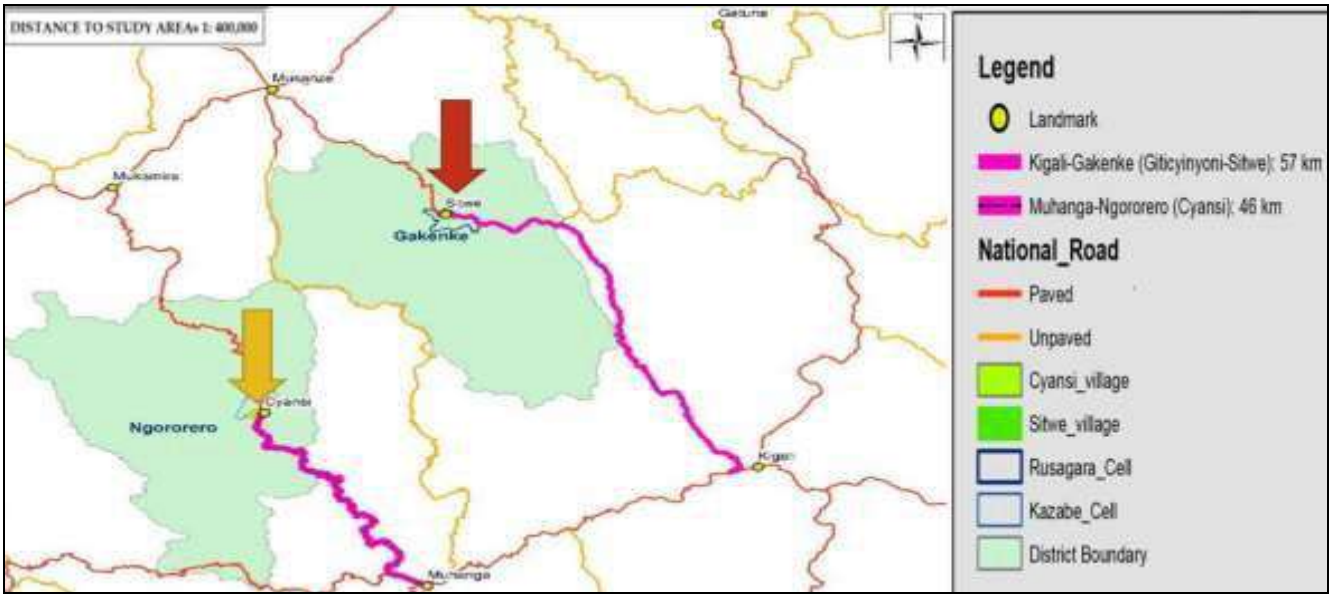


Fig 1: Map indicating 2 Districts affected by landslide

To achieve the objectives site investigation will be conducted and soil test will be conducted in soil lab. Site observation will indicate at which level landslide have affected the area. These tests are moisture content test, Atterberg limits, sieve analysis test and direct shear test.

Fig 1: Soil sample

Fig 2: Fixing shear box in direct shear device

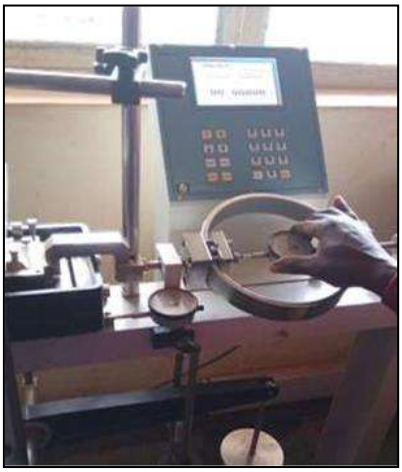


Fig 3: Initialize gauges to zero

Fig 4: Record the readings on the data sheet

Results and findings

Water content

To take soil sample, one specimen was taken at a deep of 1.5 m and results indicated that water content is 27.231 and the second specimen was taken at a deep of 2.5m and the water content is about 20.649.

Table 1: Water content

NATURAL WATER CONTENT TEST
SAMPLE SOIL FROM NGORORERO DITRICT, LAYER 1.
DEPTH: 1.5m

Specimen number	1
Moisture can and lid number	I
MC = Mass of empty, clean can + lid (grams) W1(g)	1254.5
MCMS = Mass of can, lid, and moist soil W2(g)	3853.5
MCDS = Mass of can, lid, and dry soil W3 (g)	3291.0
MS = Mass of soil solids (W3-W1) g	2036.5
MW = Mass of pore water (W2-W3) g	562.5
w = Water content, w%=*mass of water / dry soil x100*	27.231

NATURAL WATER CONTENT TEST
SAMPLE SOIL FROM NGORORERO DITRICT, LAYER 2.
DEPTH: 2.5m

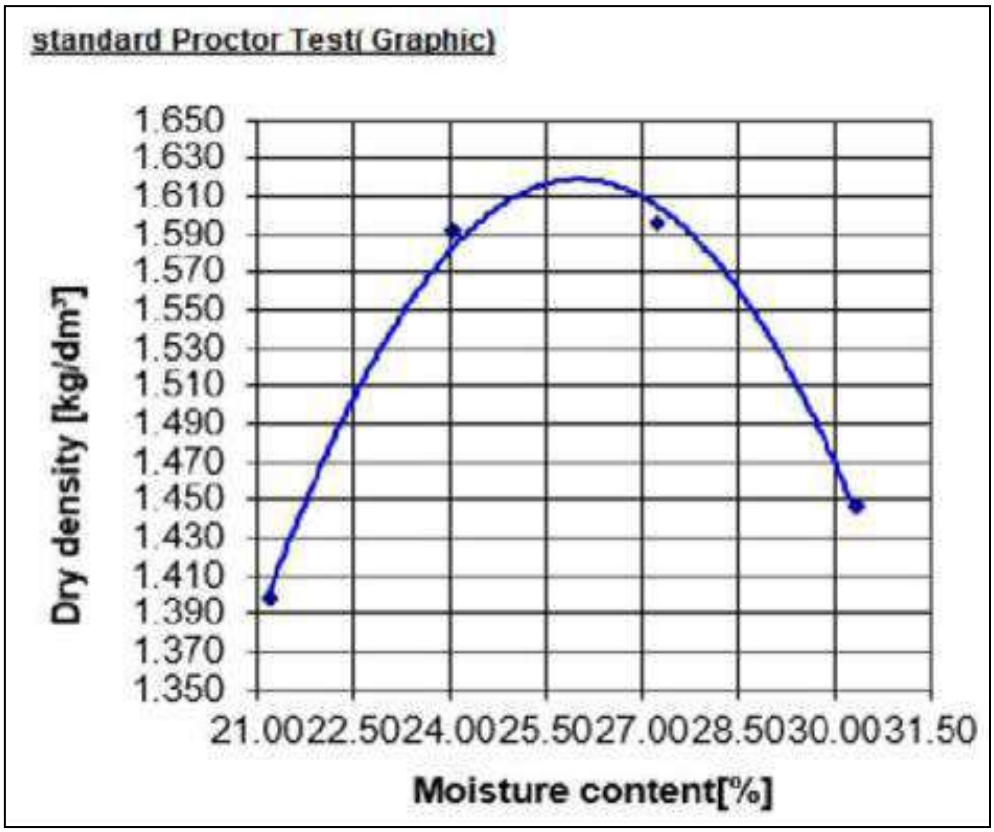
Specimen number	1
Moisture can and lid number	I
MC = Mass of empty, clean can + lid (grams) W1(g)	1212
MCMS = Mass of can, lid, and moist soil W2(g)	2452
MCDS = Mass of can, lid, and dry soil W3 (g)	2254
MS = Mass of soil solids (W3-W1) g	198.0
MW = Mass of pore water (W2-W3) g	1042.0
w = Water content, w%=*mass of water / dry soil x100*	20.649

Standard Proctor Test in Ngororero District

The results of Standard proctor test where moisture contests in mould 1,2 3,4 are 21.19%, 24.04%, 27.23%, and 30.34 respectively and results of Dry density in mould 1, 2,3,4 are 1.4, 1.59, 1.6 and 1.45 respectively, finally M.D.D is 1.60 g/cm3 and O.M.C: is 27.23%.

Table 2: Standard Proctor Test in Ngororero District

Nbr of mould		1	2	3	4
added water	%	20%	24%	28%	32%
Weight mould + Wet mat	gr	5723.5	5981.5	6034.5	5901
Weight mould	gr	4167.0	4167.0	4168.5	4168.5
Weight wet material	gr	1556.5	1814.5	1866	1732.5
Wet denstiy	g/cm³	1.694	1.975	2.031	1.886
Volume mould	cm³	918.80	918.80	918.80	918.80
Dry density	g/cm³	1.40	1.59	1.60	1.45
Pan N°		I	II	III	IV
Weight pan -Wet mat	gr	319.0	676.0	510.5	452.0
Weight pan-drymat	gr	278.0	563.0	419.0	366.0
Weightpan	gr	84.5	93.0	83.0	82.5
Weight water	gr	41.0	113.0	91.5	86.0
Weight dry material	gr	194	470	336	284
Moisture content		21.19	24.04	27.23	30.34

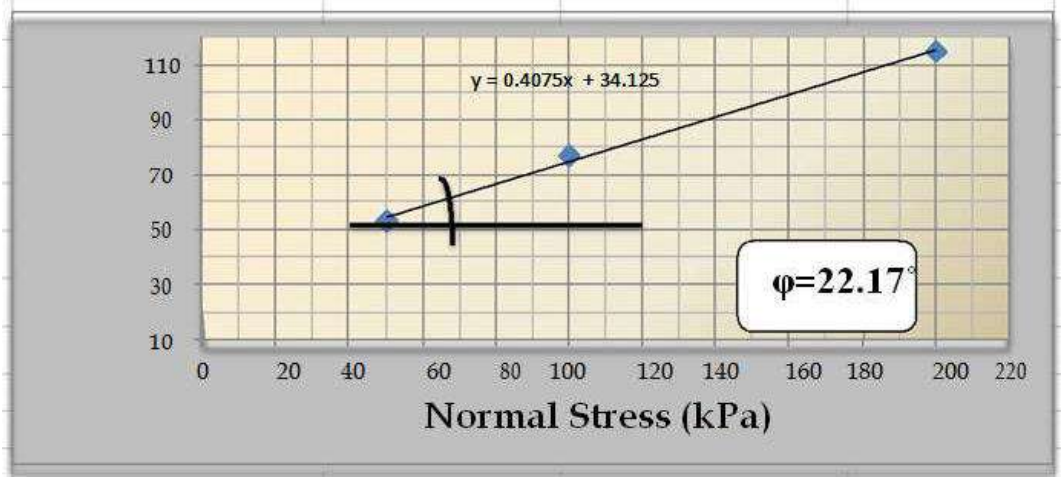


Direct Shear Test in Ngororero District

Above results indicate that cohesion is 34.13, angle of internal friction is 22.17 and slope is 41% in mentioned area.

Table 3: Direct Shear Test in Ngororero District

Bulk density(gr/cm3)	2.03	Dry Density(gr/cm3)	1.60
Box size (60*60*20)mm			
Moisture content	27.23%	Rate(mm/min)	0.375
Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
50.0	53.08	34.13	22.17
100.0	77.00		
200.0	114.92		



Note: The test carried out based on AST D3080

Conclusion and recommendation

Two samples were tested, the first sample was tested before the application of vetivers, and another sample was tested after 1 years of vetiver planted and long roots was in soil, the improvement occurred.

It is clear that normal used methods were not successful and vetiver walls mixed with banana fiber bags can solve prevailed problem of landslide across the region due to its capacity and long roots to penetrate in soil. It was established that the quality of soil depends on angle of friction, slope, and soil classification as well as cohesion of that soil. The conducted soil tests have been carried out using laboratory method. Through this study, it was observed that using vetiver walls mixed with banana fiber bags is suitable method to uproot the prevailed landslide as it has been applicable and successful in Vietnam, South Africa, Ghana, India, USA, and Australia. The use of vetiver walls or mixed with banana fiber bags is more advantageous than using retaining walls in stones and gabion walls by being cheaper, affordable and easy to apply.

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