International Journal of Scientific Research and Engineering Development-– Volume X Issue X, Year

Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

A MODEL STUDY ON THE IMPACT OF JUTE FIBRE AND GRAVITY RETAINING WALL ON SLOPE STABILITY

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Abstract:

A retaining wall is designed to hold a mass of earth in a place. Gravity retaining walls which use the gravitational force of their own weight to resist the lateral earth pressure from the soil behind them, which prevents sliding. This project discusses the behaviour of a small-scale soil slope supported by a gravity retaining wall in the foot of the slope, during artificial rainfall. Soil sample was taken from Keezhavoor, Pothencode which found to be a type of silty sand with 89.89% of sand content. The model steel tank was constructed as three portions with an angle of 45^0 on the middle portion. The model with and without jute fibre and retaining wall applied, were exposed to identical intensities of artificial rainfall for a time period of 60 minutes. The landslide movement cause displacement of retaining wall and erosion of soil, and those are evaluated. Four trials were done with natural slope, jute fibre, retaining wall and combination of jute fibre and retaining wall and by comparison, the most effective method was found as the combination of both jute fibre and retaining wall, where the displacement got reduced to 6mm. Upon adding both jute fiber and retaining wall, the percentage decrease in settlement was about 66.67%.

Keywords — **slope stability, gravity retaining wall, jute fibre.**

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I. INTRODUCTION

Slope stability analysis is a critical aspect of engineering practices aimed at ensuring structural integrity and averting the risk of human and financial losses. It involves categorizing slopes into natural and artificially-made ones, with natural slopes formed through geological processes like plate tectonics and weathering/erosion, while artificially-made slopes are constructed for various infrastructure projects such as embankments and road cuttings. The quantitative assessment of slope stability is imperative for numerous engineering endeavours, including the design of earth dams, embankments, and the analysis of natural and excavated slopes, as well as the stability assessment of foundations and retaining walls. Landslides, triggered by factors like gravitational forces, water saturation, erosion, earthquakes, and changes in groundwater levels, pose significant threats to human infrastructure and lives worldwide. Water, particularly, plays a crucial role in slope destabilization by reducing soil shear strength through saturation, leading to decreased frictional resistance between soil grains. Landslides systematically damage infrastructure and cause numerous fatalities annually, necessitating thorough understanding and proactive measures to mitigate their risks. Natural fiber-based jute geotextiles emerge as a promising solution for soil erosion control and slope stabilization due to their innate water-absorbing capacity, which aids in conserving soil moisture and anchoring soil in sloped areas. In this study, jute fibres are employed to monitor erosion levels, comparing soil erosion with and without the use of geotextiles. The study underscores the effectiveness of jute geotextiles in controlling erosion and stabilizing slopes, highlighting their

potential for sustainable engineering practices. Retaining walls serve as robust barriers designed to support soil laterally, preventing soil failure and stabilizing slopes. These structures effectively harness soil to retain it at different levels, mitigating the risks associated with natural and artificial slopes. In the current study, the focus is on the design and construction of gravity retaining walls for slope stability analysis, comparing on two types of slopes like normal and curved one, to assess their effectiveness. Specifically, the behavior of a small-scale soil slope supported by a gravity retaining wall under artificial rainfall conditions is examined, emphasizing the wall's impact on slope stability. Slope stability analysis is a crucial aspect of engineering practices, vital for ensuring the safety and integrity of structures built on natural or artificial slopes. Through the utilization of innovative solutions such as jute geotextiles and gravity retaining walls, engineers can effectively control erosion, stabilize slopes, and mitigate the risks associated with landslides. Continued research and implementation of such measures are essential for sustainable engineering practices and the protection of human lives and infrastructure against the devastating effects of slope failure.

II METHODOLOGY

- Literature survey
- Collection of materials includes Soil sample, jute fibre, model tank setup, rainfall simulator, retaining wall materials followed by tests on geotechnical properties of soil.
- Preparation of model tank setup (1.6mx0.6mx0.5m) and rainfall simulator.
- Filling slope layer with soil mixed with OMC and by providing rainfall at an intensity of 150mm/hr and evaluated the displacement of soil eroded for normal slope.
- Filling slope layer again with soil and by providing rainfall at same intensity, evaluated the displacement of eroded soil with jute, RW and both combinations.

III MATERIALS USED

SOIL SAMPLE

The soil is collected from Keezhavoor, Trivandrum, and its basic geotechnical properties are determined through various experimental tests.

Table 1: Properties of soil

Sl no	Properties	Soil
1	Specific gravity	2.51
2	% of silt and clay	0.59%
3	% of sand	89.89%
4	% of gravel	9.52%
5	Liquid limit	38%
6	Plastic limit	25.74%
7	Plasticity index	12.3
8	Soil classification	SM
9	Optimum moisture content	14%
10	Maximum dry density	1.897g/cc
11	Cohesion	0.01 kg/cm^2
12	Angle of internal friction	22.5^0
13	Unconfined compression strength, q_u	27.91 kN/m^2
14	% of silt	29.92%
15	% of clay	19.95%
16	Relative density	16.49%

MODEL TANK

A steel tank is constructed in the laboratory for the experimental study with dimensions 1.6m x 0.6m x 0.5m. Polycarbonate material is used for the construction of tank and steel is used forskeleton and the whole tank was constructed as three portions with a slope of 45^0 for the middle portion. An outlet is provided at one of the front corner sides to collect the runoff during the artificial rainfall.

JUTE FIBRE

Jute fibres are environmental friendly materials whose chemical composition includes cellulose, hemicellulose, pectin, lignin, wax and water. In this study jute fibers of thickness 10mm was placed over the top layer of soil and found out the displacement of slope for every 10 minutes of a rainfall intensity 150mm/hr.

Table 2 : Properties of Jute fibre

Sl no	Properties	Soil
1	Puncture resistance (mm)	18
2	Thickness (mm)	0.233
3	Mass per unit area(g/m^2)	366.67

CONSTRUCTION OF RETAINING WALL

The materials used were cement, demolition waste, fine aggregate, coarse aggregate and steel mesh and selected with a mix proportion of 1:1:2:1 for M25 concrete.

ie., 8kg cement: 8kg fine aggregate: 16kg coarse aggregate: 8kg demolition waste

Table 3: Properties of Cement

Sl no	Properties	Soil
1	Fineness	8.67 %
2	% of water for standard consistency	30% (120 ml)
3	Type	Portland Pozzolona cement

Table 4: Properties of demolition waste

Sl no	Properties	Soil
1	Specific gravity	2.58
2	% of gravel	48.1%
3	% of silt and clay	0
4	% of sand	51.9%

IV EXPERIMENTAL PROGRAMME

4.1 MODELLING OF TANK

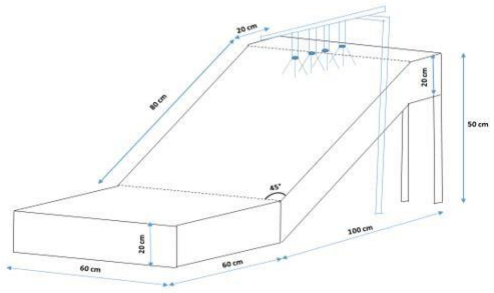


Fig 1: Schematic representation of steel tank

The tank is designed as three portions and the middle portion is constructed at a slope of 45^0. Polycarbonate material is used for the whole tank and steel bars are used for its skeleton.

4.2 SETTING UP OF RAINFALL SIMULATION SYSTEM

An artificial rainfall system with nozzles is implemented over the steel tank which provides an average rainfall of 150mm/hr as by the calculation. Four nozzles were connected parallel to the slope each with a length of 15cm and average cross sectional area of $1.5cm^2$.

4.3 MEASURINING SYSTEM

Thread and pin is aligned at a distance of 20cm apart to find the slope displacement. The slope displacement is measured for every 10 minutes of rainfall**.**

4.4 DESIGN OF RETAINING WALL

A mini gravity retaining wall was designed as per IS 456:2000 using cement, fine aggregate, coarse aggregate and demolition waste in the ratio 1:1:2:1. Three weep holes were designed for drainage as per the required spacing.

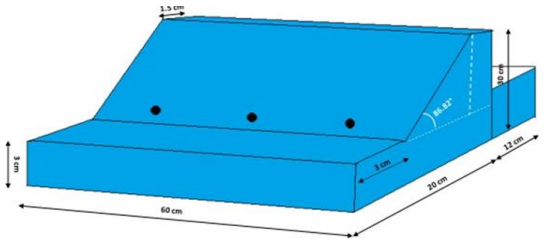


Fig 2: Deign of retaining wall

4.5 CONSTRUCTION PROCESS OF RETAINING WALL

Fig 3: Construction of retaining wall mould

Fig 4: Finished retaining wall

V RESULTS AND DISCUSSION

5.1 CASE 1: NATURAL SLOPE

Approximately 160kg of soil is filled on the slope of angle 45^0 and artificial rainfall of 150mm/hr is

provided and the displacement of slope is found out. Figure shows the natural slope before and after the stimulated rainfall. The natural slope start to fail gradually and forms large cracks at the end of provided rainfall.

Fig 5: Normal slope before and after 150mm/hr of artificial rainfall

5.2 CASE 2: SLOPE SUPPORTED WITH JUTE FIBRE

The soil got filled by layers in the steel tank and compacted to its maximum. Jute fibres ofthickness 10mm are placed on the outer layer of soil.

Fig 6 - Slope with jute fibre before and after 150mm/hr of artificial rainfall

5.3 CASE 3: SLOPE SUPPORTED BY GRAVITY RETAINING WALL

Approximately 160kg of soil got compacted to its maximum and placed over the steel tank. The gravity retaining wall was then placed at the initial portion of slope and both the backfill and passive portion was filled with river sand and gravel.

Fig 7: Normal slope with retaining wall before and after rainfall

5.4 CASE 4: SLOPE SUPPORTED BY BOTH RETAINING WALL AND JUTE FIBRE

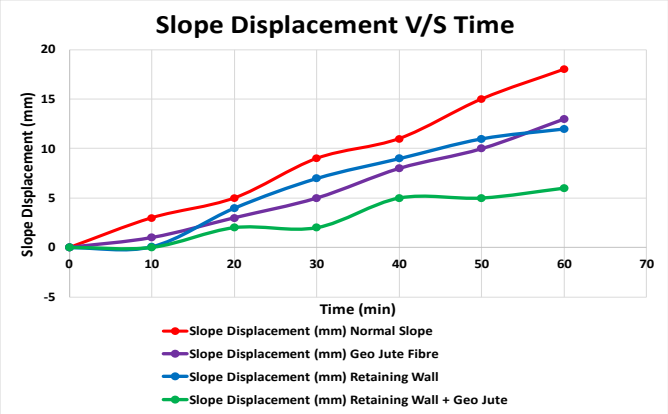
In this case, the soil got filled by layers and compacted to its maximum and jute fibre is placed over the top portion of soil and retaining wall was also placed on the initial portion of the slope area of tank.

Fig 8: Slope with both jute and retaining wall before and after 150mm/hr of artificial rainfall

DISPLACEMENT OF NORMAL SLOPE

Table 5.1 - Displacement of slope

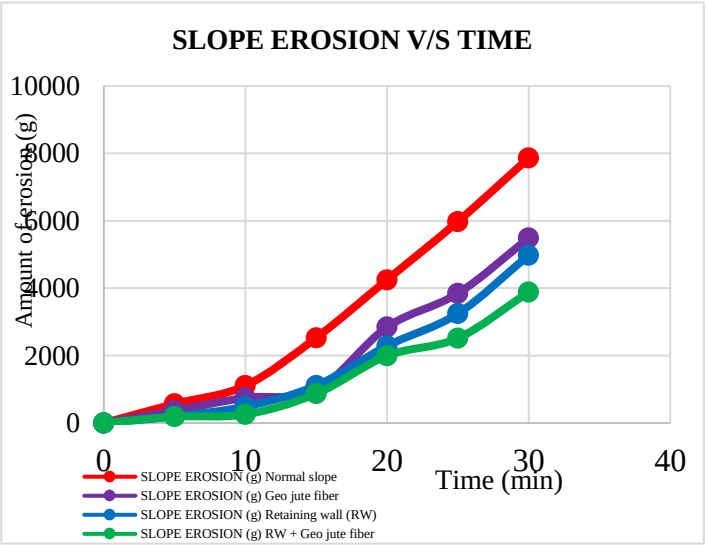
Time (minutes)	Slope Displacement (mm)			
	Normal	Jute Fibre	RW	RW + Jute Fibre
0	0	0	0	0
10	3	1	1	0
20	5	3	4	2
30	9	5	7	2
40	11	8	9	5
50	15	10	11	5
60	18	13	12	6



EROSION RATE OF NORMAL SLOPE

Table 5.2: Slope erosion v/s time

Time (min)	Normal (g)	Jute (g)	Retaining wall (g)	Jute + RW (g)
0	0	0	0	0
5	568.8	370.9	200.4	188.9
10	1110.1	750.6	490.8	256.8
15	2530.9	970.9	1110.8	870.8
20	4250.7	2847.1	2289	1997
25	5980	3846	3248	2517
30	7861.9	5488.9	4980	3887.8



VI CONCLUSIONS

- The soil is identified as silty sand with 89.89% of sand content.
- From calculations, the percentage reduction in displacement and slope erosion for normal slope was found to be 66.67% and 50.5%.
- The studies shows that the values of displacement and erosion of slope for normal slope is very low for soil with combination of jute fibre and retaining wall compared to natural slope, slope with jute fibre and with retaining wall.

REFERENCES

[1] Arbanas Z, Josip Peranic, Vedran Jagodnik, Martina Vivoda Prodan, Nina Ceh, Sara Pajalic, Davor Plazonic, "Impact of gravity retaining wall on the stability of a sandy slope in small-scale physical model", *Conference: 5th Regional Symposium on Landslides in Adriatic- Balkan Region "Landslide Modelling & Applications"At: Rijeka, Croatia*, 2022.

[2] Henok Marie Shiferaw, "Study on the influence of slope height and angle on the factor of safety and shape of failure of slopes based on strength reduction method of analysis*", Beni- Suef University Journal of Basic and Applied Sciences, 2021.*

[3] He Wang, Hongkai Chen, Yali Wang, Linfeng Han & Haizhan Li, "Reliability analysis for stability of the gravity retaining wall under mountain torrent", *Systems Science & Control Engineering, Volume 8-issue 1*, 2020.

[4] Hongwei Song , Jing Liu , Kaiyu He , Waqas Ahmad , "A comprehensive overview of jute fiber reinforced cementitious composites", *Case Studies in Construction Materials Volume 15*, December 2021.

[5] Jawad Ahmad, Mohamed Moafak Arbili, Ali Majdi, Fadi Althoey, Ahmed Farouk Deifalla, and Cut Rahmawati, "Performance of concrete reinforced with jute fibers (natural fibers): A review", Performance of concrete reinforced with jute fibers (natural fibers): A review, *Journal of Engineered Fibres and Fabrics*, 2022.

[6] Jinliang Zhuang and Jianxu Chen, "Stability Analysis of Gravity Retaining Walls with Different

Wall-back Types under Equal Section Area", *IOP Conference Series: Earth and Environmental Sciences*, 2021

[7] Mehmet Salih Keskin and Sedat Kezer "Stability of MSW Landfill Slopes Reinforced with Geogrids", *Appl.Sciences, 12(22*, 2022.

[8] Muhammad Basit Khan, Nasir Shafiq, Ahsan Waqar, Dorin Radu, Ciprian Cismaș, Muhammad Imran, Hamad Almujibah and Omrane Benjeddou, "Effects of Jute Fiber on Fresh and Hardened Characteristics of Concrete with Environmental Assessment", *Buildings 2023, 13(7), 1691*, 2023.

[9] Thomas Heinze, Stefan Wohnlich & Michael Alber, "Slope stability analysis of deep- seated landslides using limit equilibrium and finite element methods in Debre Sina area, Ethiopia", *Bulletin of Engineering Geology and the Environment volume 81*, September 2022.

[10] Zengle Li, Huimei Zhang, Bin Zhi, Xin Li, "Research on New Greenable Class Gravity Retaining Wall Structure Technology Based on Video Monitoring", *Applied Sciences 13(21):12066*, November 2023.

