A TECHNO-ORGANIC APPROACH TO ENHANCE SLOPE STABILITY IN LANDSLIDE-PRONE ENVIRONMENTS

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Introduction:

Slope stability refers to the ability of a slope or hillside to resist the downward movement or collapse of soil and rock materials. Landslides are a common form of slope failure, which can result in significant damage to property and infrastructure, loss of life, and environmental impacts. Slope stability and landslides are important considerations in engineering geology and geotechnical engineering, particularly in the planning, design, and construction of infrastructure projects such as roads, bridges, and buildings. Some common causes of slope instability include earthquake, heavy rainfall or snowmelt, changes in soil moisture content, and the removal of support at the base of a slope due to excavation or construction activities.

The soil collected from Swamimukku, Kerala was affected by landslide. Hence required tests should be conducted in order to know the properties of soil. In the project we thrive to use organic materials to improve the soil stability. The organic materials that will be used are coir and sunflower stem. Different percentages of these materials will be added according to trial-and-error method. Hence from the test results, the optimum percentage of materials to be used to stabilize the slope will be determined. A model is prepared and rainfall will be stimulated to know the failure pattern of slope.

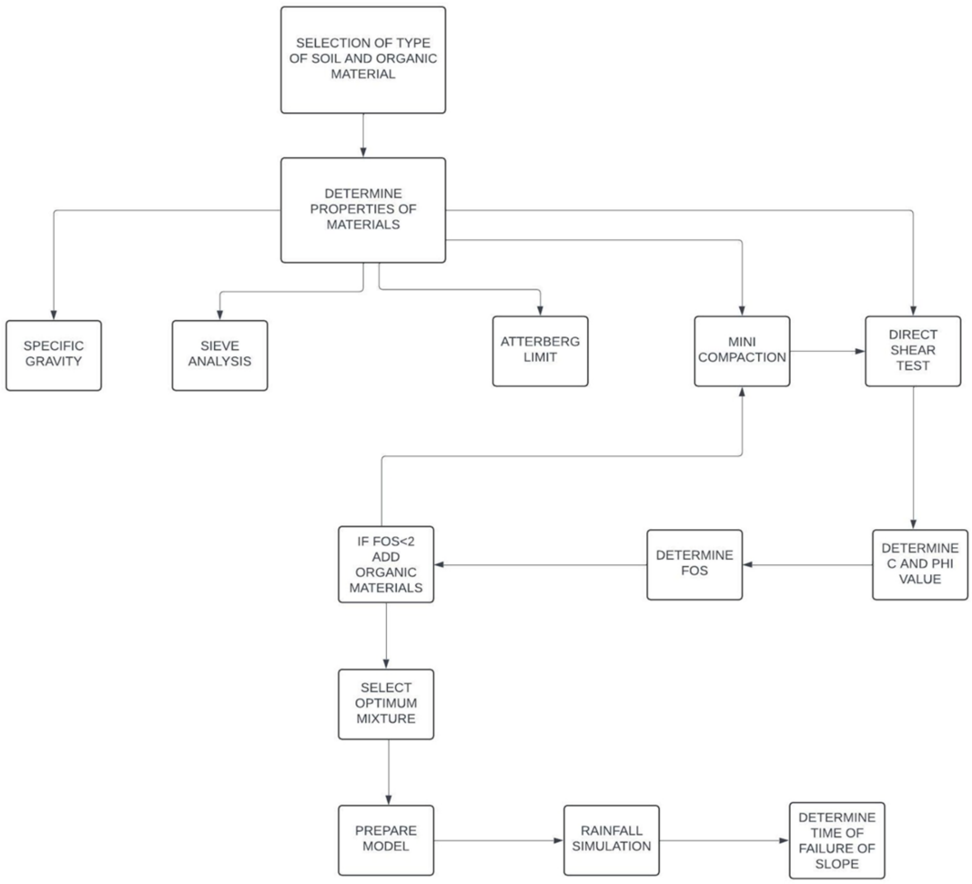
Objectives:

- **_Comprehensive Soil Analysis:_** Conduct thorough testing on soil samples from Swamimukku, Kerala, to ascertain their physical and mechanical properties. This involves a series of laboratory tests such as grain size distribution, Atterberg limits, and shear strength tests. Understanding these properties will help identify the factors contributing to the slope's instability and inform the stabilization strategy.

- **_Evaluation of Organic Stabilizers:_** Investigate the use of organic materials, specifically coir and sunflower stem, as soil stabilizers. This objective includes determining how different percentages of these materials affect the soil's cohesiveness and overall stability. By conducting a series of controlled experiments, the project aims to evaluate the effectiveness of these natural stabilizers compared to conventional methods.

- ***Optimization of Stabilizer Mix:*** Utilize a trial-and-error approach to identify the optimal mix of coir and sunflower stem required to achieve the best possible soil stability. This involves systematically varying the proportions of the organic materials added to the soil and assessing the resultant changes in stability through laboratory tests and physical modeling.
- ***Simulation and Model Testing:*** Develop a physical model of the slope to simulate real-world conditions and test the stability improvements under various scenarios. This includes creating a scaled-down model of the slope, applying the optimized mix of organic stabilizers, and subjecting the model to simulated rainfall. Observing the model's response to these conditions will provide insights into the failure patterns and the effectiveness of the stabilization techniques.

Methodology:



- A soil of 20kg has been collected from Swamimukku, Kerala where recently landslide had occurred where the water table of the area is 4.77meters.
- Then 10kg of sample is oven dried for 24hrs to conduct different experiments to classify the type of soil.
- The experiments to be conducted are

1. Specific gravity test
2. Atterberg’s limits
3. Sieve analysis
4. Mini compaction test
5. Direct shear test

- All the tests conducted are according to procedures referred from IS CODE 2720.
- From the experiments Atterberg’s limits, specific gravity and sieve analysis the type of soil is classified.
- According to the test procedure mentioned in IS CODE, mini compaction test is performed to determine the maximum dry density (MDD) and optimum moisture content (OMC) of the soil.
- Then the triaxial test is performed to find the shear strength parameters that is cohesion and angle of friction of the soil.
- Using these two parameters cohesion “c “and angle of friction “Φ”, the Factor of safety (FOS) is calculated by analytical method (Taylor's Stability method) and software analysis for comparison different slope angles considered.
- From the obtained results, the slope angles whose FOS is less than 1.5 is considered for further steps.
- The organic materials used for stabilization of slopes in the project are SUNFLOWER STEM & COIR.
- Initially the sunflower stem is dried completely and kept in oven for 24hrs similarly the coir is also kept in oven for drying.
- Now the oven dried stems are taken and shredded using shredder and the sample is ready.
- Then the oven dried coir is cut into the length of 1 – 2 cm and the sample are ready.
- The combination of organic materials is added with the soil in different proportions according to the matrix of percentage selected by trial-and-error method.
- Then the soil is again tested to determine the OMC and MDD value with each combination and triaxial test is performed to obtain the c and Φ value and FOS is found.
- If the FOS is again less than 1.5, then more permutations and combinations of organic materials are to be added.
- The optimum percentage of organic materials (coir, sunflower stem) are determined where FOS is more than 1.5 for the selected slope angles.

Results:

- The specific gravity of soil is 2.57.
- Liquid limit = 55%
- Plastic limit = 37.65 %

- Plasticity index = 17.35 %
- From particle size distribution graph

D_{60}	1.1
D_{30}	0.7
D_{10}	0.2
Coefficient of uniformity C_u	5.5
Coefficient of curvature C_c	2.23

- Sample ID's selected

Sample ID	% of Coir	% of Sunflower stem
S0	0	0
S1	0.25	0.5
S2	0.25	0.75
S3	0.25	1
S4	0.5	0.25
S5	0.75	0.25
S6	1	0.25
S7	0.25	0.25

- Mini compaction test

Matrix	OMC (%)	MDD (kN/m^3)
S0	20.29	11.77
S1	18.16	13.24
S2	16.93	12.65
S3	18.17	12.36
S4	17.45	12.65
S5	16.56	12.45
S6	18.10	12.06
S7	18.8	12.55

- Direct shear test

Matrix	Cohesion (kPa)	Angle of internal friction (Φ)
S0	49.28	2.685°
S1	58.85	2.93°
S2	50.02	2.74°
S4	52.8	2.519°
S7	53.93	2.79°

- Computation of fos for various angles

Angles (β)	S0	S1	S2	S4	S7
10°	3.04	3.603	3.087	3.221	3.312
20°	2.3	2.438	2.110	2.182	2.243
30°	1.837	2.178	1.865	1.948	2.002
40°	1.761	2.089	1.788	1.869	1.920
50°	1.673	1.988	1.699	1.779	1.825
60°	1.605	1.908	1.630	1.708	1.752
70°	1.55	1.854	1.583	1.660	1.702
80°	1.52	1.816	1.55	1.626	1.667

- Hydrology Bench Experiment:

Without additive:

For 40˚, time of failure is 1 min 33 sec.

For 30˚, time of failure is 1 min 50 sec.

With additive:

For 40˚, time of failure is 2 min 21 sec.

For 30˚, time of failure is 4 min 20 sec.

Conclusion:

- The above-mentioned tests were conducted according to the IS 2720 CODE BOOK, and the test results were obtained. From these tests results it is concluded that the soil collected from landslide-affected zone is cohesive clayey soil.
- It is concluded that from MINI COMPACTION TEST, the samples S1, S2 S4 S7 are having high "MDD" & "OMC" values compared to other samples. Hence, these samples are selected.
- The DIRECT SHEAR TEST conducted on these 4 samples indicated that sample S1 gives the highest "c" & "Φ" value compared to other samples.
- By conducting Hydrology Benching Rainfall experiment, for both zero % additive and S1 sample (with additive), it is concluded that the time of failure has been increased after mixing additives to the soil.

Scope for future work:

- ***Long-Term Field Studies:*** Conducting extended field trials in various geographic and climatic conditions to evaluate the long-term performance and durability of coir and sunflower stem as soil stabilizers. Monitoring these sites over several years will provide insights into the materials' longevity, resistance to biodegradation, and effectiveness under different environmental stresses.
- ***Comparative Analysis:*** Expanding the study to include a wider range of organic and natural materials, such as jute, bamboo fibers, and biochar. Comparative analyses of these materials can identify the most effective and sustainable options for different types of soils and slope conditions.
- ***Soil-Plant Interaction:*** Investigating the role of vegetation in conjunction with organic stabilizers. Research can focus on how the root systems of certain plants interact with coir and sunflower stem to further enhance soil stability and prevent erosion.
- ***Economic Analysis:*** Performing cost-benefit analyses to compare the economic viability of organic stabilization methods against traditional techniques. This includes assessing initial costs, maintenance expenses, and potential savings from reduced environmental impact and improved resilience of infrastructure.