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The Use of Lime Sludge and Rice Husk Ash in the Stabilization of Road Subbases: A Project Management Plan

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Abstract

Cement and lime are common stabilizers which could promote high cost for soil stabilization, prompting the need for sustainable alternatives. Utilizing agro-industrial waste by-products as stabilizers offers a cost-effective solution to replace cement and lime. This project management plan (PMP) investigates the feasibility of using locally available lime sludge and rice husk ash for road subbase stabilization to achieve desired strengths and environmental impact assessments. The PMP focuses on an institutional project with a three-member team, involving preparing soil samples, lime sludge, and rice husk ash, blending samples, conducting Compaction and California Bearing Ratio (CBR) tests, performing environmental impact assessments, and preparing a project terminal report with findings disseminated to stakeholders. Additionally, it excludes the use of other additives for subbase stabilization, large-scale road construction, long-term maintenance, and stabilization of other infrastructure components.

Keywords: Project management plan, road subbase, stabilization, lime sludge, rice husk ash

1. Introduction

The increasing demand for sustainable infrastructure solutions has led to a critical need for alternative materials that can reduce the environmental impacts associated with traditional construction practices. Cement and lime, commonly used stabilizers in road subbases [1], contribute significantly to greenhouse gas emissions and resource depletion [2-3].

In recent years, there has been a growing interest in exploring alternative materials for road construction that are more sustainable and environmentally friendly. Several studies have been conducted to evaluate the efficacy, sustainability, and environmental friendliness of various materials for road subbase stabilization [4-6]. Among the most promising materials identified in these studies are lime sludge and rice husk ash. Lime sludge, a byproduct of the water treatment process, and rice husk ash, a residue from rice processing, are two such materials that have gained attention [7]. These materials are often considered waste products and are typically disposed of in landfills, contributing to environmental pollution. However, when properly treated and utilized in road construction, they can offer a valuable and sustainable alternative to traditional stabilizers.

Lime sludge and rice husk ash possess several characteristics that make them suitable for use in road subbases [8-10]. Lime sludge, for example, contains calcium hydroxide, which has cementitious properties and can improve the strength and durability of road subbases. Rice husk ash, on the other hand, is rich in silica, which can enhance the resistance of road subbases to moisture and frost. Additionally, both materials have a low carbon footprint compared to traditional stabilizers, making them attractive options for sustainable infrastructure development. The use of these waste materials can help to reduce the consumption of natural resources, mitigate greenhouse gas emissions, and minimize landfill waste. Furthermore, it can provide economic benefits by reducing the costs associated with waste disposal and creating new opportunities for sustainable materials utilization.

To ensure the successful implementation of a project, a comprehensive Project Management Plan (PMP) is essential. The PMP will outline the project objectives, scope, timeline, resources, and risk management strategies this will ensure that all stakeholders are aligned in the project's goals. This structured approach facilitates effective communication among team members, sponsors, and regulatory agencies, which is vital for addressing challenges that may arise during the project lifecycle. Properly-managed projects are products of systematically organized, executed, and finalized project undertakings that adhered to constraints of time, budget, and quality [11-13].

In this work, a PMP is established for the feasibility of using locally available lime sludge and rice husk ash for road subbase stabilization to achieve desired strengths and environmental impact assessments. Recently, this lime sludge from Bukidnon, Philippines has been studied with fly ash for road subbase stabilization [14-16]. It resulted to increase of soil strengths (California bearing ratios) with increasing fly ash contents [14-15]. However, the stabilized materials were assessed as not environmentally-safe. It was then recommended to vary instead the amounts lime sludge [16]. Fly ash-based materials should be of no environmental problems when applied for construction [17-18]. Hence, this PMP specifically seeks to replace fly ash with rice husk ash with the aim of producing a more environmentally-sound subbase materials while maintaining the desired strengths.

2. Methods

This project management plan (PMP) is for a 10-month, institutionally-funded project with a team of three members. It consists of three sections: (1) project charter, (2) management strategy & definition of success, and (3) project plan. The project aims to assess the effectiveness of lime sludge and rice husk ash in stabilizing road subbase materials and enhancing their strengths. The entire process includes soil sample preparation, lime sludge and rice husk ash preparation, blending of samples, compaction and California Bearing Ratio (CBR) tests, environmental impact assessments, and final report preparation and dissemination.

3. Results

The project management plan (PMP) is presented below. The PMP aims to achieve acceptable California Bearing Ratios (CBR) for stabilized subbase materials and ensure positive environmental impact. Exclusions include the use of additives other than lime sludge and rice husk ash, large-scale road construction, long-term maintenance activities, and stabilization of other infrastructure components like foundations or embankments.

1. Project Charter

1.1. Background

Cement and lime are the most common stabilizers in soil treatment [19]. However, increased dependence on these stabilizers results to a higher cost on soil stabilization. Replacing them with potential industrial by-products could be an effective solution [16]. The use of these by-products could improve soil properties such as bearing capacity, water permeability, and resistance to liquefaction [20]. Improving the strength and durability results to suitability to construction purposes [21].

Significant impacts of lime sludge [14-16, 22-24] and rice husk ash [25-27] as stabilizers have been investigated already. And the potential combination of these materials as stabilizers have been tested further [28-30]. Thus, this project seeks to utilize locally available lime sludge and rice husk ash in road subbase stabilization, with the aim of having no environmental safety issues prior to their utilization.

The lime sludge from Bukidnon, Philippines was already tested for the said purpose, along with fly ash. The stabilized subbases resulted to increase of strengths with increasing fly ash amounts [14-15] but with environmental problems [16]. Although this fly ash has been utilized already for many applications [14-17, 31], obtaining the optimized properties with no negative environmental impact remains a challenge. Hence, this project specifically aims to replace fly ash with another locally available resource, the rice husk ash.

1.2. Project Objectives

The key objectives for this project are:

- To evaluate the potential combination of lime sludge and rice husk ash in stabilizing road subbase materials
- To improve the California bearing ratios (CBR) of road subbases
- To conduct environmental impact assessment for the lime sludge/rice husk ash stabilized road subbases

1.3. Project Scope

The scope of this project includes:

- Preparation of soil samples, lime sludge, and rice husk ash
- Preparation of blended samples
- Compaction and California Bearing Ratio (CBR) tests
- Environmental impact assessment tests
- Preparing project terminal report and disseminating findings to stakeholders

The scope statement is given in details later.

1.4. Project Benefits

The project offers environmental benefits through waste material utilization, potential cost savings in road construction, and improved road subbase performance. Specifically, the process herein is economical and environmentally friendly, reducing production time and costs for cement and lime, while preventing harmful gas emissions. It also conserves natural land resources [32] and promotes sustainability by utilizing daily-generated wastes. Researchers gain professional development and expertise in soil stabilization, contributing to civil engineering and materials engineering fields through academic publications.

1.5. Project Risks and Assumptions

Risk Management Plan in the last section provides a detailed discussion of project risks. The assumptions include having sufficient lime sludge and rice husk ash obtained in nearby areas. Access to well-equipped laboratory and testing facilities at the university is also assumed. Additionally, it assumes cooperation and support from stakeholders.

2. Management Strategy & Definition of Success

This project will be successful if these are met:

- Completion of project deliverables;
- Total cost of the project not exceeding 300, 000 Php.

Here are the management strategies for achieving the criteria above:

Secure a detailed testing plan using standardized methods to evaluate strength and ensure accuracy through regular reviews. Continuous performance monitoring and adjustments will optimize the stabilization method. An initial environmental impact study will establish baseline conditions and key parameters for ongoing monitoring, ensuring adherence to environmental regulations and sustainable practices. Data analysis will quantify benefits, and detailed reports will be prepared for stakeholders and regulatory bodies.

Develop an efficient documentation system and train the team, regularly reviewing and auditing project records for accuracy. Engage stakeholders through progress meetings and reports, actively soliciting feedback for improvements. Establish a formal approval process, presenting final report for discussion and obtaining documented approval. Disseminate findings through presentations and publications to ensure wider visibility.

3. Project Plan

3.1. Scope Statement

The project scope statement has already been mentioned in the following items:

- Project Charter; and
- Project Assumptions.

In addition, the technical considerations in Table 1 below are indispensable for the implementation and achieving of the project objectives.

Table 1. Technical Considerations for the Project

Technical Requirements	
Material Selection and Compatibility	Assess the suitability of lime sludge and rice husk ash for soil stabilization by evaluating their chemical composition, particle size distribution, and reactivity with soil constituents to ensure compatibility and achieve desired engineering properties.
Mix Design Optimization	Conduct laboratory tests to determine optimal mix proportions of lime sludge, rice husk ash, and soil for achieving target performance criteria, considering soil type, moisture content, curing conditions, and long-term performance.
Environmental Impact Assessment	Evaluate the potential environmental impact of using lime sludge and rice husk ash for soil stabilization, addressing concerns related to leaching of contaminants, groundwater pollution, and ecosystem disruption, and implement mitigation measures like proper disposal of unused materials, containment of runoff water, and groundwater quality monitoring.
Performance Monitoring and Evaluation	Develop a comprehensive monitoring plan to assess the short-term and long-term performance of stabilized subbase materials in actual field conditions.
Data Management and Documentation	Develop an efficient data management system to accurately record and track project activities, laboratory test results, and performance data, maintaining detailed documentation of all project-related information, including design specifications, construction procedures, and environmental assessments.
Safety Protocols and Compliance	Establish safety guidelines and protocols for handling, storing, and applying project materials, including lime sludge and rice husk ash, to protect project personnel while ensuring compliance with regulatory requirements and industry standards for the use of stabilized soil mixtures in road construction projects.

3.1.1 Project Scope Description

This project aims to assess the effectiveness of lime sludge and rice husk ash in stabilizing road subbase materials and enhancing their strengths, promoting sustainable infrastructure development. The scope includes preparing soil samples, lime sludge, and rice husk ash, blended samples, and conducting compaction and California Bearing Ratio (CBR) tests. It also involves environmental impact assessment tests. Finally, the project will prepare a terminal report and disseminate the findings to stakeholders. Further, the technical requirements listed in Table 1 shall be carried as well.

3.1.2 Project Deliverables

- Physical and Index Properties of the Subbase Material
- Oxide Analyses of Lime Sludge and Rice Husk Ash

- Mix Variations
- Compaction Test Results
- California Bearing Ratio (CBR) Test Results
- Environmental Impact Assessment Report
- Final Project Terminal Report

3.1.3 Acceptance Criteria

- Acceptance in the California bearing ratios (CBR) of stabilized subbase materials
- Positive environmental impact assessment
- Comprehensive and accurate documentation of all project activities and results
- Approval of final report and findings by stakeholders

3.1.4 Project Exclusions

- The project will focus solely on stabilizing road subbase materials with lime sludge and rice husk ash, excluding any other additives.
- The project excludes large-scale road construction and any long-term maintenance activities beyond the designated monitoring period.
- The project will not cover the stabilization of other infrastructure components, such as foundations or embankments.

3.2 Work Breakdown Structure

The project for lime sludge (LS)/rice husk ash (RHA) stabilized road subbases can be done in five activities as shown in Fig. 1 below. These activities include preparation of raw materials (soil samples, lime sludge and rice husk ash) and blended samples, conduct of compaction and California Bearing Ratio (CBR) tests, environmental impact assessment, and report preparation and results dissemination. And each of the activities has their own work packages to deliver.

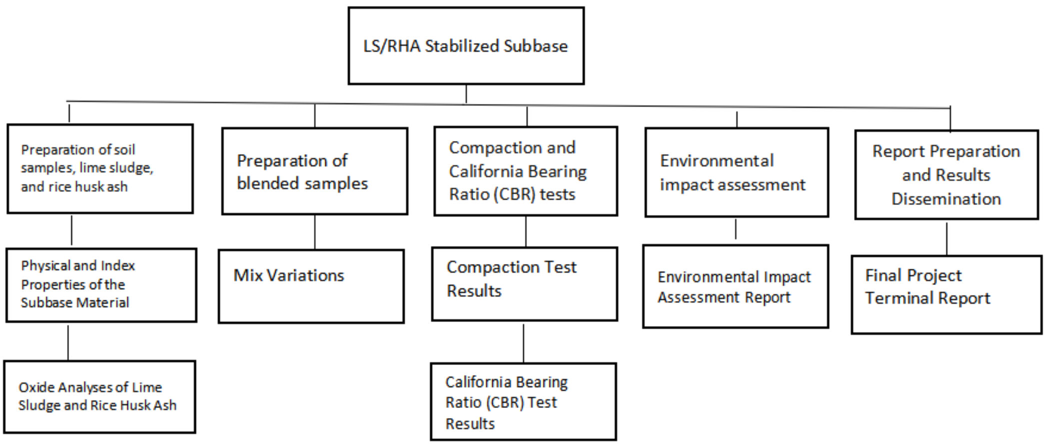

Fig. 1. Work Breakdown Structure

3.3 Project Budget Overview

This institutional project has a duration of 10 months. The budget for all the activities and their corresponding packages is shown in Table 2 below. The project is designed for a team composed of three to be led by a project leader. The overall budget would amount to 300,000 Php.The total actual cost of implementing the project should not exceed to the overall budget.

Table 2. Project Budget Overview

Items of Expenditure	Amount (Php)
I. Personal Services	
Project Leader	50,000
2 Project Members	60,000
Sub-Total	110,000

II. Maintenance and Other Operating Expenses (MOOEs)	
Transportation Expenses	15,000
Supplies and Materials	5,000
Communications	3,000
Experimentation & Laboratory Services	152,000
Representation Expenses	5,000
Contingency	10,000
Sub-Total	190,000
Grand Total	300,000

3.4. Project Schedule

The summary for the 10-month duration project schedule is shown in Table 3 below. It is further broken down in gantt chart and network diagram formats as show in Figs. 2 and 3 below. From Table 3, it can be shown that this project shall commence with a literature review and some preliminary studies. Them lab testing and mix design follows and shall take for two months. It is also observed that field application and monitoring would be completed after five months. After this, data analysis and report writing and then results dissemination, which shall be completed both in one month.

Activity	Activity Name	% Complete	Duration (Months)
1	Preparation of soil samples, lime sludge, rice husk ash and cement	100%	2
2	Preparation of blended samples	100%	1
3	Compaction and California Bearing Ratio (CBR) tests	100%	4
4	Environmental impact assessment tests	100%	2
5	Preparing and disseminating reports to share project findings and recommendations with stakeholders	100%	1

Table 3. Summary of Project Schedule

3.4.1 Project Schedule Gantt Chart

Fig. 2 below shows the gantt chart for the conduct of the 10-month duration project. It stipulates specific activities to complete the project for the desired duration.

Subbase course soils are randomly selected based on the Philippines' Department of Public Works and Highways (DPWH) recommendations. Soil samples undergo various physical, index, and mechanical tests following ASTM standards. These tests are sieve analysis, specific gravity determination, Atterberg limits, compaction testing, and California Bearing Ratio (CBR) testing. The Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) values from the compaction test are used in the CBR test. Additionally, the hygroscopic moisture content (HMC) is determined by oven-drying the soil samples at 100±10°C for 24 hours.

Lime sludge and rice husk ash, collected from local sources in the Philippines, are air-dried, sieved, and subjected to a loss on ignition (LOI) test to ensure fineness before mixing with Type 1 Ordinary Portland cement (OPC). The cement, also sieved, is combined with soil, lime sludge, rice husk ash and water, ensuring thorough mixing until a uniform color is observed.

The mixtures are varied within the range recommended by the DPWH and previous studies. Following DPWH guidelines, cement is added in amounts ranging from 6% to 10% of the dry soil, with a maximum variation of 1% in this process. Rice husk ash is added at intervals of 10% by soil dry weight, ranging from 10% to 50%, while lime sludge is added at 10% intervals. Once the soil aggregate, lime sludge, rice husk ash and OPC are combined, compaction and California bearing ratio (CBR) testing to blended samples follow. Environmental impact assessment is also conducted to the stabilized materials.

A project terminal report is prepared after the project is completed. The project findings also are disseminated to concerned stakeholders.

3.4.2. Project Network Diagram

The network begins with examining the research materials including, the determination of physical and index properties of subbase material, and oxide analyses of both lime sludge and rice husk ash. Preparation for the mix varations for compaction and California bearing ratio (CBR) tests follow, then, the conduct of environment impact assessment of the stabilized materials. When the project gets completed, a project terminal report is to be made. The corresponding network diagram for Table 4 above is shown in Fig. 3 below.

Table 4. Network Information

Activity	Description	Preceding Activity
A	Physical and Index Properties of the Subbase Material	None
B	Oxide Analyses of Lime Sludge and Rice Husk Ash	A
C	Mix Variations	B
D	Compaction Test Results	C
E	California Bearing Ratio (CBR) Test Results	C
F	Environmental Impact Assessment Report	D,E
G	Final Project Terminal Report	F

Activities	Month									
	1	2	3	4	5	6	7	8	9	10
Select a site for soil sampling.										
Collect and prepare soil sample.										
Prepare lime sludge and rice husk ash.										
Prepare blended samples.										
Determine the compaction behavior of the treated subbase course.										
Determine the California bearing ratio (CBR) values for the treated subbase course.										

Conduct environmental impact assessment.										
Make a final project terminal report.										
Disseminate findings to stakeholders.										

Fig. 2 Project Schedule Gantt Chart

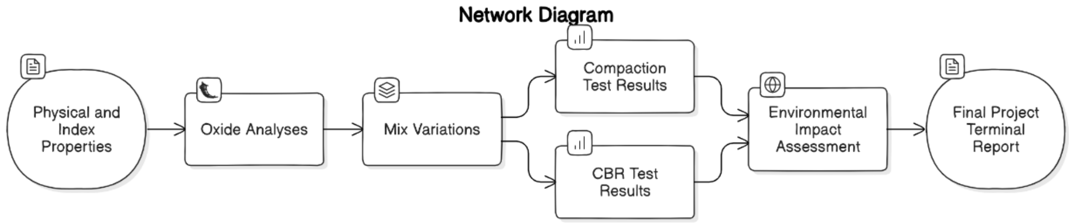

Fig. 3. Network Diagram

3.5. Human Resource (HR) Roles and Responsibilities

3.5.1. Organizational Structure

This PMP will be based at the University of Science and Technology of Southern Philippines (USTP), a state-owned university in Cagayan de Oro City, Philippines where a team of three has instiutional project leader/manager who leads the preparation of proposal in coordination with the Research Office thru its Research Program Officer. The proposal is endorsed by the Research Director if it is in order.The Vice Chancellor for Research and Innovation recommends its approval after the Head of the Accounting Office signifies the availability of funds. Finally, the Chancellor approves it. See Fig. 4 below.

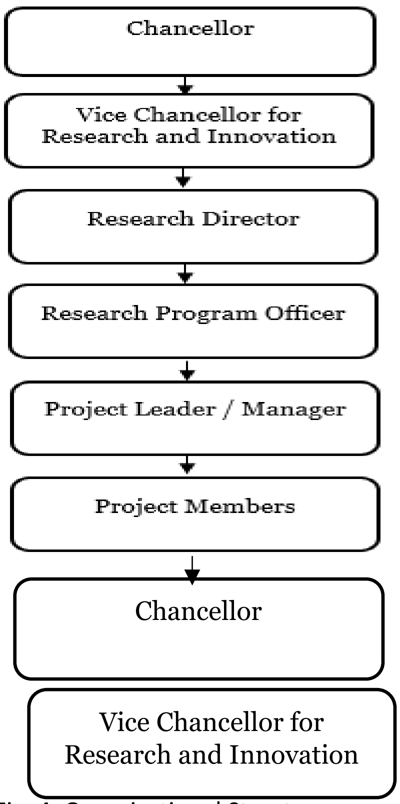

Fig. 4. Organizational Structure

3.5.2. RACI Matrix

According to Table 5 below, the project team, led by the project leader/manager, is responsible for executing the institutionally-funded project. The table stipulates specific activities and deliverables to accomplish to complete the project. This execution typically involves coordination with the Research Office thru its Research Program Officer and Research Director, external supplier, and various university units, including Procurement, Accounting, Inspection, and Supply units.

3.6. Stakeholder Management and Communication Plan

At USTP, the project leader/manager leads the execution of the research project and ensuring its objectives are met. The team may meet regularly and must coordinate with the Research Office, providing updates through the Research Program Officer and Research Director. They are expected to submit progress reports and a final terminal report upon project completion. Team members should also coordinate with the Procurement, Inspection, Accounting Units as well as the Supply Office regarding supplies and materials. Consultation meetings with the Chancellor and Vice Chancellor for Research and Innovation may be scheduled if required, especially for serious financial issues. This is shown in Table 6 below.

3.7. Risk Management Plan

Table 7 presents the project's risk management plan. Technical risks involve the potential failure of strength tests to achieve expected stabilization results, addressed through preliminary studies, pilot tests, and backup plans. Environmental risks from using lime sludge and rice husk ash are mitigated by initial environmental assessments, continuous monitoring, and eco-friendly practices.

Financial risks, such as budget overruns, are managed with a detailed budget and regular reviews. Schedule risks are mitigated by creating a detailed schedule with buffer times and monitoring progress. Quality, health and safety, data management, performance, weather, and legal risks are addressed through strict quality control, comprehensive protocols, reliable systems, extensive monitoring, weather contingencies, and legal compliance.

Table 5. RACI Matrix

Activity	Work Package	Responsible (R)	Accountable (A)	Consulted (C)	Informed (I)
Preparation of soil samples, lime sludge, and rice husk ash	Physical and Index Properties of the Subbase Material	Project Members	Project Leader/Manager	Project Leader/Manager	Research Program Officer
	Oxide Analyses of Lime Sludge and Rice Husk Ash	Project Members	Project Leader/Manager	Project Leader/Manager	Research Program Officer
Preparation of blended samples	Mix Variations	Project Members	Project Leader/Manager	Project Leader/Manager	Research Program Officer

Compaction and California Bearing Ratio (CBR) tests	Compaction Test Results	Project Members	Project Leader/Manager	Project Leader/Manager	Research Program Officer
	California Bearing Ratio (CBR) Test Results	Project Members	Project Leader/Manager	Project Leader/Manager	Research Program Officer
Environmental impact assessment	Environmental Impact Assessment Report	Project Members	Project Leader/Manager	External supplier, Procurement, Accounting, Inspection, and Supply units	Research Program Officer
Report Preparation and Results Dissemination	Final Project Terminal Report	Project Members	Project Leader/Manager	Research Program Officer	Research Director

Table 6. Stakeholder Management and Communication Plan

Stakeholder	Role/Interest	Impact on Project	Communication Strategy	Frequency	Responsible Person/s
Chancellor's Office	Approves the research funding	High	Consultation meetings	As required	Chancellor
Office of the Vice Chancellor for Research and Innovation	Recommends the approval of the research funding	High	Consultation meetings	As required	Vice Chancellor for Research and Innovation
Research Office	Supervises the the conduct of research project	High	Project Terminal Report, Progress reports, meetings	As required	Research Director/Research Program Officer
Project Team (Researchers)	Executes the research project	High	Daily updates, regular meetings	Daily/Weekly	Project Leader/Manager
Procurement Unit	Manages the acquisition of goods and services,	Medium	Coordination meetings	As required	Procurement Unit Head

	ensuring optimal cost, quality, and compliance				
Accounting Unit	Oversees project budget and financial resources	Medium	Coordination meetings	As required	Accounting Unit Head
Inspection Unit	Ensures acquired goods and services meet quality standards and contract requirements before acceptance	Medium	Coordination meetings	As required	Inspection Unit Head
Supply Office	Manages inventory and ensures timely distribution of supplies and materials	Medium	Coordination meetings	As required	Supply Office Head

Table 7. Risk Management Plan

Risk	Inherent Rating			Strategies to Reduce Probability	Strategies to Reduce Impact	Residual Rating			Status: Has this risk been controlled?
	Probabi-lity	Impact	PI Rating			Probabi-lity	Impact	PI Rating	
Strength tests may not produce the expected stabilization results	Possible	Minor	Medium	Conduct thorough preliminary studies and pilot tests to refine mix proportions and methods.	Have backup plans and alternative stabilization techniques.	Unlikely	Insignifi-cant	Low	Yes
Negative environme	Possible	Minor	Medium	Conduct initial environme	Use eco-friendly practices	Unlikely	Insignifi-cant	Low	Yes

ntal impact from using lime sludge and rice husk ash				nt-tal assessmen ts and continuous monitoring to ensure complianc e with environme nt-tal standards	during project activities.				
Budget overruns due to unforesee n expenses	Unlikel y	Minor	Mediu m	Develop a detailed budget with contingen-cies.	Regularly review and adjust the budget as needed.	Unlikel y	Insignifi -cant	Low	Yes
Project delays due to technical challenges, supply issues, or environme n-tal factors	Possibl e	Minor	Mediu m	Develop a detailed project schedule with buffer times for critical activities.	Monitor progress regularly and adjust the schedule as needed.	Unlikel y	Insignifi -cant	Low	Yes
Poor quality of strength test results	Unlikel y	Minor	Mediu m	Implement strict quality control procedure s and regular audits.	Use standardiz ed testing methods and validated equipment .	Unlikel y	Insignifi -cant	Low	Yes
Lack of stakeholde r engageme nt or	Unlikel y	Insignifi-cant	Low	Develop a comprehe nd-sive stakeholde r engageme nt plan.	Regularly communi-cate project progress and address	Rare	Insignifi -cant	Low	Yes

support					stakeholder concerns promptly.				
Loss or corruption of project data	Unlikely	Minor	Medium	Use reliable data management systems with regular backups.	Implement access controls to protect data integrity.	Rare	Insignifi-cant	Low	Yes
Stabilized subbase materials may not perform as expected in the long term	Possible	Minor	Medium	Conduct extensive performance monitoring and adjust methods based on findings.	Use conservative estimates for performance expectations.	Unlikely	Insignifi-cant	Low	Yes

4. Conclusion

A project management plan (PMP) for stabilizing road subbases using locally available lime sludge and rice husk ash has been initiated. This PMP outlines a 10-month institutionally-funded project, carried out by a team of three researchers. The project aims to achieve acceptable strengths for the stabilized materials while ensuring positive environmental impact assessments. The goal is to develop rice husk ash-based construction materials that are environmentally-safe for road subbase application.

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