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A Management Plan for an Institutional Research Project on Road Subbase Stabilization with Fly Ash, Lime Sludge and Rice Husk Ash

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Abstract: In chemical stabilization, overdependence on the use of cement and lime keeps soil stabilization costs high and thus, requires a sustainable and cost-effective alternative. Agro-industrial waste by-products are utilized as stabilizers to replace cement and lime. In this work, project management plan (PMP) for the stabilization of road subbases using locally available fly ash, lime sludge and rice husk ash was proposed to assess the feasibility of combination of latter resources in the stabilization of road subbases, with acceptable strengths and positive environmental impact assessments. Here, the PMP is centered on an institutional project based on a state university in Cagayan de Oro City, Philippines. The entire process is composed of literature review, laboratory testing, field application, performance monitoring, environmental and cost analysis, and project terminal report preparation. Lastly, it excludes use of other additives for subbase stabilization, large-scale road construction, long-term maintenance, and stabilization of other infrastructure components.

Keywords: Management Plan, Subbase Stabilization, Fly Ash, Lime Sludge, Rice Husk Ash

Introduction

The stability of civil engineering structures is dependent on the geotechnical properties of soil, and successful pavement design requires quality in both the top layer and the underlying layers like base, subbase, and subgrade [1]. Subbases and bases, made from compacted smaller rocks with gaps, act as structural layers to distribute wheel loads and prevent overstressing the subgrade [2]. Improving the geotechnical properties of these pavement layers through stabilization is vital for conserving construction materials, ensuring proper structure function by treating soils to enhance their strength and durability beyond their original classification [3]

Soil stabilization enhances soil properties, addressing issues such as low bearing capacity, settlement, water permeability, and liquefaction risk [4], which threaten the stability of constructions like roads, buildings, embankments, and foundations. Various soil stabilizing methods, including chemical stabilization, have been developed to mitigate these concerns and ensure the durability and longevity of structures [5].

As to chemical stabilization, over-dependence of cement and lime requires a sustainable alternative; and utilizing industrial and agro-industrial waste by-products as stabilizers has emerged as a proven and effective solution [6]. Among these by-products that could replace cement and lime are lime sludge [1, 6-12], hypo sludge [13-16], rice husk ash [17-20], and fly ash [6-8, 21-25]. The goal is to enhance the strength and durability of the soil that could make it suitable for construction [3].

The fly ash from a coal power plant in Villanueva, Misamis Oriental, Philippines has been tested already by the host and even the neighboring towns for construction purposes [6-8, 26-27]. This fly ash with lime sludge from a sugar mill in Bukidnon, Philippines was tested to stabilize road subbases [6-8]. It resulted increase of the soil strengths (California bearing ratios) with increasing amounts of fly ash [7]. However, the stabilized soils were assessed not environmentally-safe [6].

Therefore, this project management plan (PMP) is seeking to add rice husk ash in the mixture to obtain acceptable strengths, at the same time, lessen the environmental impact. This PMP is designed for an institutionally-funded project whose project team is composed of three members.

Methodology

This project management plan (PMP) is designed for a 10-month duration institutionally-funded project, on the basis of a project team of three members. The PMP is composed of three sections: (1) project charter, (2) management strategy & definition of success and (3) project plan. Here, the project assesses the effectiveness of fly ash, lime sludge, and rice husk ash in stabilizing road subbase materials and enhancing their strength. The entire process is composed of literature review, laboratory testing, field application, performance monitoring, and environmental and cost analysis.

Results and Discussion

Primarily, this PMP seeks to obtain acceptable California bearing ratios (CBR) of stabilized subbase materials and ensure a positive environmental impact. It excludes use of other additives for subbase stabilization, large-scale road construction, long-term maintenance, and stabilization of other infrastructure components. The project management plan (PMP) is presented below.

Project Charter

Background

Chemical stabilization requires cement, lime, asphalt, and even fly ash in the soil treatment; for which cement and lime are the most common stabilizers [28]. Over-dependence on the latter substances keeps soil stabilization costs high, nequiring a sustainable and cost-efficient

alternative. Replacing cement and lime with industrial and agro-industrial waste by-products as stabilizers is a proven and effective solution [6].

Among the by-products used as stabilizers are lime sludge [1, 6-12], hypo sludge [13-16], rice husk ash [17-20], and fly ash [6-8, 21-25]. Utilizing industrial by-products in soil treatment should improve soil properties like bearing capacity, water permeability, and resistance to liquefaction [4]. Enhanced strength and durability make the soil suitable for construction purposes [3]. Improving the geotechnical properties of subbases or bases is vital for the proper function and success of pavement structures [1].

The fly ash from a coal power plant in Villanueva, Misamis Oriental, Philippines, along with lime sludge from a nearby sugar mill in Bukidnon was tested for stabilizing road subbases [6-8], resulting in increased soil strengths [7]. However, environmental safety concerns were evident [6]. To address this, the project aims to incorporate rice husk ash into the mixture to retain strengths while reducing environmental impact.

Project Objectives

The key objectives for this project are:

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

Project Scope

The scope of this project includes:

- Literature review on the use of fly ash, lime sludge and rice husk ash in soil stabilization
- Laboratory testing of different mix proportions and stabilization techniques
- Field application and performance monitoring of stabilized subbase materials
- Analyzing the environmental impact and cost-effectiveness of the proposed stabilization method
- Preparing final terminal report and disseminating project findings to stakeholders

The scope statement is given in details in Section 3.1.

Project Benefits

The benefits of the project include environmental advantages through waste material utilization, potential cost savings in road construction, and improved performance of road subbases. Additionally, researchers involved gain opportunities for professional development in soil stabilization. Successful outcomes provide data for academic publications contributing to civil and materials engineering fields. Skills development and sustainable practices contribute to personal satisfaction and positive impacts on infrastructure and the environment.

Project Risks and Assumptions

Detailed discussion of project risks in Section 3.7, Risk Management Plan. The assumptions include the availability of sufficient fly ash, lime sludge and rice husk ash from local industries, as well as access to well-equipped laboratory and field testing facilities in the university. Cooperation and support from stakeholders are also assumed.

Management Strategy & Definition of Success

This project will be successful if these are met:

- Completion of project deliverables mentioned in Section 3.1.2.
- Total cost of the project not exceeding 360, 000 Php.

Here are the management strategies for achieving the criteria above:

A detailed testing plan will evaluate the strength, with regular reviews to ensure accuracy. Regular performance monitoring and adjustments based on results will optimize the stabilization method. Conduct an initial environmental impact study to establish baseline conditions and identify key parameters for ongoing monitoring. Ensure adherence to environmental regulations, use sustainable practices, and regularly assess the impact of stabilization methods using control sites for comparison. Analyze the data to quantify benefits and prepare detailed reports for stakeholders and regulatory bodies.

Develop documentation system and ensure team training on proper practices. Regularly review and audit project records for completeness and accuracy. Moreover, regularly engage stakeholders with progress meetings and progress reports to keep them informed and address concerns. Actively solicit and incorporate stakeholder feedback to improve the quality and relevance of final report. Present final report in meetings for discussion, and obtain approval from the stakeholders.

Project Plan

Scope Statement

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

- Project Charter (Section 1); and
- Project Assumptions (Section 1.5)

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		<ol style="list-style-type: none"> 1. Assess the suitability of fly ash, lime sludge and rice husk ash for soil stabilization based on their chemical composition, particle size distribution, and reactivity with soil constituents. 2. Ensure compatibility between the stabilizing agents (fly ash, lime sludge and rice husk ash) and the soil matrix to achieve desired engineering properties.
Mix Design Optimization		<ol style="list-style-type: none"> 1. Conduct laboratory tests to determine the optimal mix proportions of fly ash, lime sludge, rice husk ash, and soil for achieving target performance criteria such as strength, durability, and permeability.

		2. Consider factors such as soil type, moisture content, curing conditions, and long-term performance when designing the stabilized soil mixtures.
Environmental Assessment	Impact	1. Evaluate the potential environmental impact of using fly ash, lime sludge and rice husk ash for soil stabilization, including concerns related to leaching of contaminants, groundwater pollution, and ecosystem disruption. 2. Implement mitigation measures to minimize environmental risks, such as proper disposal of unused materials, containment of runoff water, and monitoring of groundwater quality.
Performance Monitoring and Evaluation		1. Develop a comprehensive monitoring plan to assess the short-term and long-term performance of stabilized subbase materials under actual field conditions. 2. Evaluate the performance of the stabilized materials in terms of load-bearing capacity, pavement distress, moisture content, and drainage characteristics.
Data Management and Documentation		1. Develop an efficient data management system to record and track project activities, laboratory test results, field observations, and performance data. 2. Maintain detailed documentation of all project-related information, including design specifications, construction procedures, quality assurance records, and environmental assessments.
Safety Protocols and Compliance		1. Establish safety guidelines and protocols for handling, storing, and applying fly ash, lime sludge, rice husk ash, and other materials. 2. Ensure compliance with relevant regulatory requirements, industry standards, and permitting procedures governing the use of stabilized soil mixtures in road construction projects.

Project Scope Description

This project aims to assess the effectiveness of fly ash, lime sludge and rice husk ash in stabilizing road subbase materials, enhancing their strengths. It seeks to promote sustainable infrastructure development by utilizing these industrial by-products. This includes a comprehensive literature review, laboratory testing, field application, performance monitoring, environmental and cost analysis. Additionally, the project involves detailed reporting and dissemination of findings. Further, the technical requirements listed in Table 1 shall be included as well.

Project Deliverables

- Literature Review Report
- Preliminary Study Report
- Laboratory Test Results

- Mix Designs
- Field Application Report
- Performance Monitoring Report
- Environmental and Cost Analysis Report
- Final Project Terminal Report

Acceptance Criteria

- Improvement 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 terminal report and findings by stakeholders

Project Exclusions

- The project will not cover the stabilization of road subbase materials with additives other than fly ash, lime sludge and rice husk ash.
- The project does not include large-scale road construction or long-term maintenance activities beyond the specified monitoring period.
- The project will not address the stabilization of other infrastructure components such as foundations or embankments.

Work Breakdown Structure

The project for fly ash (FA)/lime sludge (LS)/rice husk ash (RHA) stabilized road subbases has five (5) main activities as shown in Fig. 1 below. These activities include literature review and preliminary studies, laboratory testing and mix design, field application and monitoring, data analysis and report writing and results dissemination. Each of these activities has corresponding work packages to deliver, including a literature review report, preliminary study report, laboratory test results, mix designs, field application report, performance monitoring report, environmental and cost analysis report, and final project terminal report.

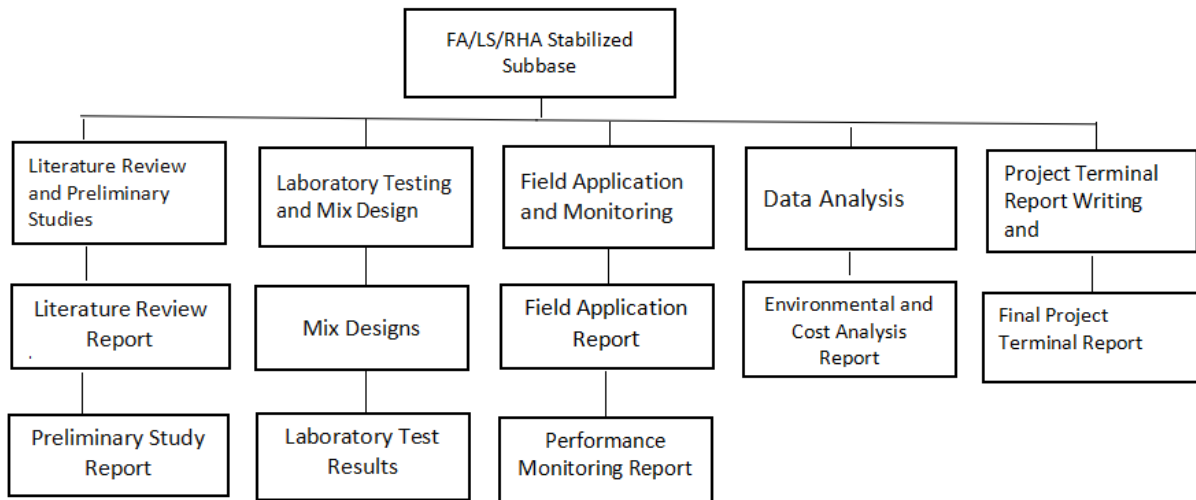


Fig. 1. Work Breakdown Structure

Project Budget Overview

The institutional project is designed to have a duration of 10 months and to be executed by a team composed of three. Table 2 shows budget for conducting all the activities to complete the project in the desired duration. The overall budget is 360,000 Php. This means that the total actual cost of implementing the project should not exceed to the latter amount, as indicated in Section 2 (Management Strategy & Definition of Success).

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	212,000
Representation Expenses	5,000
Contingency	10,000
Sub-Total	250,000
Grand Total	360,000

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. Then lab testing and mix design follow and shall take for two months. It is also observed that field application and monitoring would be completed in five months. After this, data analysis and report writing and then results dissemination, which shall be completed both in one month.

Table 3. Summary of Project Schedule

Activity	Activity Name	% Complete	Duration (Months)
1	Literature Review and Preliminary Studies	100%	1
2	Laboratory Testing and Mix Design	100%	2
3	Field Application and Monitoring	100%	5
4	Data Analysis	100%	1
5	Project Terminal Report Writing and Dissemination of Findings	100%	1

Project Schedule Gantt Chart

Fig. 2 below shows the gantt chart for the 10-month duration project. It can be shown that the five main activities stipulated in Table 3 above can be done specifically in twelve specific tasks/activities.

Subbase course soils are randomly selected based on the recommendations of the Department of Public Works and Highways (DPWH) of the Philippines. 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 $100\pm 10^{\circ}\text{C}$ for 24 hours.

Fly ash, 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, fly ash, 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. Once the soil aggregate, fly ash, 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.

Activities	Month									
	1	2	3	4	5	6	7	8	9	10
1. Conduct a comprehensive literature review.	■									
2. Prepare a preliminary study report.	■									
3. Design various mix proportions.		■								
4. Conduct laboratory tests to evaluate mix performance.		■	■							
5. Document laboratory test results.		■	■							
6. Field work				■	■	■	■	■		
7. Monitor the performance of stabilized materials.				■	■	■	■	■		
8. Document field application procedures and observations.				■	■	■	■	■		
9. Analyze data from laboratory and field tests.									■	
10. Prepare environmental and cost analyses reports.									■	
11. Prepare project terminal report.										■
12. Disseminate results to stakeholders.										■

Fig. 2 Project Schedule Gantt Chart

Project Network Diagram

The network starts with literature review report that could be basis for conduct of preliminary studies for the mix design formulations and the conduct of lab tests. After these, there would be field application procedures and performance monitoring of stabilized subbase materials. Moreover, there's analysis of data from laboratory and field tests. There is also preparation of comprehensive terminal report on findings and analyses. After that, presentation and

dissemination of results to stakeholders are necessary. Recommendations are considered to be incorporated in the final research paper for publication purposes. This is shown in Table 4 below. The corresponding network diagram for Table 4 above is shown in Fig. 3 below.

Table 4. Network Information

Activity	Description	Preceding Activity
A	Literature Review Report	None
B	Preliminary Study Report	A
C	Mix Designs	B
D	Laboratory Test Results	B
E	Field Application Report	C,D
F	Performance Monitoring Report	C,D
G	Environmental and Cost Analysis Report	E,F
H	Final Project Terminal Report	G

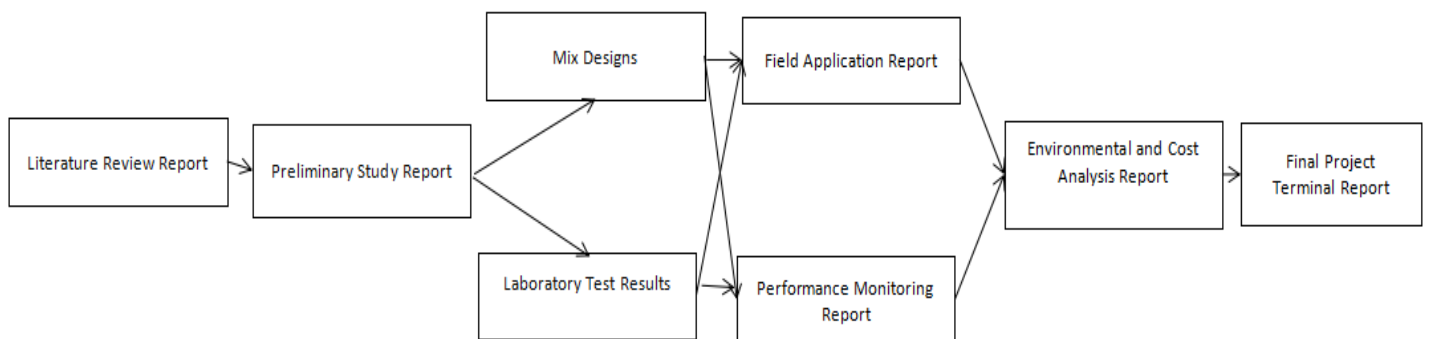


Fig. 3. Network Diagram

Human Resource (HR) Roles and Responsibilities

Organizational Structure

At the University of Science and Technology of Southern Philippines (USTP), a state-owned university in Cagayan de Oro City, Philippines, a research team composed of three has project leader/manager that leads the drafting of institutional proposal in coordination with the Research Program Officer at the Research Office. If everything is in order, proposal is endorsed by the Research Director. Moreover, the Vice Chancellor for Research and Innovation recommends its approval after the Head of the Accounting Office signifies the available of funds. Finally, the Chancellor approves it. See Fig. 4 below.



Fig. 4. Organizational Structure

RACI Matrix

According to Table 5 below, the project team that is led by the leader/manager is responsible for the conduct of research and the execution of the institutionally-funded research project. The specific activities and deliverables are stipulated in the table. This execution is normally in coordination with the external suppliers, Research Program Officer, Research Director, and other units of the university such as the Procurement, Accounting, Inspection and Supply units.

Table 5. RACI Matrix

Activity	Work Package	Responsible (R)	Accountable (A)	Consulted (C)	Informed (I)
1. Literature Review and Preliminary Studies	Literature Review Report	Project Members	Project Leader/Manager	Project Leader/Manager	Research Program Officer
	Preliminary Study Report	Project Members	Project Leader/Manager	Project Leader/Manager	Research Program Officer
2. Laboratory Testing and Mix Design	Mix Designs	Project Members	Project Leader/Manager	Project Leader/Manager	Research Program Officer
	Laboratory Test Results	Project Members	Project Leader/Manager	External Supplier/s, Accounting, Procurement, Inspection and Supply Units	Research Program Officer
3. Field Application and Monitoring	Field Application Report	Project Members	Project Leader/Manager	Project Leader/Manager	Research Program Officer
	Performance Monitoring Report	Project Members	Project Leader/Manager	Project Leader/Manager	Research Program Officer
4. Data Analysis	Environmental and Cost Analysis Report	Project Members	Project Leader/Manager	Project Leader/Manager	Research Program Officer
5. Project Terminal Report Writing and Dissemination of Findings	Final Project Terminal Report	Project Members	Project Leader/Manager	Research Program Officer	Research Director

Stakeholder Management and Communication Plan

The project leader/manager is responsible for executing the research project and ensuring that the project objectives are accomplished. The team may meet regularly or daily for the project. The team needs to coordinate the Research Office thru the Research Program Officer and Research Director concerned and give update on matters related to the implementation of the research. As such, the team is expected to submit progress reports to the office, and the final

project terminal report if the project gets completed. As the need arises, the members of the team also are encouraged to have coordination meetings with other concerned stakeholders such as the Procurement Unit, Inspection Unit and Accounting Unit especially on matters related to supplies, services and materials procurement. They could also schedule consultation meetings with the Chancellor and Vice Chancellor for Research and Innovation as maybe required, or if there are serious financial issues that need to be addressed. This is shown in Table 6 below.

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, ensuring optimal cost, quality, and compliance	Medium	Coordination meetings	As required	Procurement Unit Head
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

Risk Management Plan

Table 7 shows the risk management plan for this project. Technical risks involve the possibility that laboratory and field tests may not yield the expected stabilization results. The team shall conduct thorough preliminary studies and pilot tests, refine mix proportions, and have backup plans and alternative stabilization techniques. Environmental risks come from potential negative impacts of using fly ash, lime sludge and rice husk ash, which can be mitigated through initial environmental assessments and continuous monitoring to ensure compliance with standards, along with employing eco-friendly practices.

Financial risks like budget overruns are addressed by developing a detailed budget with contingencies and regularly reviewing it. Schedule risks, such as project delays, are mitigated by creating a detailed schedule with buffer times and monitoring progress. Quality risks are countered by implementing strict quality control procedures, and stakeholder risks are mitigated through a comprehensive engagement plan. Health and safety risks, data management risks, performance risks, weather risks, and legal risks are addressed by implementing appropriate protocols, using reliable systems, conducting extensive monitoring, planning for weather contingencies, and ensuring compliance with legal requirements.

Table 7. Risk Management Plan

Risk	Inherent Rating			Strategies to Reduce Probability	Strategies to Reduce Impact	Residual Rating			Status: Has this risk been controlled?
	Probability	Impact	PI Rating			Probability	Impact	PI Rating	
Laboratory and field 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	Insignificant	Low	Yes
Negative environmental impact from using fly ash and rice husk ash	Possible	Minor	Medium	Conduct initial environmental assessments and continuous monitoring to ensure compliance with environmental standards.	Use eco-friendly practices during project activities.	Unlikely	Insignificant	Low	Yes
Budget overruns due to unforeseen expenses	Unlikely	Minor	Medium	Develop a detailed budget with contingencies.	Regularly review and adjust the budget as needed.	Unlikely	Insignificant	Low	Yes
Project delays due to technical challenges, supply issues, or environmental factors	Possible	Minor	Medium	Develop a detailed project schedule with buffer times for critical activities.	Monitor progress regularly and adjust the schedule as needed.	Unlikely	Insignificant	Low	Yes
Poor quality of laboratory and field test results	Unlikely	Minor	Medium	Implement strict quality control procedures and regular audits.	Use standardized testing methods and validated equipment.	Unlikely	Insignificant	Low	Yes

Lack of stakeholder engagement or support	Unlikely	Insignificant	Low	Develop a comprehensive stakeholder engagement plan.	Regularly communicate project progress and address stakeholder concerns promptly.	Rare	Insignificant	Low	Yes
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	Insignificant	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	Insignificant	Low	Yes

Conclusion

This work proposed a project management plan (PMP) for the stabilization of road subbases using locally available fly ash, lime sludge and rice husk ash. The PMP is designed for a 10-month duration institutionally-funded project with research team composed of three members. The project includes literature review and preliminary studies, laboratory testing and mix design, field application and monitoring, data analysis and report writing and results dissemination. Research publications and presentations may be given emphasis in the project as well. The project further seeks to obtain acceptable strengths for the stabilized materials while resulting to positive environmental impact assessments. Fly ash-based construction materials are aimed to be environmentally-safe to be used for construction application.

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