National University of Sciences and Technology

H-12, Islamabad, Pakistan, Phone: (051) 9085 6226 Fax: (051) 90856222

E-mail: adproj@nust.edu.pk

PROJECT Thesis

1. Project Brief

a. Project Title: Investigating the effectiveness of unique bitumen emulsion formulated by means of waste materials to stabilize the expansive soil

b. Lead Institution: **NUST Balochistan Campus**

c. Duration of Project: **1 years**

d. Total budget required: **0.5 million (PKR)**

e. Name of PI: **Adham Alnadish**

(1) Designation: Assistant Professor

(2) Date of Joining NUST: 06-07-2023

(3) Email Address: adham@nbc.nust.edu.pk

f. Name of Co-PI: Dr Salah Ud Din

(1) Designation: Hod Civil engineering department

g. Name of the project members

1) Muhammad Haroon
2) Mahad Ahmed
3) Abdul Wadood
4) Zaryab khan

2. Brief Description of Project:

Expansive soils are considered a special type of clay soils, as they show significant swelling and shrinkage deformations with changes in the content of soil moisture. The change in the volume of the expansive soil due to the moisture content leads to serious damages to concrete structures. It is documented that about 50% of Punjab province area is covered by the expansive soils. However, stabilizing expansive soil by means of bitumen emulsion is one of the well-known effective approaches.

On the other hand, the use of waste materials i.e. waste engine oil and scrap tires is considered as one of the lofty goals towards environmental sustainability. Globally, more than 1 billion of scrap tires is generated. While the annual production of plastic waste is approximately 400 million metric tons .In addition, the annual production of waste engine oil is 24 million tons worldwide. Therefore, this project is aimed to develop a unique bituminous emulsion through modifying base bitumen with waste engine oil and plastic waste. Another objective of this project is to modify the expansive soil with scrap tires. Thus, this project will provide unique and affordable solutions to overcoming the issues of expansive soil and contributing to environmental sustainability.

3. Relevant SDG Area: (List at least 1 SDG and describe the application)

This project aims to achieve some environmental sustainability goals, including climate change (SDG 13) and Industry, Innovation, and Infrastructure (SDG 9).

- **Goal 13: Climate Action-** Take urgent action to combat climate change and its impacts

The formulation of base bitumen with waste materials such as plastic waste and waste engine oil can contribute significantly to achieving SDG 13. This is because modifying base bitumen with plastic waste and waste engine oil will contribute towards environmental sustainability through utilizing these waste materials in engineering project, which in turn will decrease the quantity of these materials in landfill.

- **SDG 9: Industry, Innovation, and Infrastructure** - Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation.

Developing a bitumen emulsion by utilizing waste materials will contribute to achieving SDG 9. This is because the use of waste materials will significantly decrease the cost of bitumen emulsion. Additionally, stabilizing the expansive soil with waste materials-formulated emulsion will introduce significant enhancement in the performance of expansive soil. This in turn will significantly extend the service life of concrete structures built on expansive soil.

4. Background / Literature Review:

Expansive soil is considered a serious issue that negatively affects the foundations of concrete structures. However, several methods can be utilized to stabilize the expansive soil. Stabilizing expansive soil by means of bitumen emulsion is one of the well-known effective approaches. Thajeel et al. [1], investigated stabilizing the expansive soil with bitumen emulsion. In the study, the expansive soil was stabilized with different percentages of bitumen emulsion i.e. 2-10% in 2% increment. The authors found that stabilizing the expansive soil at the proportion of 10% significantly decreased swelling pressure and swelling potential. In another study

conducted by Syed et al. [2], the expansive soil was stabilized with Alkali-Activated Binder and Cement. The findings of the study demonstrated that the strength of the stabilized subgrade significantly improved by about 23%. Fard et al. [3] studied the effect of stabilizing the soil by means of bitumen emulsion and waste Polypropylene Fibers. The proportions of the bitumen emulsion were 0, 5, 10, 15, 20% by weight of the soil, while the dosages of the waste polypropylene fibers were 0, 0.25, 0.5, 0.75, and 1%. The stabilized soil was evaluated in terms of California load-bearing capacity and uniaxial compressive strength. The researchers found that stabilizing the soil with bitumen emulsion and waste polypropylene fibers at the proportion of 15% and 1% significantly enhanced the bearing capacity and uniaxial compressive strength of the stabilized soil.

On the other hand, it is documented that stabilizing the expansive soil with scrap tires significantly improves the performance of the expansive soil. Lu et al. [4] evaluated the potential use of scrap tires in terms of stabilizing the expansive soil. In their study, different dosages of crumb rubber has been added to the expansive soil i.e. 0%, 1%, 3%, 6%, 10%, 15% and 25% by weight of the soil. The study findings illustrated stabilizing the expansive soil with 10% of crumb rubber enhanced the stress-strain response, volume change, unconfined compression strength, resilient modulus, and strain at failure of the expansive soil. In another study done by Elhakim et al. [5], the expansive soil was stabilized with different contents of scrap tires i.e. 5, 10, 15% by weight of the soil. The authors found that at the proportion of 10% the swelling potential and unconfined compressive strength of the expansive soil significantly improved. Yang et al. [6] observed that stabilizing the expansive soil with 20% of scrap tires significantly enhanced dynamic triaxial, California load ratio, unconfined compression, direct shear, and consolidation of the expansive soil.

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5. Problem Statement:

Punjab is one of the largest provinces in Pakistan, which suffer from the existence of expansive soil [7]. It is known that expansive soil poses a real concern to the foundations of construction structures. This is because when expansive soil is exposed to water, it swells while shrinking when it dries, and this in turn leads to the generation of critical stresses on the foundations, which may lead to the collapse of concrete structures.

On the other hand, waste materials have become a real threat to environmental sustainability due to the steady increase in the production of the waste materials. Scrap tires, plastic waste, and waste engine oil are among the most important wastes that are generated in abundance, making them a major challenge to environmental sustainability. It is reported that the global annual production of scrap tires, plastic waste, and waste engine oil is 1 billion, 40 million, and 24 million tons, respectively [8-10]. Therefore, the use of these waste materials in engineering projects is considered a lofty goal to achieve environmental sustainability.

6. Objectives of the project:

This project aims to achieve the following objectives:

1. **Formulation of bitumen emulsion by means of waste engine oil:** The base bitumen will be modified with different dosages of waste engine oil i.e. 60, 70, and 80% by weight of bitumen. The formulated emulsion will be evaluated in terms of softening point and penetration tests in order to identify the optimum content.
2. **Modifying of formulated emulsion by means of plastic waste:** The formulated emulsion will be further modified with different proportions of plastic waste i.e. 3, 6, 9% by weight of formulated emulsion. The modified formulated emulsion will be evaluated using the tests of penetration and softening point to determine the optimum content.
3. **Stabilizing the expansive soil by the formulated bitumen emulsion:** The expansive soil will be stabilized by different content of the formulated emulsion i.e. 4, 6, and 8% by weight of the soil. The performance of the stabilized soil will be studied in terms of Atterberg limits, CBR, and shear strength.
4. **Stabilizing the expansive soil by means of scrap tires:** The stabilized expansive soil with formulated emulsion will be further modified with scrap tires at the proportions of 2, 4, and 6% by weight of the soil to ensure the superior performance. The performance of the stabilized soil will be studied in terms of Atterberg limits, CBR, and shear strength. .

8. List of Outcomes / Goals of the Project:

The outputs of this project are listed as follows:

Formulation of bitumen emulsion: This project is aimed to introduce a cost-effective of bitumen emulsion incorporated waste materials as a novel contribution in terms of overcoming the issues related to the expansive soil by stabilizing the expansive soil with the formulated emulsion consisting of waste engine oil and plastic waste .

Stabilizing the expansive soil with scrap tires: Another important output of this project is to enhance the performance of the expansive soil by stabilizing the soil with scrap tires. The addition of scrap tires to the expansive soil will significantly decrease the water absorption of expansive soil, which in turn will improve the performance of the expansive soil.

Enhanced Efficiency and Cost Savings: formulation of bitumen emulsion with waste engine oil and plastic waste will significantly decrease the cost of bitumen emulsion. It is expected that the optimum content of waste engine oil will be 70-80% by weight of the bitumen. Thus, the cost of bitumen emulsion will be dramatically decreased, and this is what makes waste-modified bitumen emulsion the focus of attention of industries. Furthermore, the addition of scrap tires to the expansive soil will further enhance the performance of expansive soil.

9. Major Milestones of the Project:

The milestones of the project involve several stages as follows:

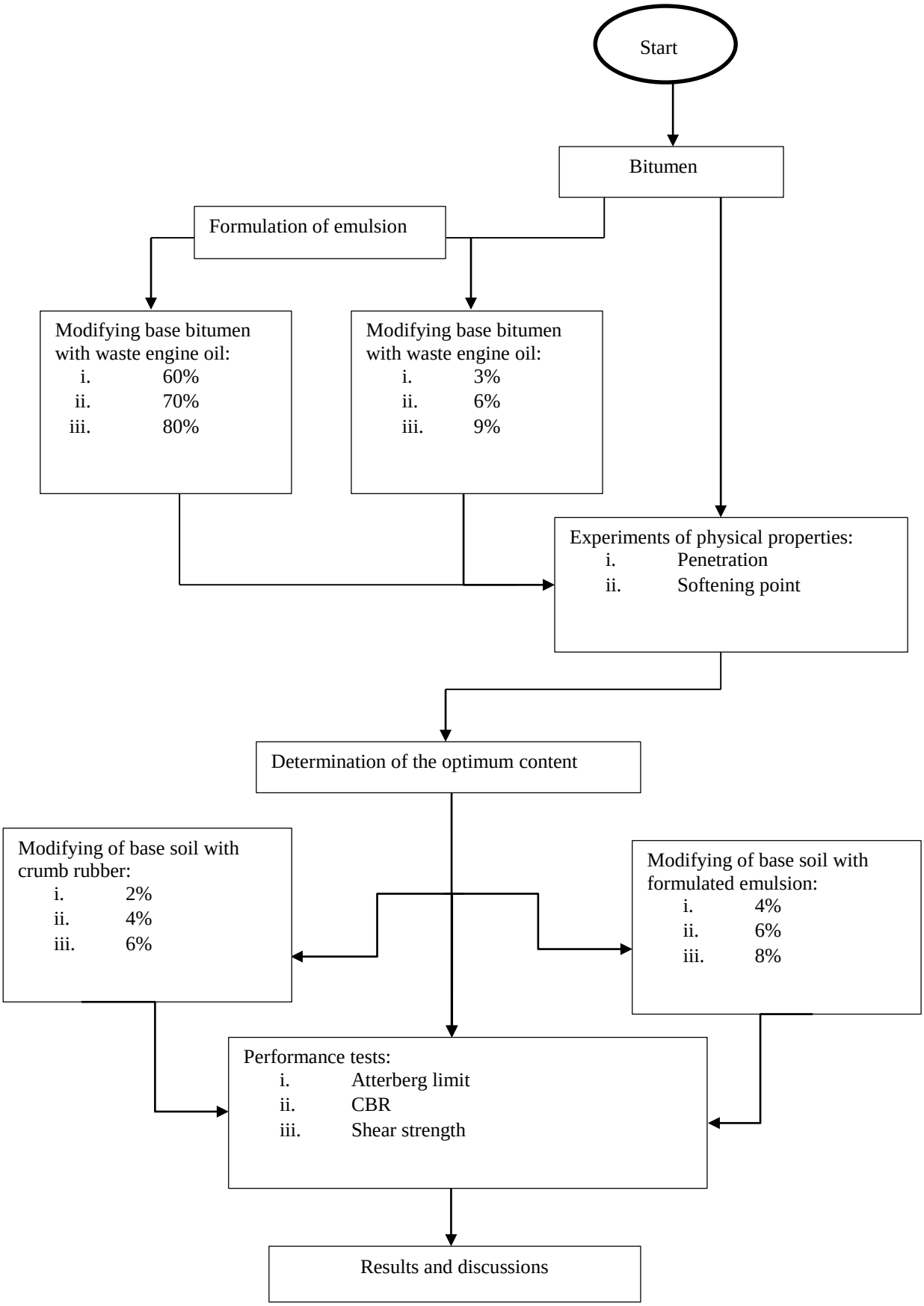
1. **Collecting of the materials:** The first stage of this project will start by collecting the waste materials that will be used in the project such as plastic waste, waste engine oil, and scrap tires. In addition, an expansive soil will be collected from the province

of Punjab and from some place of the Balochistan (i.g spin karez dam Quetta)to conduct the study.

2. **Preparation of the bitumen emulsion and conduct the experiments:** In the second stage of this project, modifying the base bitumen with waste engine oil and plastic waste will be done to formulate the bitumen emulsion. Moreover, the physical tests of penetration and softening point will be conducted to identify the optimum content.
3. **Stabilizing the expansive soil with the formulated bitumen emulsion:** In this stage, the expansive soil will be stabilized with the formulated emulsion. However, the efficiency of formulated emulsion in terms of enhancing the performance of the expansive soil will be examined through the tests of Atterberg limits, CBR, and shear strength of the soil.
4. **Stabilizing the expansive soil with scrap tires:** In this stage, the stabilized soil with the formulated emulsion will be further stabilized with scrap tires to enhance the performance of the expansive soil. However, the effectiveness of adding scrap tires to the expansive soil will be evaluated using the experiments of Atterberg limits, CBR, and shear strength of the soil.
5. **Deployment and Training:** Deploy the formulated emulsion on soil investigation and construction services and provide comprehensive training to engineers on how to effectively use the formulated bitumen and scrap tires in the expansive soil.

10. Methodology:

Figure below shows the flow chart of the project. As it is shown in the figure, the project will start by collecting the materials such as plastic waste, waste engine oil, and scrap tires. Thereafter, the formulated emulsion will be developed by modifying the base bitumen with different proportions of waste engine oil i.e. 60, 70, and 80% by weight of the bitumen. Furthermore, the formulated emulsion with waste engine oil will be further modified with plastic waste at the dosages of 3, 6, and 9% by weight of the formulated emulsion. The optimum content of the waste engine oil and plastic waste will be identified through the tests of penetration and softening point. Afterwards, the expansive soil will be stabilized with formulated emulsion by introducing the emulsion at the proportions of 4, 6, and 8% by weight of the expansive soil. The modified expansive soil with the formulated emulsion will be evaluated through the experiments of Atterberg limits, CBR, and shear strength to identify the optimum content of emulsion that produce a superior performance. Thereafter, the stabilized expansive soil with the formulated emulsion will be further stabilized with scrap tires at the contents of 2, 4, 6% by weight of the soil. However, the performance tests that will be conducted to study the effect of adding scrap tires on the behavior of expansive soil will be Atterberg limits, CBR, and shear strength.


Start
Bitumen
Formulation of emulsion
Modifying base bitumen with waste engine oil:
i. 60%
ii. 70%
iii. 80%
Modifying base bitumen with waste engine oil:
i. 3%
ii. 6%
iii. 9%
Experiments of physical properties:
i. Penetration
ii. Softening point
Determination of the optimum content
Modifying of base soil with crumb rubber:
i. 2%
ii. 4%
iii. 6%
Modifying of base soil with formulated emulsion:
i. 4%
ii. 6%
iii. 8%
Performance tests:
i. Atterberg limit
ii. CBR
iii. Shear strength
Results and discussions

11. Detailed Plan of the Project for 1st Year

Activity	Objective/s	Duration
Collection of materials	Collecting the waste materials of plastic waste, waste engine oil, and scrap tires. In addition, collecting the expansive soil from Punjab.	1 Month
Preparation the formulated bitumen emulsion and conducting the physical tests	Prepare the bitumen emulsion by modifying the base bitumen with different percentages of waste engine oil and plastic waste. Conducting the experiments of penetration and softening point to determine the optimum content	2 Months
Stabilizing the expansive soil by the formulated emulsion	Modifying the expansive soil with different proportion of the formulated bitumen emulsion. Conducting the laboratory tests of Atterberg limits, CBR, and shear strength of soil to study the performance of the expansive soil stabilized with the formulated bitumen	3 months
Stabilizing the expansive soil by the scrap tires	Amending the stabilized expansive soil with the formulated emulsion with different dosages of scrap tires. Conducting the laboratory tests of Atterberg limits, CBR, and shear strength of soil to study the performance of the expansive soil stabilized with the formulated bitumen	3 months
Data Analysis	Analyzing and discussing the obtained results from lab in the form of report.	1 months
Deployment and Training	Deploy the formulated emulsion on soil investigation and construction services and provide comprehensive training to engineers on how to effectively use the formulated bitumen and scrap tires in the expansive soil.	2 months

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