

Optimization of Biomedical Waste Ash in Subgrade Soil for Sustainable Road Pavement Construction

Khan Noorfatima Irfan¹, Shaikh Sabiya Sadik², Prof. Sagar Shinde³, Prof. Gaurav Ahire⁴,
Prof. Prashant Chavan⁵

Student, Department of Civil Engineering^{1,2}

Lecturer, Department of Civil Engineering^{3,4}

Head of Department, Department of Civil Engineering⁴

Guru Gobind Singh Polytechnic, Nashik, Maharashtra, India

Abstract: *The rapid increase in biomedical waste generation due to the expansion of healthcare facilities has created significant environmental challenges, particularly in its safe disposal. Incineration of biomedical waste produces ash, which requires effective utilization to prevent environmental hazards. This study investigates the potential use of biomedical waste ash (BMWA) as a stabilizing material in road pavement construction, specifically in subgrade soil.*

In this research, biomedical waste ash is mixed with locally available soil in varying proportions to evaluate its effect on engineering properties. Laboratory tests such as California Bearing Ratio (CBR), Standard Proctor Compaction Test, and Unconfined Compressive Strength (UCS) test are conducted to determine the strength characteristics of the modified soil. The results indicate that the inclusion of biomedical waste ash improves the bearing capacity and stability of the soil up to an optimum percentage.

The study highlights that the use of biomedical waste ash in pavement construction not only enhances soil properties but also provides an eco-friendly solution for waste disposal. This approach reduces dependency on conventional materials and promotes sustainable infrastructure development. Therefore, biomedical waste ash can be effectively utilized in subgrade stabilization with proper treatment and quality control measures..

Keywords: *Biomedical Waste Ash, Subgrade Soil, Road Pavement, Soil Stabilization, California Bearing Ratio, Sustainable Construction, Waste Utilization, Environmental Engineering*

I. INTRODUCTION

Road infrastructure plays a vital role in economic development, and the performance of pavements largely depends on the strength of subgrade soil. Weak subgrade leads to pavement failure, cracks, and increased maintenance costs.

Traditionally, materials like lime, cement, and fly ash are used for soil stabilization; however, these materials can be expensive and not environmentally sustainable.

At the same time, biomedical waste generation has increased significantly due to the growth of hospitals and healthcare facilities. Improper disposal of biomedical waste poses serious environmental and health risks. Incineration is a common disposal method, which produces biomedical waste ash as a by-product.

Utilizing biomedical waste ash in road construction can serve as a dual solution by improving soil properties and reducing environmental pollution. This study focuses on evaluating the effectiveness of biomedical waste ash in stabilizing subgrade soil for pavement construction.



II. PROBLEM STATEMENT

In modern road construction, the performance and durability of pavement structures largely depend on the strength and stability of subgrade soil. However, in many regions, locally available soil is weak, highly compressible, and exhibits low load-bearing capacity. Such soils are not suitable for supporting heavy traffic loads, leading to problems like excessive settlement, cracking, rutting, and early failure of pavements. This results in increased maintenance cost and reduced service life of roads.

At the same time, the rapid growth of healthcare facilities has led to a significant increase in biomedical waste generation. The disposal of this waste is a major environmental challenge. Incineration is commonly used to treat biomedical waste, but it produces a large quantity of ash as a by-product. This biomedical waste ash is often dumped in landfills, which can cause soil contamination, groundwater pollution, and health hazards.

Despite the availability of various soil stabilization techniques, many of them are costly and not environmentally sustainable. There is a growing need for alternative materials that are economical, eco-friendly, and easily available.

In this context, the utilization of biomedical waste ash as a stabilizing material presents a promising solution. However, the optimum percentage of ash required to achieve maximum improvement in soil properties is not clearly established. Excessive use may adversely affect soil behavior, while insufficient use may not provide the desired strength.

Therefore, this study aims to investigate the effect of biomedical waste ash on subgrade soil properties and to determine the optimum proportion that enhances strength, improves durability, and supports sustainable road pavement construction while reducing environmental pollution.

III. METHODOLOGY

The methodology adopted in this study involves a systematic experimental approach to evaluate the effect of biomedical waste ash on the engineering properties of subgrade soil.

1. Collection of Materials

The subgrade soil used in this study is collected from a local site and air-dried before testing. Biomedical waste ash is obtained from an incineration process at a healthcare facility. The collected ash is sieved to remove impurities and larger particles to ensure uniformity.

2. Preliminary Tests on Soil

Before stabilization, the basic properties of natural soil are determined by conducting the following tests: Natural moisture content

Specific gravity

Grain size distribution

Atterberg limits (Liquid limit and Plastic limit)

These tests help in classifying the soil and understanding its behavior

IV. CONCLUSION

From the experimental investigation, it can be concluded that biomedical waste ash is an effective stabilizing material for subgrade soil.

The addition of ash improves compaction characteristics and significantly increases CBR value. An optimum percentage of around 10% to 15% provides maximum strength and durability.

The use of biomedical waste ash not only enhances soil properties but also helps in reducing environmental pollution. Therefore, it is a sustainable and eco-friendly solution for road pavement construction

It is observed that the strength of soil increases up to an optimum percentage of approximately 10% to 15% of biomedical waste ash.

Beyond this limit, the strength tends to decrease due to excess ash content, which reduces the cohesion between soil particles. Therefore, the selection of optimum percentage is very important for achieving maximum efficiency.



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In addition to improving soil properties, the use of biomedical waste ash also helps in reducing environmental pollution caused by

improper disposal of medical waste. This approach promotes sustainable development by converting waste material into a useful construction resources.

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