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STABILIZATION OF EXPANSIVE SOIL USING INCINERATED WASTE ASH

Chethan K*[1], Mariyam Aleena Mahin [1], Faiz Ummaithanakam[1], Salman Musthafa T. P.[1], Abdul Hadi V. T.[1]

[1]Department of Civil Engineering, P. A. College of Engineering, Mangaluru, Karnataka, India.

Email: chethan.civil@pace.edu.in

Abstract:

Expansive soils pose significant challenges in geotechnical engineering due to their high swelling potential and low bearing capacity. This study investigates the effectiveness of utilizing incinerator hospital waste ash (IHWA) as a sustainable stabilizing agent for expansive soils. The IHWA, a byproduct of hospital waste incineration, is rich in pozzolanic materials and possesses potential for soil stabilization applications. In the present study, a biomedical waste incinerator ash and lime combination was proposed to stabilize expansive soil. Particle size analysis, Atterberg limits, free-swell, compaction, unconfined compression strength, and California bearing ratio tests were conducted on the natural soil and blended with The weak soil mixed with different percentage of IHWA with different percentage of 2.5%, 5%, 10%, 12.5% and 15%. Liquid limit test, Plastic limit test, Standard proctor test were conducted on soil stabilization. Finally, the index properties and Compaction values of soil to be improved.

Keywords: Expansive soil, Stabilization, Incinerator hospital waste ash (IHWA), Engineering properties, Sustainable construction

1. INTRODUCTION

Hospital waste, which includes needles, tubes, blades, bottles, and other plastic materials, poses significant risks for infection spread and environmental pollution. The incineration of this waste releases toxic gases like CO, CO_2, NO_2, and SO_2, as well as dioxins, and produces ash residues (bottom ash and fly ash) that contain heavy metals and other hazardous substances. Bottom ash remains inside the incinerator, while fly ash collects on post-burner equipment, both contributing to environmental contamination [1-3]. When melted at 1200°C, incinerated ash forms a molten state and cools into slag, but metals are not destroyed and can be released into the environment. Healthcare activities generate various

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hazardous wastes, including sharps, human tissues, and infectious materials, with the volume increasing due to more disposable products. This waste has a high potential for causing infection and injury, and improper management can lead to significant pollution of soil, water, and air, adversely affecting humans, animals, and plants. Effective waste management, including segregation, proper treatment, and sustainable disposal methods, is crucial to mitigate these risks and protect public health and the environment [4-6].

Biomedical waste encompasses any solid, fluid, or liquid waste, including containers and intermediate products, generated during the diagnosis, treatment, or immunization of humans or animals, as well as from research activities or the production or testing of biological products. Hospital wastes vary and include infectious, radioactive, chemical, heavy metals, and regular municipal wastes. Biomedical waste is categorized based on the risk of causing injury or infection during handling and disposal, with particular precautions required for sharps (like needles and scalpel blades), pathological wastes (such as anatomical body parts, microbiology cultures, and blood samples), and infectious wastes (including items contaminated with body fluids, dressings, catheters, and IV lines). Additionally, healthcare settings generate radioactive wastes, mercury-containing instruments, and polyvinyl chloride (PVC) plastics, which are among the most environmentally sensitive by-products. According to the World Health Organization, 85% of hospital waste is non-hazardous, about 10% is infectious, and around 5% is non-infectious hazardous waste. In India, about 15% to 35% of hospital waste is regulated as infectious waste [7].

2. LITERATURE REVIEW

Bhavya (2015) [1] reported the improvement in the strength of a cohesive soil collected fromarea in the vicinity of Renigunta Airport, India by addition of Municipal Solid Waste (MSW) incinerator ash as a soil stabilizing agent. Grain size distribution, specific gravity, Atterberg limits, maximum dry unit weight, optimum moisture content (OMC), UCS, CBR, free swell index (FSI) tests were performed on the soil sample. They used 0 to 50% of ash to stabilize the soil. The optimum bottom ash content was found at 25% considering the unconfined compressive strength of treated soil. The UCS value increased to 53.4 kPa and CBR value increased to 9.38 by addition of 25% ash. Taha (2006) presented the use of

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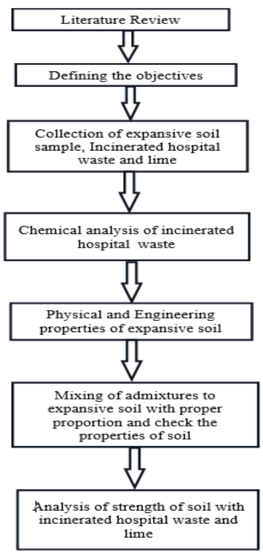
incinerator ash in stabilizing desert sands for possible use in geotechnical engineering applications. The incinerator ash was added in percentages of 2, 4, 8, 10, and 12%, by dry weight of sand. Laboratory tests such as compaction, unconfined compression, shear box and hydraulicconductivity were performed to measure the engineering characteristics of the stabilized material. The results showed substantial improvements in unconfined compressive strength and shear strength parameters (c and u). Thus, incinerator ash can be used to improve the shear strength characteristics of desert sands. The permeability of the sand–incinerator ash mixture was relatively low. Shi and Kan (2009) carried out study to investigate the feasibility of application of municipal solid waste incinerator fly ash as an auxiliary cementitious material. The water demand for normal consistency, setting time, volume stability, flexural, and compressive strength of municipal solid waste incinerator fly ash cement compound matrices were tested. The results show that the MSWI fly ash has some cementitious activity, but the reactivity is relatively lower and its addition to cement may lead to retardation of cement hydration.

3. OBJECTIVE AND METHODOLOGY

3.1 Objective of the study

- To find optimum percentage of incinerated hospital waste and lime.
- To analyze change in geo-technical properties with modified soil with natural soil.

3.2 Methodology



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4. EXPERIMENTAL INVESTIGATIONS

The detailed experimental programme of the present study was undertaken to investigate the changed behavior of the available red soil when mixed with easily available local stabilizingadmixtures like MSWA in different proportions individually or in combinations. This will enable to examine not only suitability of these composite materials in the construction of sub-grade for flexible pavement, but also to decide the optimum mixing proportion for cost effective construction. Initially the geotechnical property like Atterberg limit of the soil and stabilized soil had been determined. The necessary experiment on made to determine the compaction characteristics i.e. optimum moisture content (OMC) and maximum dry density (MDD) by conducting Standard Proctor Compaction tests of those soils. The different tests were conducted in order to determine the different characteristics and properties of the soil.

5. RESULTS AND DISCUSSIONS

5.1 Atterberg Limit (Casagrande Method)

Table. 1: Atterberg Limits of Soil – IHWA Mixes.

S.No	IHWA(%)	Liquid limit (%)	Plastic limit (%)	Plasticity index (%)	Group
1	0	52.3	30.8	21.6	MH
2	2.5	53.3	32.4	20.9	MH
3	5	53.5	33	20.5	MH
4	7.5	54.2	34.2	20	MH
5	10	54.7	35.1	19.6	MH
6	12.5	55.4	36.1	19.3	MH
7	15	56.1	37	19.1	MH

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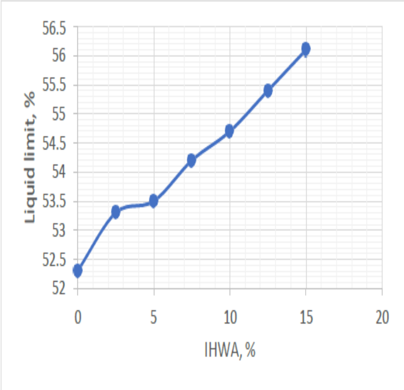

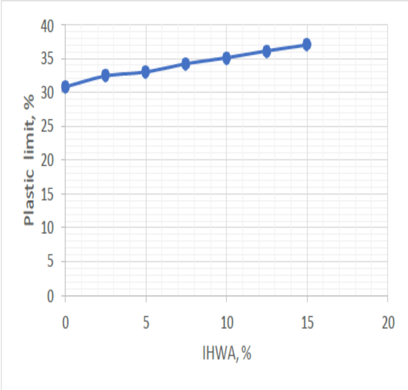

Fig. 1: Liquid limit test results **Fig. 2: Plastic limit test results**

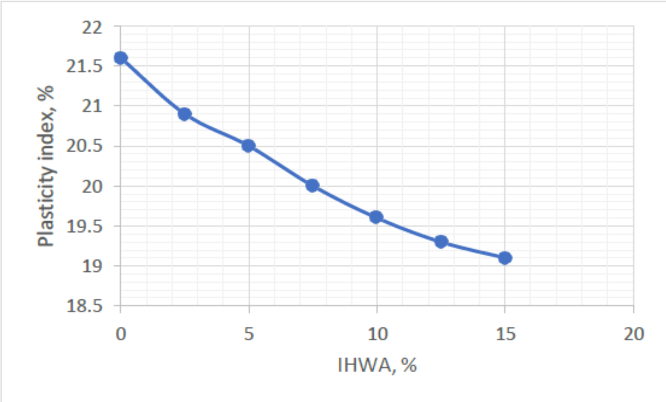

Fig. 3: Plasticity index test results.

5.2 Compaction test (Standard proctor method)

Table. 2: OMC and MDD of Soil- IHWA Mixes

S.No	IHWA %	MDD(g/cc)	OMC (%)
1	0	1.436	26.8
2	2.5	1.420	27.3
3	5	1.398	28.6
4	7.5	1.352	29.4
5	10	1.342	30.6
6	12.5	1.280	31.5
7	15	1.242	32.2

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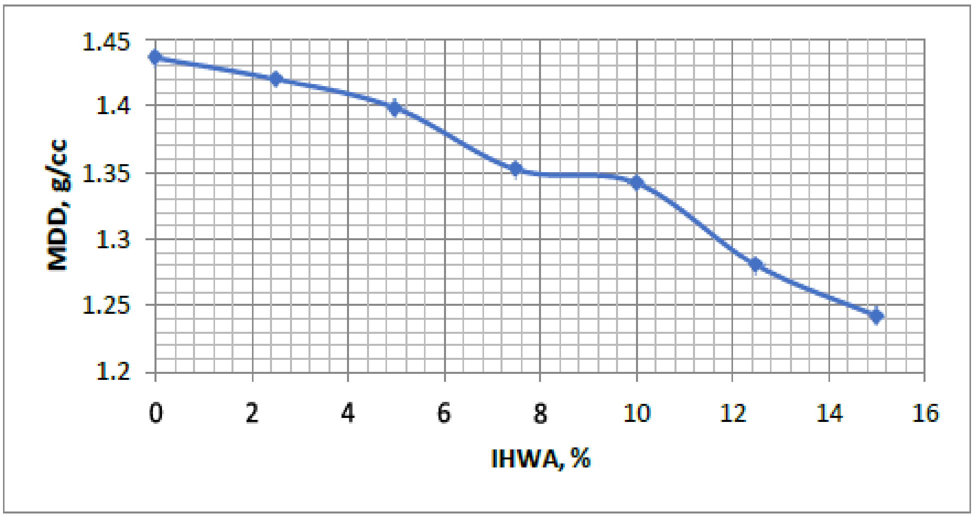

Fig. 4: OMC curve for soil + IHWA.

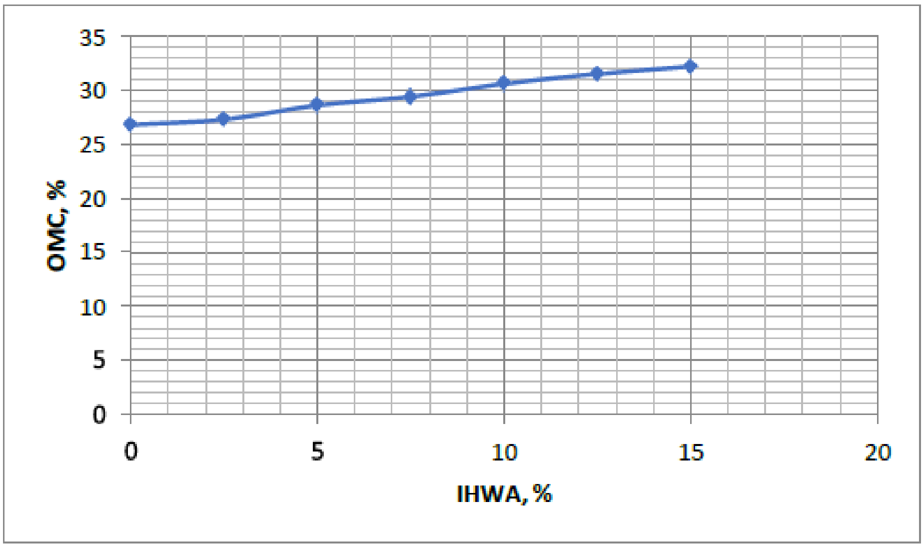

Fig. 5: MDD curve for soil + IHWA.

1. The liquid limit of the soil alone was found to be 52.4%. The liquid limit of the soil with addition of 15% IHWA was found to be increased by 7%, when compared to liquid limit of soil alone.
2. The plastic limit of the soil alone was found to be 30.8%. The plastic limit of the soil with addition of 30% IHWA was found to be increases by 20%, when compared to plastic limit of soil alone.
3. The plasticity index of the soil alone was found to be 21.6%. The plasticity index of the soil with the addition of 30% IHWA was found to be decreased by 11.5%, when compared to plasticity index of soil alone.

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4. The optimum moisture content (OMC) and maximum dry density (MDD) of soil alone was found to be 26.8% and 1.436 g/cc respectively. The MDD of the soil with addition of 30% IHWA by weight of soil is found to be decreases by 13.51% and the corresponding OMC is increased by 20.15%.

6. CONCLUSIONS

On the basis of present experimental study, the following conclusions are drawn

1. The Expansive soil was identified as Intermediate compressible inorganic clay is designed (MH) on Indian Standard classification system. IHWA was used to stabilize the soil for construction in this study and a sufficient cementitious property was found in IHWA.
2. On addition of different percentage of IHWA in the soil (0 to 15%), the plasticity index decreases with an increase in the proportion of rice husk ash from 0% to 15%. The percentage decreases in plasticity index value of soil from 21.6 to 19.1, IHWA stabilized soil respectively.
3. The compaction characteristic of stabilized soil found to be dependent on the plastic nature of the soil. For medium plastic soil, addition of stabilizer to soil reduced the maximum dry density while increasing the optimum moisture content irrespective of stabilizer type.

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