Influence of Sawdust in Clay as a Landfill Liner

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Abstract— A landfill liner is the component of landfill that serves as a barrier system to minimize contaminant migration from the landfill to ground water table. This report investigates how the application of sawdust influences the geotechnical properties of bentonite in order to determine its suitability for use as landfill-liner. A series of laboratory tests were conducted on unstabilized and stabilized clay in order to determine the effects of various proportions of sawdust (1,2,3,…,6%) on the stabilisation. Results show that liquid limit, plastic limit and maximum dry unit weight of the soil decreased with increasing sawdust content while the optimum moisture content and hydraulic conductivity increased with increasing sawdust content. The stabilization of the bentonite with ≤ 5% sawdust content was recommended for use as landfill liners, as they meet the liner requirements.
Key words: Sawdust, Clay, Landfill Liner

I. Introduction

Due to the increase in industrialization and population, large quantities of waste are generated in different forms. The wastes produced are of mainly solid type wastes such as mining waste, municipal waste, construction and demolition waste, sewage sludge waste, hazardous waste, coal ash, agricultural waste etc. When these types of wastes are dumped on the ground, it causes several environmental problems. Solid waste disposal facility is designed on the concept of contained waste by isolating them from the environment by providing an impermeable liner at the base and impermeable cover at the top of the waste is called a landfill.

The landfills are of various types such as engineered landfill, sanitary landfill and secured landfill. The engineered type of landfill is the environmentally acceptable disposal of waste on ground. Sanitary landfills are where non hazardous waste is spread in layers, compacted and covered with earth at the end of each working day. Secure landfills are those where hazardous waste is disposed of by burial, in holes or trenches in ground lined with impervious plastic sheeting to prevent leakage or leaching of dangerous substances into soil and water supply.

Engineered containment systems are the modern landfills which have been designed to minimize the impact of solid waste on the environment and human health. The modern landfills are provided with a liner system for isolating the landfill contents from the environment and also for protecting the soil and ground water from pollution originating in the landfill. An important threat caused to the ground water posed by modern landfills is leachate. Leachate and landfill gases are the important constituents formed inside the landfill. Leachate is the liquid compound that formed as the reactions occurred inside the landfill. It varies widely in its composition regarding to the type of wastes that present in the landfill and age of the landfill.

II. Materials Used

Two different materials were used in this research: clayey soil, Sawdust.

A. *Clayey Soil*

Soil for the present study was collected from Associated Chemicals, Kochi. Sodium bentonite was taken from there. The properties of soil were tested and tabulated in Table I. Based on Indian Standard Classification System (ISCS), the soil is classified as Clay of high compressibility (CH). Unconfined compression test was conducted to confirm the soil is medium. The grain size distribution of clay was found out using hydrometer analysis (IS: 2720 (Part 4)- 1983) is shown in Fig. 1.

B. *Sawdust*

The sawdust used in the study was collected from a local woodmill site in poovar, Thiruvananthapuram, Kerala, India. The collected sawdust was first dried and screened over sieve size 4.75mm to remove any impurities. The properties of sawdust were tested and tabulated in Table II. The grain size distribution of sawdust was found out by sieve analysis (IS: 2720 (Part 4)- 1983) is shown also in Fig.1.

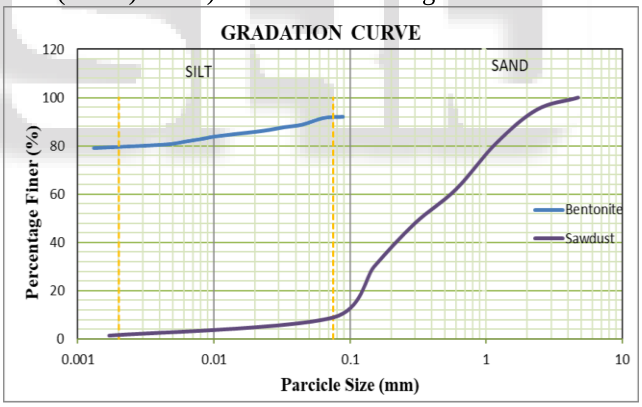

Fig. 1. Grain size distribution curves for clayey soil and Sawdust

Soil Properties	Values Obtained
Specific gravity	2.59
Liquid limit (%)	332
Plastic limit (%)	50
Shrinkage limit (%)	24.6
Plasticity Index (%)	282
IS Classification	CH
OMC (%)	38
Percentage of clay (%)	80
Percentage of silt (%)	11.8
Percentage of sand (%)	8.2
UCS (kPa)	84.924
Coefficient of permeability (cm/s)	0.2X 10-7

TABLE 1: PROPERTIES OF CLAYEY SOIL

Soil Properties	Values Obtained
Specific gravity	1.1

Effective Size D10(mm)	0.075
D60(mm)	0.55
D30(mm)	0.15
Co-efficient of curvature, C_C	0.55
Uniformity Co-efficient, C_u	7.33

TABLE 2: PROPERTIES OF SAWDUST

III. METHOD OF STUDY

A. *Tests conducted*

Following tests were conducted.

1) Atterberg's limit test (IS: 2720 (Part 5)-1983)
2) Standard proctor test (IS: 2720 (Part 7)-1983)
3) Unconfined Compressive Strength Test (IS 2720 Part 10)
4) Permeability Test

B. *Method of Study*

The prime part of the study is to determine the geotechnical engineering properties of the collected sample through various laboratory analysis. The study was carried out by performing atterberg limit, compaction, unconfined compressive strength and permeability test by adding varying percentages of sawdust.

IV. RESULTS AND DISCUSSIONS

A. *Variation of Properties of Clayey Soil by the addition of Quarry Dust*

To study the variation of Atterberg's limits (liquid limit, plastic limit and plasticity index clayey soil – sawdust mixes were prepared with varying percentages of sawdust. Atterberg's limits were determined as per IS: 2720 (Part 5)-1983. The variation of Atterberg's limits is shown in Fig. 2.

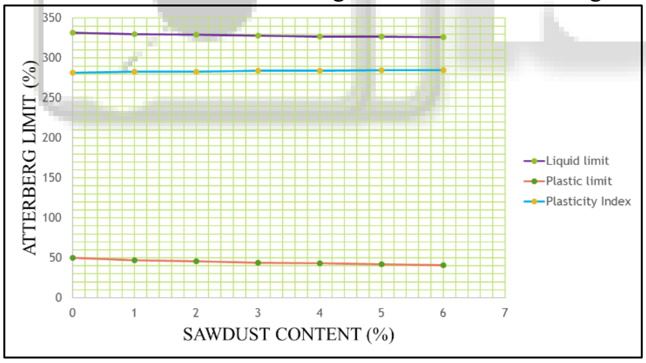

Fig. 2. Variation in Atterberg's limits with varying percentages of sawdust in Clayey soil

It was observed that the liquid and plastic limits decreased, while the plasticity index of the bentonite surprisingly slightly increased as its sawdust content increased. This may be due to the extremely high plasticity of the bentonite.

Clayey soil with varying percentages (0,1,2,3,4,5 and 6) of sawdust were prepared and compaction characteristics (Optimum Moisture Content, OMC and Maximum Dry Density, MDD) were determined for each mix using standard proctor test as per IS: 2720 (Part 7)-1983. The obtained values of MDD and OMC are tabulated in Table III.

Soil mix	Compaction characteristics	
	MDD (g/cc)	OMC (%)
Clay	1.65	24.5
Clay + 1% sawdust	1.645	24.25
Clay + 2% sawdust	1.641	24.02
Clay + 3% sawdust	1.639	23.97
Clay + 4% sawdust	1.632	23.61
Clay + 5% sawdust	1.627	23.28
Clay + 6% sawdust	1.622	23.13

TABLE 3: COMPACTION CHARACTERISTICS OF CLAYEY SOIL- SAWDUST MIXES

It was observed that OMC increased, while the MDD decreased, as the sawdust content in the clay increased. With increasing sawdust content, the treated samples required more water in order to attain the MDD. This is because some of the water in the sawdust-modified samples gets absorbed by the sawdust. However, the MDD achieved decreased with increasing sawdust content. This can be attributed to the lower specific gravity of the sawdust.

To study the variation of UCS of clayey soil – sawdust mixes were prepared with varying percentages of sawdust. Unconfined compressive strength was determined as per IS: 2720 (Part 10). The obtained values of UCS is tabulated in Table IV.

Soil mix	Unconfined compressive strength (kg/cm^2)
Clay	84.924
Clay + 1% sawdust	112.48
Clay + 2% sawdust	116.697
Clay + 3% sawdust	120.914
Clay + 4% sawdust	133.466
Clay + 5% sawdust	139.644
Clay + 6% sawdust	129.25

TABLE 4: UCS OF CLAYEY SOIL- SAWDUST MIXES

UCS of the treated samples decreased with increasing sawdust content. The sawdust has a low density and compressive strength compared with that of bentonite. This explains why the UCS of the treated clay and bentonite decreases as their sawdust contents progressively increased. The optimum value is obtained for 5% of sawdust treated bentonite.

The variation of the permeability of the treated clay and bentonite with their sawdust contents are presented in Fig. 3. The permeability of a soil gives a measure of the ease with which water flows through it.

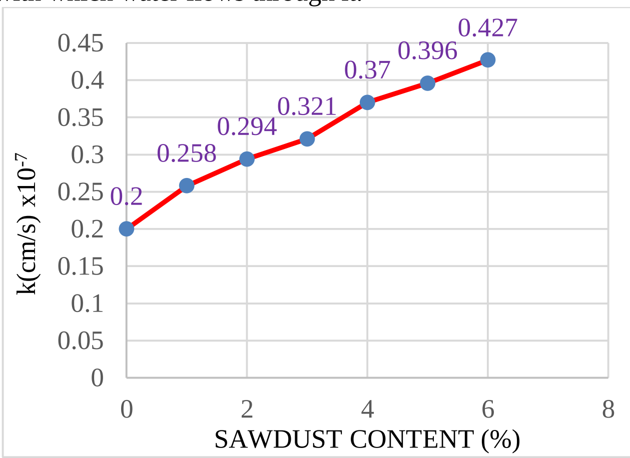

Fig. 3 shows that the higher the sawdust content, the easier it is for the water to flow through sawdust-treated bentonite. This is attributed to the increasing pore space in the treated bentonite as their sawdust content increases.

V. CONCLUSIONS

The following conclusions are deduced from this study:

1) As per the liner specification of Boyton and Daniel, bentonite can be used as a liner material.
2) Addition of sawdust to the clay reduce liquid limit, plastic limit and increase plasticity index as well as hydraulic conductivity of the clay
3) As sawdust content increased, OMC increased 0.945times for bentonite and 0.94 times & MDD decreased 1.02 times than unstabilised soil
4) 5% is the optimum % of sawdust which has higher UCS value

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