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Compaction and seepage characteristics of Fly ash mixed with Bentonite

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The present study has been carried out to find out the compaction properties and seepage characteristics of fly ash and bentonite mixtures. Laboratory tests were conducted at different proportions of fly ash and bentonite. Fly ash, a waste generated by thermal power plants is as such a big environmental concern. The investigation reported in this paper is carried out to study the utilization of fly ash in lining applications with bentonite additive so as to provide an environmentally consistent way of its disposal and reuse. Fly ash is generated in tons as a residue from burning of coal in the power plants. The components of fly ash vary according to the type of coal being burned. But mainly all fly ash include substantial amounts of silicon dioxide (SiO2) (both amorphous and crystalline) and calcium oxide (CaO). Bentonite is clay formed as a result of chemical weathering of volcanic ash. It consists of montmorillonite. Due to its swelling properties, bentonite provides as a self-sealing, low permeability hydraulic barrier. Fly ash is cohesion less material and having very low compressive and shear strength however its strength can be increased by adding low cost cohesive materials such as lime and clayey soil whereas bentonite is clay having high swelling properties when it comes in contact with the water. Wastes are generated more and more with increasing industrialisation and population growth. Based on the safety level, these wastes can be controlled by different options such as waste reduction, separation and recycling, resources recovery through waste processing, waste transformation, and environmentally sustainable disposal on land. The most frequently used disposal option for solid waste in the landfill because of its low cost and efficiency. In the present study seepage and compaction characteristics of fly ash mixed with bentonite are studied to enable its use in various engineering applications such as land fill liner and subgrade material of pavements.

Keywords: *Fly ash, Bentonite, lining applications, subgrade material*

Introduction

Landfills are the most popular municipal solid waste disposal system. The design of liner is made so as to isolate the waste from the environment minimizing the passage of leachate into the groundwater. To ensure this the important characteristics for compacted landfill liners are selection of materials, hydraulic conductivity, strength, compressibility and contaminant retention capacity. Fly ash is the notorious waste product of coal based electricity generating thermal power plants, known for its ill effects on agricultural land, surface and sub-surface water pollution, soil and air pollution and diseases to mankind. Researchers have proposed few ways of reusing fly ash for variety of application. Fly ash particles are almost totally spherical in shape, allowing them to flow and blend freely in mixtures. With this in view, the present study purports to examine the suitability of fly ash as a landfill liner material. The major objective of this study is to maximize the use of fly ash for the liner application. Therefore, different fly ash-bentonite mixes were subjected to hydraulic conductivity, Shear strength and compressibility evaluation. Mishra[1] et al. (2010) worked on mixtures of expansive soil such as bentonite with fly ash and pond ash can is used as compacted barriers. Lakshmikanth H[2](2004) worked on the Properties of Fly ash as Hydraulic Barrier, Soil and Sediment Contamination. Yilmaz[3] (2001) was carried out an investigation on the utilization of fly ash and bentonite mixture as a bottom and/or upper liner material at waste disposal areas. In this study, Catalagziflyash was mixed with bentonite, as binding material, at 10, 20 and 30 percentages (dry weight bentonite/dry weight Catalagziflyash) to obtain less permeable liner material 1. Alam J[4] et el. (2012) also worked on the Seepage characteristics and geotechnical properties of fly ash mixed with bentonite. Bello[5] (2013) worked on the basic attributes of a suitable liner. the presence of significant amount of a clay minerals and having a hydraulic conductivity less than or equal to 1×10-7acm/s. Therefore, different fly ash-bentonite mixes were subjected to different tests to determine its swelling properties.

Materials used

Fly ash

The fly ash used in this present study is an industrial by-product obtained from the Sanjay Gandhi Thermal power plant situated in Birsinghpur Tehsil in Umaria district of Madhya Pradesh. Fly ash used in this study is class F fly ash.

Bentonite

The bentonite used for the project work was Sodium bentonite which is naturally occurring hydrated aluminium silicate clay. It exhibits extremely high swelling and water absorbency properties. Bentonite used in this study is sodium bentonite purchased from the market of Jabalpur in Madhya Pradesh.

Methodology

All the tests were carried out as per the relevant Indian Standards for determining the compaction behaviour and swelling properties of fly ash and bentonite mixture at various proportions varying from 4 % bentonite, 8% bentonite, 12% bentonite and 20% bentonite with remaining fly ash content P.V.V.Satyanarayana[6] et al. (2013) works on the red soil and bentonite mixture and obtained that the mixture is best suited for lining purpose.

Compaction Characteristics

Heavy compaction test was carried out on specimens as per IS 2720 (Part VIII) 1980. The compaction curves for fly ash-bentonite mixture was obtained and the OMC and MDD values are given in Table.

These OMC and MDD values obtained from laboratory compaction test provide a reference point while estimating the actual water content of the field-compacted soil liner. The variation of MDD and OMC of the compacted fly ash-bentonite mixtures are presented in the Figure.

S No.	Bentonite content (%)	Bentonite fly ash mixture	
		OMC	MDD
1	0	39	1.125
2	4	36	1.143
3	8	34	1.16
4	12	32.5	1.19
5	20	30.5	1.27

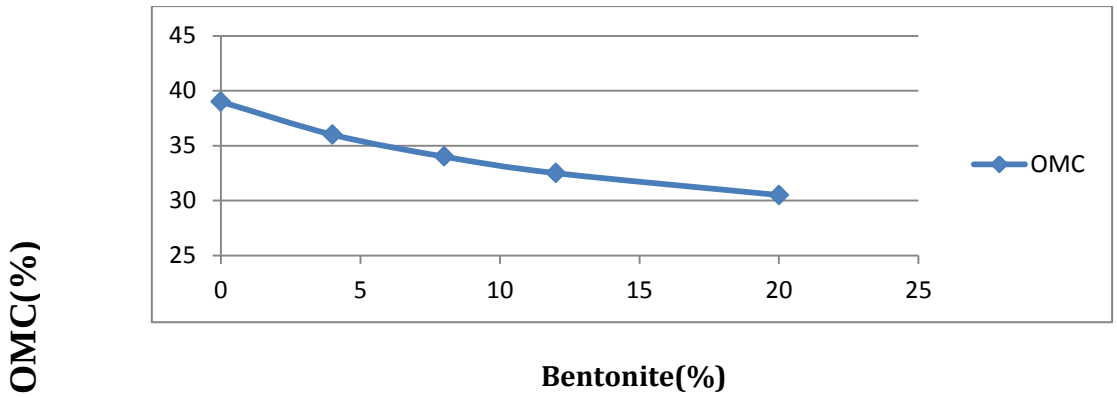

Fig. Variation of Optimum moisture content with bentonite

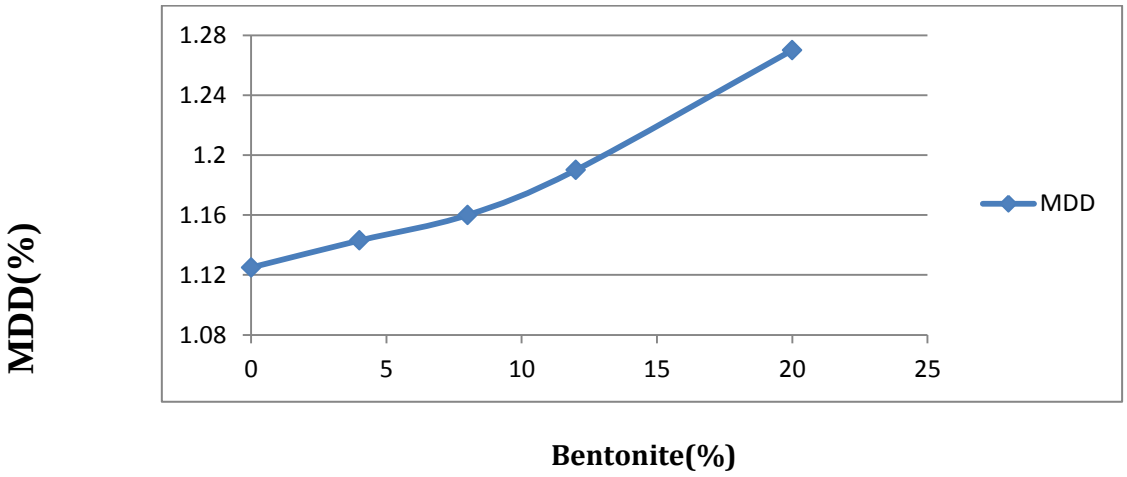

Fig. Variation of maximum dry density with bentonite

Permeability Characteristics (IS: 2720- Part 17, 1986)

The permeability of pure fly ash and bentonite as well as of their mixes was measured by Falling Head Test method, after their compaction at optimum moisture content, maximum dry density and by saturating it for three days.

Formula used: The coefficient of permeability has been determined by the relation.

$$K=[2.303\ aL\ /\ (At)].Log_{10}(h_1/\ h_2)$$

K = Coefficient of permeability in cm/sec. at test temperature

a = Inside cross sectional area of stand pipe in cm2

A = Cross sectional area of soil sample

L = Length of soil sample in cm

h_1 =Initial head in cm

h_2= Final head in cm

t = Time interval in seconds in which the head drop from h_1 to h_2

S No.	Bentonite Content	Coefficient of Permeability of Bentonite Fly ash Mixture(cm/sec)
1	0	$148x10^{-7}$
2	4	$130x10^{-7}$
3	8	$115x10^{-7}$
4	12	$17.9x10^{-7}$
5	20	$.9x10^{-7}$

Conclusions

- With increase in the bentonite content, the maximum dry density (MDD) of the mixture is increased and the optimum moisture content (OMC) is decreased.
- An increase in bentonite content of 12%-20% induced plasticity in the fly ash-bentonite mixture which led to better bonding between particles upon compaction.
- The conclusion drawn from the present study is that 20% bentonite-fly ash mix is an optimum mix that can be safely used as a subgrade material of pavements and as cover or liner at waste disposal sites, as per the design criteria clays with permeability $<1x10^{-7}$cm/sec is considered for landfill liner.
- Up to 8% bentonite, the permeability reduces at a constant rate of about 9 %, thereafter up to 20% bentonite, the reduction in the value of permeability was observed to be about 7%. So a mixture of fly ash mixed with 20% bentonite may be used as a low permeable mass.

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