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Swelling Properties of Fly Ash Mixed with Bentonite

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Abstract-The present study has been carried out to find out the swelling properties of fly ash and bentonite mixtures. Laboratory tests were conducted at different proportions of fly ash and bentonite. Fly ash is a naturally cementitious coal combustion by-product. It is extracted by the precipitators in the smokestacks of coal-burning power plants to reduce pollution. Fly ash is cohesion less material and having very low compressive and shear strength however its strength can be inceased 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. Major problem associated with fly ash is its disposal a large area of land required for disposal and toxicity associated with heavy metal leached to groundwater. The major objective of this study is to determine the swelling characteristics this mixture in order to use it in lining applications.
Keywords: Fly ash, Bentonite, lining applications

I. INTRODUCTION

In a developing country like India, the maximum electricity is generated from the thermal power plants which use coal for the production of electricity. Power being considered as an engine of growth, has always been a focus area for most of the developing countries including India. The power generation in India has increased from 1362 MW in 1947 to 42849.38 MW up to March 2016. Coal based power plant requires coal of high calorific value to generate optimum heat consequently to generate electricity, in this process a buy product which is also waste fly-ash or coal ash is produced. In India coal reserve is mainly is of lignite so the power plant burns this and produces ash, Indian coal average ash content is 35-38 percent. We require electricity, we burn coal and we produce fly-ash. Every year 100-130 million tonnes of fly ash is produced out of which only 70 to 80 mllion tonnes is utilised every year and remaining fly ash is wasted. A large amount of the fly ash produced is disposed in monofills. In the course of experimental studies, the chemical, physical and mineralogical properties of the swelling clay to be stabilized and the fly ash were investigated. Lakshmikanth H[1](2004) worked on the Properties of Fly ash as Hydraulic Barrier, Soil and Sediment Contamination The disposal of fly ash is becoming expensive each year due to the large area of land needed for its disposal. One of the amicable solutions to the problem is reuse of fly ash for some meaningful applications.so mixing bentonite with the fly ash in order to use it for various engineering applications. Yilmaz[2] (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[3] et el. (2012) also worked on the Seepage characteristics and geotechnical properties of fly ash mixed with bentonite. Therefore, different fly ash-bentonite mixes were subjected to different tests to determine its swelling properties.

A. Materials Used

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.

B. Bentonite

Bentonite is type of clay mineral (Montmorillonite) which is cheap and easily available. Bentonite used in this study is sodium bentonite purchased from the market of Jabalpur in Madhya Pradesh.

II. METHODOLOGY

The following tests were conducted for determining the 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. S.P.Singh[4] et al.

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(2015) works on the coal ash and bentonite mixture and obtained that coal ash and 20% mixture is best suited for laboratory work.

A. Specific Gravity

The specific gravity of bentonite and fly ash is determined by using pycnometer method by the following formula

$$G = \frac{M_2 - M_1}{(M_2 - M_1) - (M_3 - M_4)}$$

Specific Gravity of Soil by Pycnometer

Where M1=mass of empty Pycnometer,

M2= mass of the Pycnometer with dry soil

M3= mass of the Pycnometer and soil and water,

M4 = mass of Pycnometer filled with water only.

G= Specific gravity of soils.

Material	Specific gravity
Fly ash	2.32
Bentonite	2.83

B. Atterberg Limits

Representative samples of the soil were taken to determine Atterberg limits (plastic and liquid limits) by using the size fraction passing through 0.425 mm sieve.

C. Liquid Limit (LL)

Casagrande apparatus was used to determine the liquid limit. The liquid limit of fly ash is found out to be 51% which is very less as compared to that of bentonite. Bentonite used in this research have very high liquid limit.

D. Plastic Limit (PL)

The plastic limit was determined with the thread-rolling method. The plastic limit of bentonite is found out to be 65%. The mixture shows plasticity after about 12% of bentonite content in it.

E. Shrinkage Limit (SL)

The shrinkage limit is obtained by Mercury dish experiment. The shrinkage limit of bentonite is found out to be 5%. The mixture of coal ash and bentonite shows a considerable increase in the shrinkage limit.

S No.	Bentonite and fly ash mixture			
	Bentonite (%)	LL (%)	PL (%)	SL (%)
1	0	51	-	40
2	4	52	-	38
3	8	54	-	37
4	12	62.5	42	36
5	20	70	43.5	35.5

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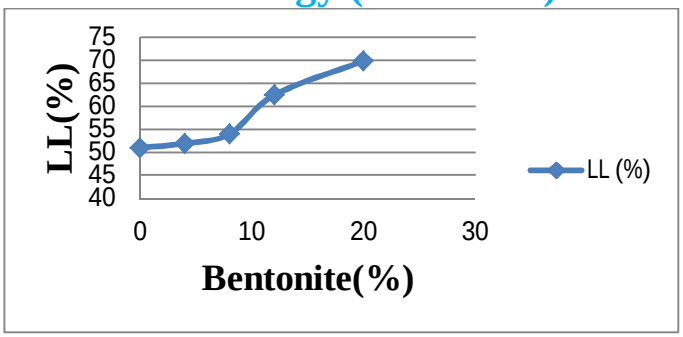

Fig. Variation of Liquid Limit with Bentonite content

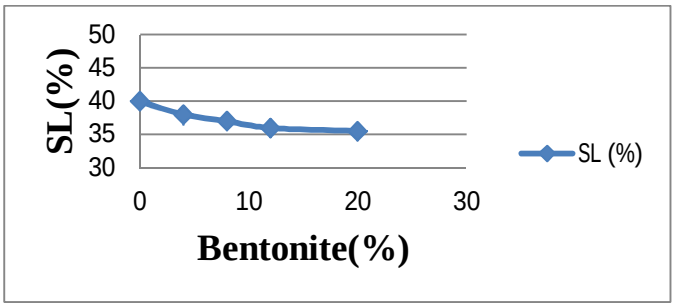

Fig. Variation of Shrinkage Limit with Bentonite content

F. Differential Free Swell (Dfs)

Free swell or differential free swell, also termed as free swell index, is the increase in volume of soil without any external constraint when subjected to submergence in water.the formula used is

DFS = [Vd – Vk] / Vk x 100%

where,

Vd = volume of soil specimen read from the graduated cylinder containing distilled water.

Vk = volume of soil specimen read from the graduated cylinder containing kerosene.

Bentonite (%)	DFS (%)
0	-
4	30
8	84
12	130
20	171

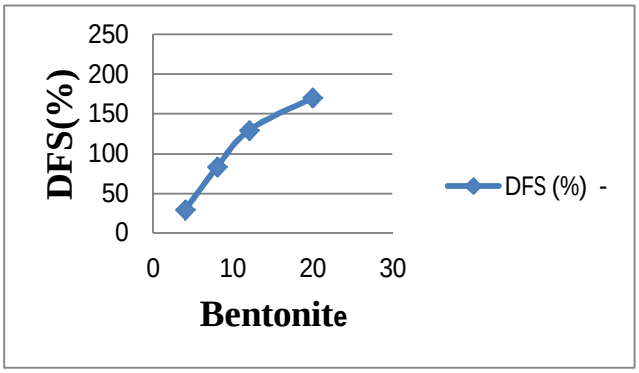

Fig. Variation of DFS with Bentonite content

III. RESULTS AND DISCUSSIONS

Plain fly ash is cohesionless material which remains in non-plastic state up to 20% bentonite-fly ash mixes. Hence the bentonite up to 20% can be used as admixture to improve the geotechnical properties of fly ash.

There was a variation in Shrinkage Limit in the fly ash-bentonite mixture with the addition of bentonite, without formation of prominent shrinkage cracks.

An increase in bentonite content of 12%-20% induced plasticity in the coal ash-bentonite mixture which led to better bonding between particles upon compaction.

IV. CONCLUSIONS

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 cover or liner at waste disposal sites since it acts as a better sealant at this proportion.

The Differential Free Swell of the mixture increased with the addition of bentonite, resulting as a better sealant.

As bentonite have higher swelling properties but as fly ash is added its swelling nature is decreased making it suitable for liner purpose.

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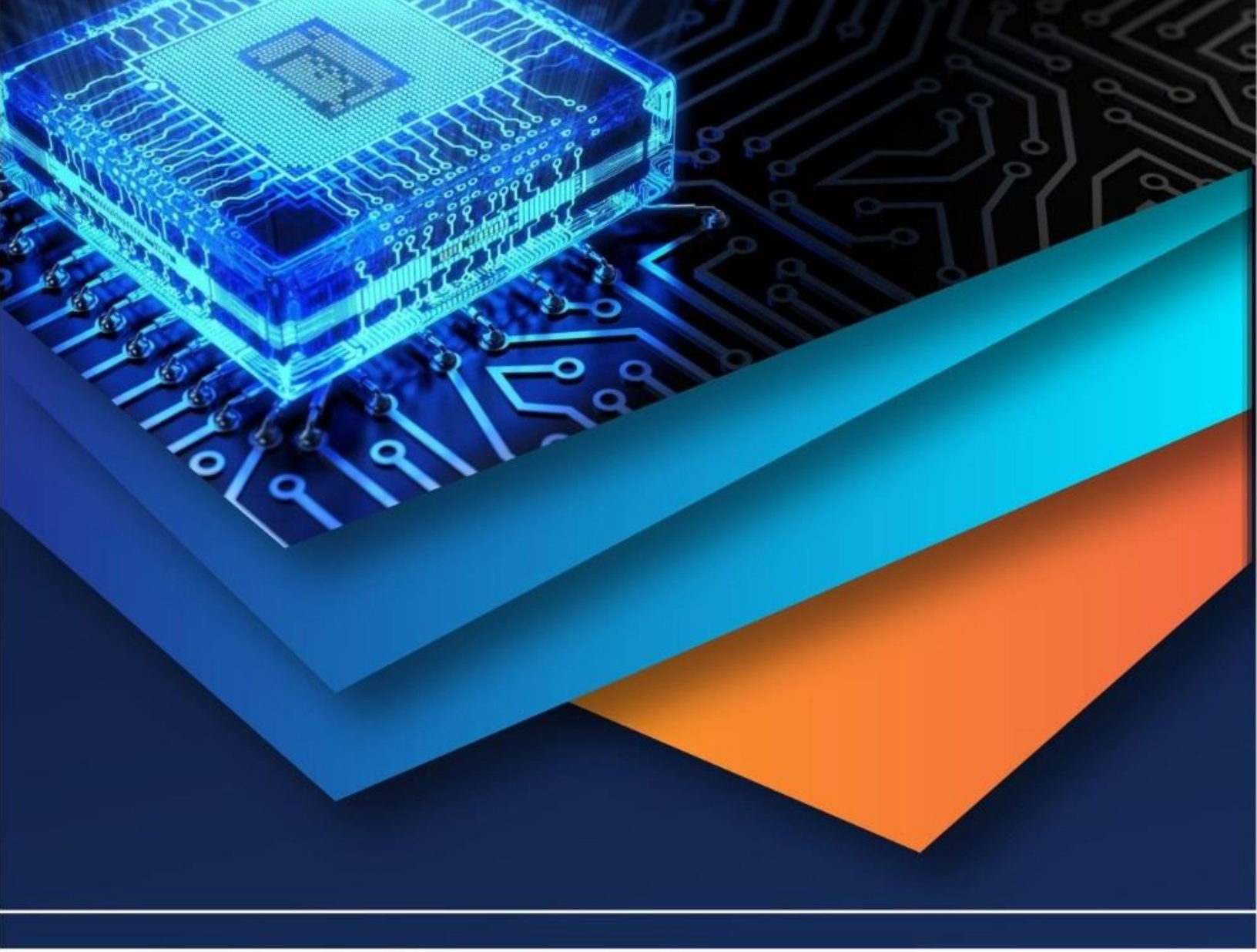

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