JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

STRENGTH AND COMPRESSIBILITY CHARACTERISTICS OF BOTTOM ASH

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Abstract: In India, coal is a major source of fuel for power generation. About 60% of power is produced using coal as fuel. Indian coal has a very high ash content resulting in huge quantity of ash generation in the coal based thermal power stations. Bottom ash is the coarse, granular, incombustible by-product of coal combustion that is collected from the bottom of furnaces. This ash is dark grey in colour, and is about the size of sand. In the year 2020, approximately 19.6 million tons of bottom ash was produced. Geotechnical engineering provides vast scope for utilization of bottom ash as a substitute to soil in embankments and subgrades. Knowledge of geotechnical characteristics of bottom ash helps to promote bulk utilization of bottom ash. Many successful case histories have been reported by many researchers on the utilization of bottom ash in various civil engineering applications like replacement of fine aggregate in cement and as fill/back fill materials. Bottom Ash is successfully used in the construction of embankments as a fill material (C. William hovel et al. (1990), as a partial replacement of cement (Mohd Sani, et. al., (2010)), In the present paper an attempt is made to study the suitability of bottom ash as fill / back fill material. many researchers are reveals the strength characteristics (ϕ and CBR value) of bottom ash and its suitability in civil engineering constructions. This paper mainly focusing compressibility characteristics (C_v & C_c) bottom ash. To study the compressibility characteristics of bottom ash, it was tested in one dimensional consolidometer and the coefficient of consolidation (C_v) under different consolidation

1.Introduction

The benefits of quicker and less expensive construction have led to the widespread usage of reinforced earth retaining walls in a variety of civil engineering projects. In reinforced earth retaining walls, soil serves as both backfill and fill material. Certain soils are utilized as backfill for traditional retaining walls and in the construction of embankments. In order to foresee settlements and guarantee the serviceability of structures built on a layer of compressible soil, the fill material or soil must be compressible. Alternative, more affordable fill materials should be investigated because the price of traditional fill materials has increased. The use of various industrial wastes

and by-products, including coal ashes, crusher dust, granulated blast furnace slag, and other marginal soils like fine sand, has been made possible by recent research studies.

2.Literature Review

Saurabh Kajal, et. al., (2017) have studied the effect of use of coal bottom ash as partial replacement of fine aggregates in various percentages (10, 15, 20 and 25%) on concrete properties such as compressive strength, splitting tensile strength test and flexural strength. The test results shows that at fixed water cement ratio, workability decreased with the use of coal bottom ash as a replacement of fine aggregate in concrete. Compressive strength of bottom ash concrete at the curing age of 28 days increased when compared to control concrete.

Wei – Hsing Huang and C. William hovel used bottom ash as embankment material as "Geotechnics of waste fills-theory and practice, 1990 and they concluded that, It can be concluded that properties of power plant bottom ash compare favourably with those of traditional natural granular soils and that the material can be successfully utilised as a fill material.

3.Details of the Study:

3.1 Bottom Ash

Bottom Ash (BA) is generated as a by-product at Thermal Power Plant. About 105 million metric tons BA is produced every year in India. Detailed laboratory instigations are carried out for geotechnical characterisation of BA collected from NTTPC, Ibrahimpatnam, Vijayawada. IS heavy compaction tests (IS 2720 part VII) are conducted to determine OMC and MDD values of BA. The strength and compressibility characteristics of BA are determined by testing the specimens prepared at OMC-MDD state. To study the properties of BA in saturated state, the specimens prepared in OMC-MDD state are saturated and the tested .

Table 1: Index Properties of Bottom Ash

Property	Value
Specific Gravity	1.99
Grain Size Distribution	
a) Gravel (%)	3
b) Sand (%)	81
c) Fines (%)	15
d) D_{10} (mm)	0.90
e) D_{30} (mm)	2.52
f) D_{60} (mm)	6.35
g) C_u	7.05
h) C_c	1.11
Plasticity Characteristics	
a) Liquid Limit	NP
b) Plastic Limit	NP
Equivalent IS Classification	Poorly Graded

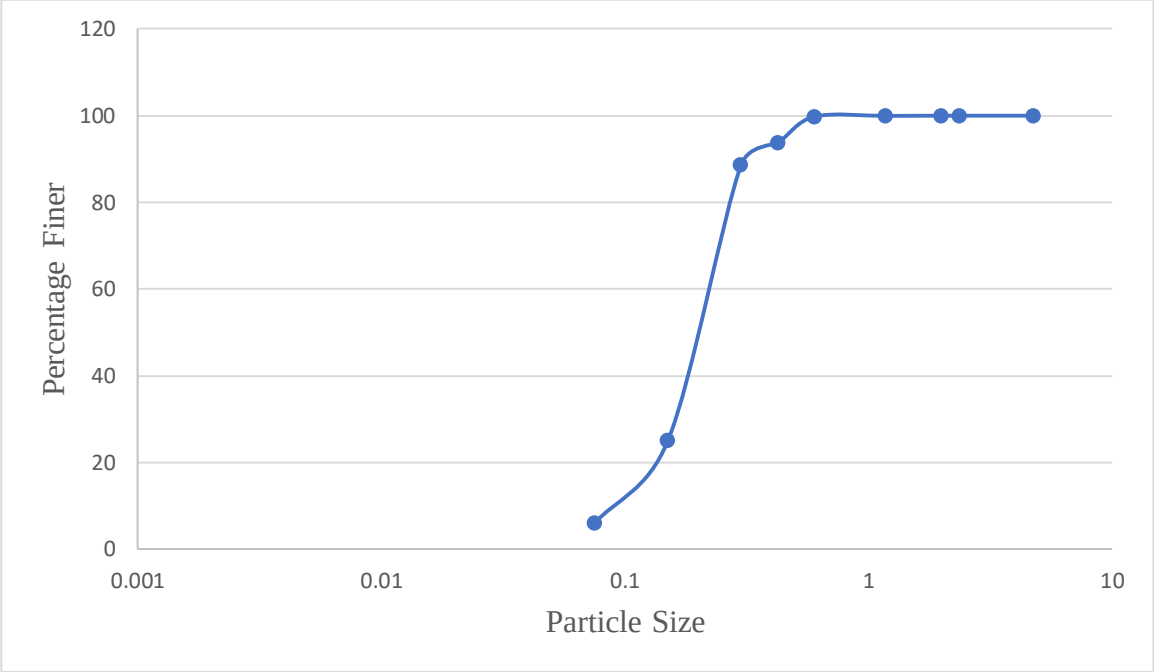

Fig.1 Grain Size Distribution of Bottom Ash

Table 2. Engineering Properties of Bottom Ash

Property	Value
Compaction Characteristics a) Optimum Moisture Content (%) b) Maximum Dry Density (g/cc)	 20 0.72
Shear Parameters i). OMC-MDD Condition a) Cohesion b) Shearing Resistance(ϕ) ii). Saturated Condition c) Cohesion d) Shearing Resistance(ϕ)	 0 32° 0 29°
CBR Value (%) i)Unsoaked Condition ii)Soaked Condition	 7 4.2
Coefficient of Permeability, k (m/s)	$3.45x10^{-3}$
Free Swell Ratio	1.13

Table .3. Coefficient of Consolidation of Bottom Ash

Applied Pressure (kN/m^2)	t_{90} (s)	C_V (m^2/s)	Avg.C_v(m^2/s)
160	9.6	1.9×10^{-4}	1.09×10^{-4}
320	17.3	0.98×10^{-4}	
640	35.4	0.41×10^{-4}	

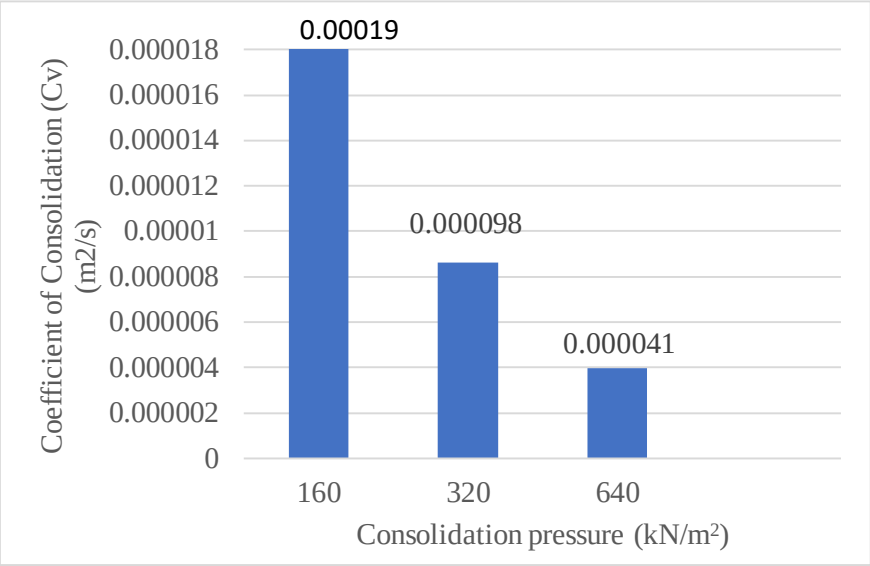

Fig. 2 Variation of C_v with consolidation pressure for Bottom Ash

Table.4. Compression Indices of Bottom Ash

Compressibility State	C_c
OMC-MDD	0.028
Saturated	0.143

4. Results and Discussion

4.1 Index Properties

From Table1, the gradation characteristics indicates that the Bottom Ash contains predominantly sand size particles. Hence, BA is cohesionless and non-plastic in nature. Based on the C_u and C_c values determined from gradation curve (Fig. 1), it is classified in IS classification group as SMN (Non Plastic Poorly Graded Silty Sand).

4.2 Engineering Properties

From Engineering Properties of BM presented in Table 2, the results indicate that the ash contains lower value of MDD (0.72 g/cc) compared to the conventional fill materials (sand-1.8g/cc and Moorum-2.0g/cc). Further, MA has higher value of shearing resistance (29°) in saturated state with no fines and it meets the requirements of frictional fill specified by Jones (1985). Hence, it may be used as fill material in construction of reinforced soil structures, particularly Reinforced earth retaining walls. The material is coarse grained with light weight and fair permeability ($3.45x10^{-3}$m/s) and so, it can be effectively used as back fill material behind the retaining structures. Table 3 and Figure 4 indicate that the coefficient of consolidation is decreased with increase in consolidation pressure. Table 4 reveals that BA has compression index (C_c) value in saturated state as 0.143, which is in the range of value of compression index of commonly used fill material of embankments, i.e low compressible clays (C_c= 0.14-0.23).

5.Conclusions:

Based on the experimental studies conducted on Bottom Ash in the present work, the following conclusions are drawn.

- Bottom Ash is coarse grained material with no fines and has good frictional characteristics (ϕ= 29°) in saturated condition. Hence, it is suitable for use as backfill material in retaining structures and as fill in the construction of reinforced soil walls.

➢ Bottom Ash is suitable for use in the construction of high embankments as it has soaked CBR of 4.2%. However, it need to be contained using coarser bunds on either side, as it is unbound material.

➢ The compression Index of Bottom Ash (0.143) is in the range of compression index of commonly used embankment fill material, i.e., low compressible clay.

6.References

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