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**RESEARCH ARTICLE**

# COLLAPSIBLE BEHAVIOR OF COMPACTED COAL ASH

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## *Abstract*

Coal ash a waste material is widely used in construction of fills and embankments. Compacted coal ash fills are likely to undergo collapse on inundation, permeation, saturation, sluicing or infiltration of rainwater, depending upon the circumstances. The susceptibility to collapse compression has become the most significant geo-technical property of the fill. The present study has worked out the various factors which are influencing the collapsible behavior of coal ash. Consolidation test were performed on compacted fly ash (FA), bottom ash (BA) and the mixture of the two (45% FA and 55% BA). The results revealed that BA and the mixture of the two show negligible collapse while the FA is more susceptible to collapse.



## INTRODUCTION

The fly ash is disposed off either in dry form or mixed with water and discharged as slurry into locations called ash ponds, lagoons or dykes. The quantity of fly ash produced worldwide is enormous and keeps increasing every passing year. The coal reserves of India are estimated around 200 billion metric tons. Because of this wide availability 90% of Indian thermal stations have coal as their energy generating source. Presently, India produces nearly 100 million metric tons of coal ash that is expected to double in the 10 years. The most common method adopted in India for disposal of coal ash is the wet method. Thus ash ponds currently occupy nearly 26,300 ha of land in India.

The fly ash slurry, after undergoing consolidation process under its self weight exhibits different engineering properties than those of compacted after dewatering. Many partly saturated soils undergo reduction in volume when their moisture content increased, but without any change in the applied stress is called collapsible soils or metastable soils. This phenomenon is exhibited by soils during a change of state from unsaturated to a saturated condition.

It is commonly assumed that only sandy or silty soils exhibits collapse, however it has been reported compacted soil in general can exhibit collapse (Barden et al 1973, Cox 1978) Clayton (1980) reported occurrence of collapse in a compacted chalk fill. Compacted soils that exhibit collapse typically have an open type of structure with many voids which give rise to a metastable structure. The dry density and water content of soil specimens at the time of compaction are the primary soil properties that control the amount of collapse. Foss (1973), Popesue (1986), Lefebvre and Ben Belfadhel (1989) also conducted studies on collapse of soil. Meckechine (1989) stated that

unsaturated soils having dry density lower than 1.6 $Mg/m^3$ are liable to collapse, but initially unsaturated condition is a prerequisite for collapse.

From the available literature it has been seen that information regarding the metastable/ collapse behavior of compacted coal ash is generally missing. So, in the present study the collapse behavior of FA, BA and mixture of the two ( 45% FA and 55% BA )at different water content , densities and stresses have been investigated in detail. The detailed investigation shows that FA has good potential for use in geotechnical applications. This not only solve the problem of disposal but also prevent the environmental pollution.

**EXPERIMENTAL INVESTIGATION**

To study the collapsible behavior of compacted coal ash different types of samples with different conditions have been tested. Single oedometer collapse test was conducted. Three different combinations (i) Bottom Ash (BA) (ii) Fly Ash (FA) (iii) Fly Ash 45%+ Bottom Ash 55%. Was choosed for the testing. For preparation of sample Standard proctor Compaction was used. Test specimens for all collapse test was prepared by Standard compaction method.The test method covers the determination of one dimensional collapse that occurs when unsaturated soils are permeated with water. The physical properties of the material are tabulated in table 1 and the chemical characteristics are tabulated in table 2

## RESULT AND DISCUSSIONS

***Table 1: Physical Properties of Material***

| Material | Specific gravity(G) | MDD (gm/cc) | OMC in % |
|---|---|---|---|
| FA | 2.14 | 1.220 | 24 |
| BA | 2.20 | 1.210 | 26 |
| Mixture(45% FA&55% BA) | 2.24 | 1.320 | 27 |

***Table 2: Chemical Characteristics of Material***

| | |
|---|---|
| Silica($SiO_2$) | 60.12% |
| Alumina($Al_2O_3$) | 30.16% |
| Iron Oxide($Fe_2O_3$) | 6.36% |
| Lime(CaO) | 1.00% |
| Magnesia(MgO) | 0.53% |
| Soda($Na_2O$) | 0.06% |
| Sulphates($SO_3$) | 0.01% |

The results obtained from the test help in the study of the effect of water content, dry density and pressure on the collapse potential of coal ash. Table 3 shows the compaction proctor test results.

***Table 3: Compaction Proctor results***

| **Water Content in %** | **Dry density in gm/cc** | | |
|---|---|---|---|
| | **FA** | **BA** | **Mixture of (FA & BA)** |
| **10** | **1.142** | **1.046** | **1.170** |
| **15** | **1.151** | **1.025** | **1.178** |
| **20** | **1.179** | **1.072** | **1.220** |
| **25** | **1.120** | **1.134** | **1.310** |
| **30** | **1.200** | **1.220** | **1.243** |
| **35** | **1.138** | **1.088** | **1.165** |

| Load (P) $Kg/cm^2$ | Void Ratio | | | Co-efficient of volume change($cm^2$/kg) | | | Compression Index | | |
|---|---|---|---|---|---|---|---|---|---|
| | F.A | B.A | Mixture of F.A &B.A | F.A | B.A | Mixture of F.A and B.A | F.A | B.A | Mixture of F.A and B.A |
| 0.25 | 0.77 | 0.820 | 0.70 | | | | | | |
| 0.50 | 0.76 | 0.810 | 0.67 | $28.8x10^{-3}$ | $11.2X10^{-2}$ | $14.4x10^{-3}$ | | | |

Metastable potential ( Jenning & Knight ) is given by the relation

$$C_p = (e_1 - e_2)/(1+e_0)$$

Where $C_p$ is the collapse or metastable potential

The greater the collapse (metastable) potential the greater is the collapse and greater is the damage to the structure. If $C_p$ is less than unity no collapse will occur. When $C_p$ is between 1 to 4 collapse will be moderate and if $C_p$ is greater than 4 sever collapse will occur.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.00 | 0.74 | 0.806 | 0.59 | $21x10^{-3}$ | $64.2x10^{-4}$ | $21x10^{-3}$ | 0.067 | 0.073 | 0.066 |
| 2.00 | 0.72 | 0.800 | 0.58 | $77x10^{-4}$ | $32.2x10^{-4}$ | $72.1x10^{-4}$ | | | |
| 4.00 | 0.70 | 0.780 | 0.55 | $59x10^{-4}$ | $62.6x10^{-4}$ | $40.5x10^{-4}$ | | | |

***Table 4: One Dimensional Consolidation Test Results***

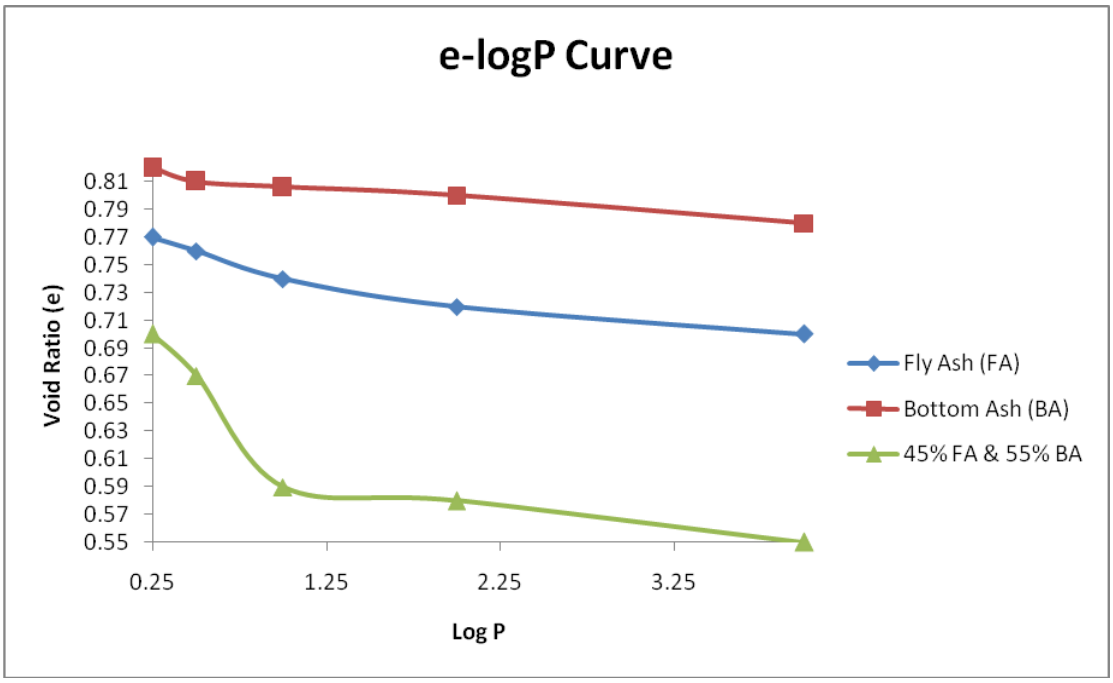


***Fig:- Graph showing the variation of void ratio with load***

## CONCLUSIONS

The detailed investigations carried out on coal ash shows that fly ash has a good potential for use in geotechnical applications. Its low specific gravity, freely draining nature , ease of compaction, insensitiveness to changes in moisture content, good frictional properties etc can be gainfully exploited in the construction of embankments, roads, reclamation of low-lying areas, fill behind retaining structures etc. It can be also used in reinforced concrete construction since the alkaline nature will not corrode steel. This not only solves the problems associated with the disposal of fly ash (like requirement of precious land, environmental pollution etc) but also helps in conserving the precious top soil required for growing food.

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