International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No. (02), January 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

STUDY OF ENGINEERING PROPERTIES OF BLACK COTTON SOIL WITH POND ASH

Er. Dharm Raj Suwalka[1], Er. Amit Kumar Jangid[2], Er. Jitendra Khatti[3]

[1]*Scholar M.Tech. (Geotechnical Engineering), Civil Engineering Dept., UTD, RTU, Kota (India)*

[2]*Scholar Ph.D. (Geotechnical Engineering), Civil Engineering Dept., UTD., RTU, Kota (India)*

ABSTRACT

Black Cotton soil is expansive soil which expands when it contacts with water. This is the major reason of failure of black cotton soil strata. Different areas having different types of black cotton soil and it is engineering properties. These properties may be improved by adding or mixing the different types of admixture or fibre or stabilizing materials. Most of the times, the black cotton soil is stabilized by synthetic fibres and natural fibres. The polypropylene, polyester are synthetic and jute is natural fibre. This research paper deals with how to improve engineering properties of black cotton soil with different percentage of pond ash. In this research, the pond ash is mixed from 0% to 50% in black cotton soil. The engineering parameters are also determined by conducting tests. For studying the engineering properties of black cotton soil with different percentage of pond ash, the Atterberg's limits (Liquid Limit, Plastic Limit, Plasticity Index), standard proctor test, differential free swelling index, swelling pressure and wet sieve analysis tests are conducted.

Keywords: Pond Ash, Plasticity Index, Degree of Expansiveness, Maximum Dry Density, Shear Strength, Swelling Pressure

I. INTRODUCTION

Black cotton soil covers the 51.8 million hectares land in India. The black cotton soil is very hard when dry but lose it strength completely when in wet condition. Expansive soils are a worldwide problem that poses several challenges for civil engineers. Expansive soils, which are also called as well – shrink soil, have the tendency to shrink and swell with variation in moisture content. As result of this variation in soil, significant distress occurs in soil, which is subsequently followed by damage to the overlying structure. The recent past huge amount of fly ash and pond ash are generated by the thermal power plants. It is a major cause of concern for the people living around the power plants. The current rate of utilization of pond ash is only about 35% to 40% but production of ash is more than to utilization. Mainly, ash is used in design of highway pavement and roads. The black cotton soil can be stabilized by using ash. In this research paper the black cotton soil is stabilized by pond ash and engineering properties are studied. For studying the engineering properties of black cotton soil, the pond ash is mixed with 0% to 50% by weight of black cotton soil.

II. LITERATURE REVIEW

For the improving the engineering properties of black cotton soil, many researchers did work on the black cotton soil with different stabilizing materials. In the past many researchers have carried out their research work for improving the engineering properties of black cotton soil using different types of admixture, stone dust and fibre. Some detailed literatures have been reviewed on this topic i.e. related to black cotton soil engineering properties and some of the reviewed of the reviewed literatures are presented in proceeding paragraphs.

Cokca A (2001) prepared mix specimen of black cotton soil with pond ash, he mixed pond ash with different parentage. He cured black cotton mix specimen for 7 and 28 days to obtain the strength of mix specimen. He determined that swelling pressure decreased by 75% after 7 days curing and 79% after 28 days curing when soil specimens were treated with 25% class C fly ash (18.98% of CaO).

Phanikumar and Sharma (2004) studied the effect of Fly Ash on engineering properties of expansive soil through an experimental program. The effect on parameters like free swell index (FSI), swell potential, swelling pressure, plasticity, compaction, strength and hydraulic conductivity of expansive soil was studied. The ash blended expansive soil with FLY ASH contents of 0, 5, 10,15 and 20% on a dry weight basis and they inferred that increase in FLY ASH content reduces plasticity characteristics and the FSI was reduced by about 50% by the addition of 20% Fly Ash. The hydraulic conductivity of expansive soils mixed with Fly Ash decreases with an increase in Fly Ash content, due to the increase in maximum dry unit weight with an increase in Fly Ash content. When the Fly Ash content increases there is a decrease in the optimum moisture content and the maximum dry unit weight increases. The effect of Fly Ash is akin to the increased compactive effort. Hence the expansive soil is rendered more stable. The untrained shear strength of the expansive soil blended with Fly Ash increases with the increase in the ash content.

Satyanarayana et. al. (2004) aimed to study the mutual effect of addition of lime and fly ash on the engineering properties of expansive soil. They found that 70%, 26% and 4% were the optimum percentage mixture of the ingredients for the construction of roads and embankments.

Baytar A. (2005) studied the stabilization of expansive soils using desulphogypsum and fly ash acquired from a thermal power plant by 0% to 30%. A variable percentage of lime (0% to 8*) was appended into the expansive soil – desulphogypsum – fly ahs mixture. The samples, thus formed, were cured for a period of 7 days and 28 days. It was observed that swelling percentage decreases about 23 and there was an increase in rate of swell with increasing percentage of stabilizer in mixture. The curing process reduced the swelling percentage further, and with the addition of 30% desulphogypsum and 25% fly ash, reduction in swelling too.

Brooks (2009) studied "soil stabilization with fly-ash and rice husk ash" and reported that the rice husk ash (RHA) content of 12% and a fly-ash content of 25% are recommended for strengthening the expansive sub grade soil while a fly-ash content of 15% is recommended for blending into RHA to form a swell reduction layer. Fly-ash is an industrial waste obtained from thermal power plants by burning of coal. The test result showed a significant improvement in compaction and CBR characteristics. And fly-ash is found to be an effective waste material for the stabilization of expansive soil.

Jakka et al. (2010) studied the geotechnical characteristics of pond ash samples, sampled from the outflow and inflow points of two ash pond areas in India. Strength characteristics were obtained using CD (consolidated drained) and CU (consolidated undrained) triaxial tests with pore water pressure measurements, conducted on loose and compacted specimens of pond ash samples under different confining pressures. Ash samples collected from the inflow point of ash pond area exhibited similar behaviour to sandy soils in many aspects. Their strength was higher than the reference material (Yamuna sand), though their specific gravity and MDDs are significantly lower than sands. Ash samples from the outflow point of ash pond area exhibited significant differences in their values and properties as compared to the samples from the inflow point of the ash pond area. Samples from the outflow point had low Shear strength particularly in loose state in which case static liquefaction is observed. **Saran A. (2011) -** conducted various tests on pond ash and found that the dry density of compacted specimens changed from 10.90 to 12.70kN/m3 with the change in the compaction energy from 357 to 3488kJ/m3, whereas the OMC decreased from 38.82 to 28.09%. It is also concluded that by reducing the percentage of water content from the OMC, the UCS value will be increased at a sustained DOS of 13% and 14 % and then, will be decreased in standard proctor density as well as in modified proctor density due to the lubrication of the surface of ash particles. A linear relationship was found to exist between the unconfined compressive strength and the compaction energy. When pond ash is reinforced with fibre, its ductility is increased.

III. EXPERIMENTAL INVESTIGATIONS

Various such as Atterberg's limit (liquid limit and plastic limit), Differential free swelling, Swelling pressure, OMC and MDD, UCS, etc tests have been performed to find out the engineering properties of black cotton soil as well as soil mixed with pond ash. The percentage of pond ash may have varied from 0% to 50% at 10% interval.

3.1 Material Used

- **Black Cotton Soil –** About 100 kg of soil sample for the present work was collected from the Borkheda, Kota.
- **Pond Ash –** The pond ash sample is collected form Kota Thermal Power Station, Kota.

3.2 Atterberg's Limits

The for classifying the soil, pond ash and mix specimen of soil, the wet sieve analysis for black cotton soil and Atterberg's limit test are conducted. For determining the type of soil, the wet sieve analysis of soil particles is done by using 75-micron sieve. It is found that the soil particles are passed more than 50% and the soil is classified as fine grain soil based on these results classification is done as per IS 1498 (1970). In Atterberg's limit test, the soil and pond ash Atterberg's limits are determined separately and these tests are also conducted for mix specimen of the black cotton soil with different percentage of pond ash. The results of Atterberg's limit is shown in Table 3.1.

The liquid limit and plastic limit are 41.41% and 18.46% determined for black cotton soil. Pond ash is having 35.91% liquid limit and it is Non – plastic material. Its observed that the plasticity index is more than to pond ash. That shows, when amount of pond ash increases, the plasticity index varied. The plasticity index of black cotton soil was found to be 22.95%.

Table 3.1: Atterberg's limit for different specimen

Test Specimen	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Specimen Classification
Black Cotton Soil (BCS)	41.41	18.46	22.95	CI
Pond Ash (PA)	35.91	Non - Plastic	Non - Plastic	CL
BCS + 10% PA	39.99	19.45	20.54	CI
BCS + 20% PA	38.62	18.30	20.32	CI
BCS + 30% PA	35.37	16.38	18.99	CI
BCS + 40% PA	34.90	14.89	20.01	CL
BCS + 50% PA	34.66	14.45	20.21	CL

From Table 3.1, the value of liquid limit and plastic limit continuously decreases from 39.99% to 34.66% and 19.45% to 14.45% respectively in mix specimen. When 30% pond ash is mixed in black cotton soil. the plasticity index decreased 18.99%. The graphical representation of plasticity limit of mix specimen is shown in fig. 3.1.

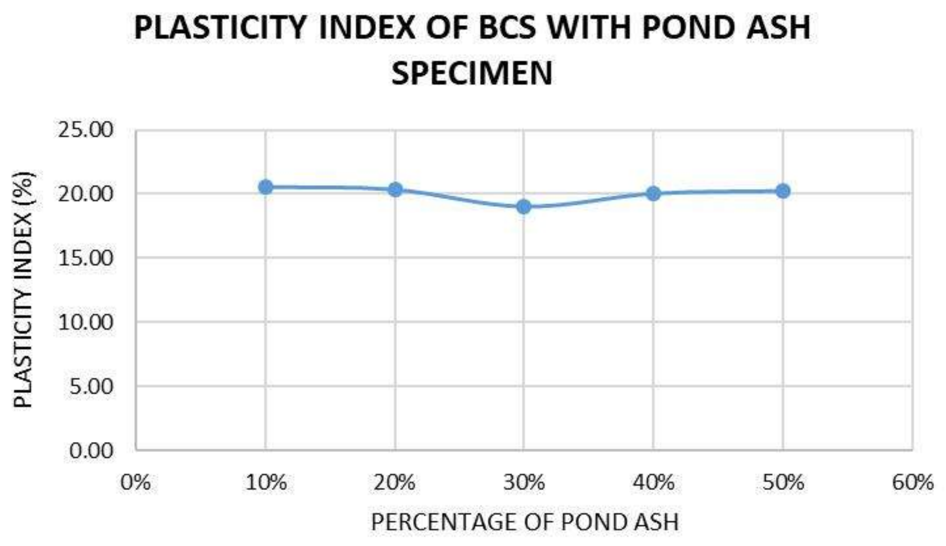

Fig. 3.1 – Plasticity characteristics of mix specimen

From Table 3.1, it is observed that the black cotton soil is inorganic soil of medium plasticity clay and pond ash is inorganic fine of low plasticity. When the amount of the pond ash increases, the behaviour of soil comes from medium plasticity to low plasticity clay.

3.3 Standard Proctor Test

The object of test is to find out optimum moisture content and maximum dry density of black cotton soil with varied percentage of Kota stone slurry. The results of standard proctor test are shown in Table 3.2.

From Table 3.2, it is observed that the maximum dry density of soil is 1.725 kg/cm^3 determined. With increasing the percentage of pond ash in clay, the maximum dry density decreases with increasing the percentage of pond ash. The maximum dry density 1.685 kg/cm^3 is obtained for 10% pond ash mix specimen. The maximum dry density and optimum moisture content was obtained 1.240 kg/cm3 and 26.2% respectively for pond ash. The graphical representation of standard proctor test is shown in fig. 3.2.

Table 3.2: Standard Proctor Test for Black Cotton Soil, Kota Stone Slurry and Mix Specimen

Test Specimen	MDD (kg/cm^3)	OMC (%)
Black Cotton Soil (BCS)	1.725	17.4
Pond Ash (PA)	1.240	26.2
BCS + 10% PA	1.685	17.5
BCS + 20% PA	1.654	17.1
BCS + 30% PA	1.675	15.5
BCS + 40% PA	1.675	14.9
BCS + 50% PA	1.680	14.0

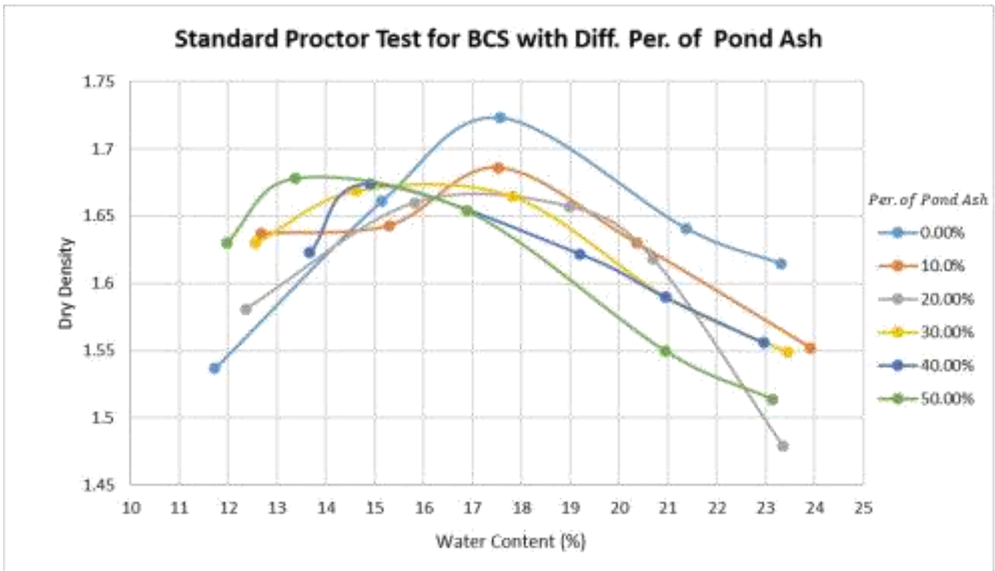

Fig. 3.2 – Standard proctor test for black cotton soil and mix specimen

3.4 Differential Free Swelling

The object of testing is to find out the free swell index of soil which helps to identify the potential of specimen. The test results were obtained on the basis of IS 2720 (Part 40) 1977. The test results are shown in Table 3.3 and graphical representation is also shown in fig. 3.3.

Table 3.3 – DFS results for black cotton soil and mix specimen

Test Specimen	Free Swell Index (%)	Degree of Expansiveness	Percentage Decrease
BCS	53.33	Very High	-
BCS + 10% PA	47.62	High	10.71
BCS + 20% PA	45.45	High	14.78
BCS + 30% PA	26.92	Moderate	49.52
BCS + 40% PA	25.93	Moderate	51.38
BCS + 50% PA	22.22	Moderate	58.33

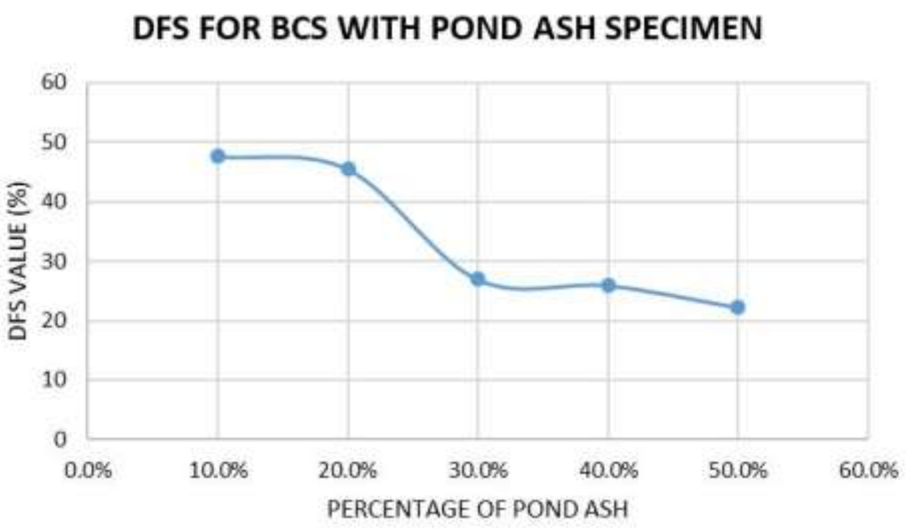

Fig. 3.3 – DFS of Mix Specimen

From fig. 3.3, it has observed that with increasing the percentage of pond ash in the clay, the degree of expansiveness decreases. The clay is having high degree of expansiveness and the value is 53.33%. This degree of expansiveness, decreases from 55.33% to 22.22%. This is meant, when 50% pond ash is added in clay, the expansiveness decreases about 58.33%.

3.5 Swelling Pressure

The swelling pressure test is also conducted for determining the pressure for black cotton soil and with different percentage of Kota stone slurry. The results are based on IS 2720 (Part 41) 1977. The obtained results are shown in Table 3.4 and graphical presentation is shown in fig. 3.4.

Table 3.4 – Swelling Pressure Results for BCS and Mix Specimen

Test Specimen	Pressure (kg/cm^2)	Percentage Decrease
Black Cotton Soil (BCS)	1.10	-
BCS + 10% PA	1.00	9.09
BCS + 20% PA	1.00	9.09
BCS + 30% PA	1.00	9.09
BCS + 40% PA	0.90	18.18
BCS + 50% PA	0.85	22.73

Fig. 3.4 shows, the variation of swelling pressure with dial reading for black cotton soil and with varied percentage of pond ash. It is also observed that the swelling pressure value for clay is 1.1 kg/cm^2. By varying percentage of pond ash in black cotton soil, at 10% of pond ash in black cotton soil, the swelling pressure is 1.00 kg/cm^2 and there is decrement is 9.09%. Further with increasing the amount of pond ash upto 50% in clay, the swelling pressure decreased from 22.73% from swelling pressure of clay.

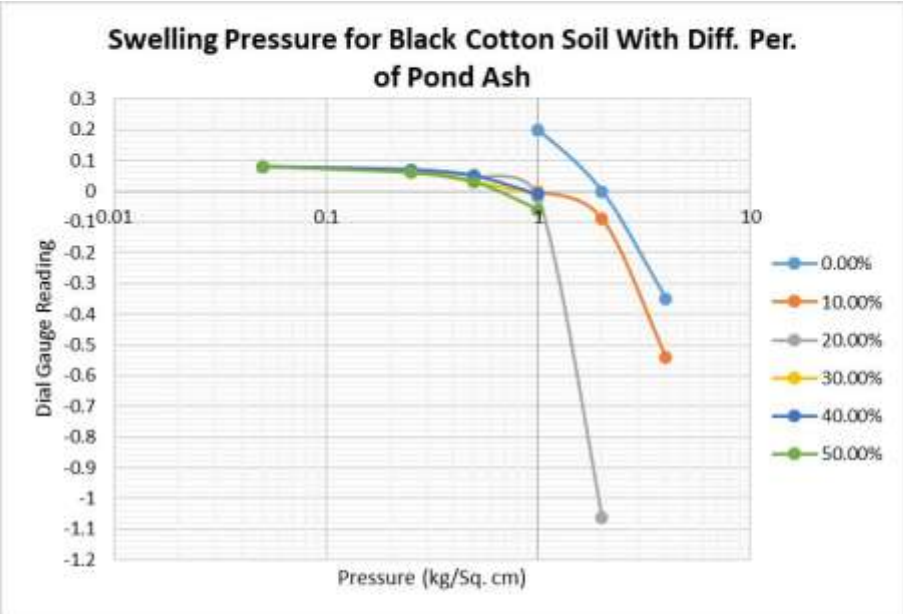

Fig. 3.4 – Swelling pressure for black cotton soil with different percentage of pond ash

3.6 Unconfined Compressive Strength

The object of testing is to determine the shear strength parameter of clay and mix specimen by loading axially cylindrical specimen. The test results are obtained according to IS 2720 (part 10) 1973. The observation and calculation of UCS test is shown in Table 3.5.

Table 3.5 – UCS Test for Black Cotton Soil and Mix Specimen

Test Specimen	UCS, q_u (N/cm^2)	Shear Strength C_u (N/cm^2)	Percentage Decrease in C_u
Black Cotton Soil (BCS)	15.97	07.98	-
BCS + 10% PA	02.13	01.06	86.77
BCS + 20% PA	10.30	05.15	35.95
BCS + 30% PA	14.38	07.19	10.59
BCS + 40% PA	09.57	04.79	40.48
BCS + 50% PA	04.62	02.31	71.26

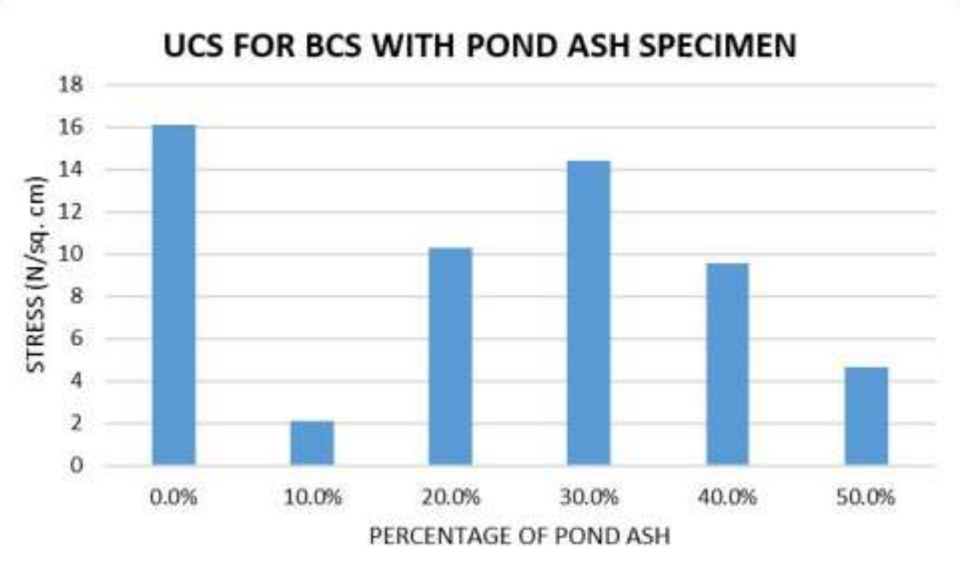

Fig. 3.5 – UCS for black cotton soil and with diff. per. of pond ash

From fig. 3.5, it is observed that the unconfined compressive strength of black cotton soil is 15.967 N//cm^2 and shear strength is 7.983 N/cm^3. The maximum value of UCS is 14.38 N/cm^2 determined for 30% pond ash with black cotton soil. The shear strength value 7.19 N/cm^2 is determined for 30% mix specimen, which is decreased 10.59% from shear strength value of black cotton soil.

IV. DISCUSSIONS ON TEST RESULTS

The black cotton soil changes it is behaviour due to pond ash. The pond ash is non - plastic material and black cotton soil is inorganic clay of medium plasticity but when amount of pond ash increases, the black cotton soil changes behaviour from CI to CL. When plasticity of the mix specimen decreases, it means the differential free swell and swelling pressure also decreases. The maximum dry density and optimum moisture content is determined at 10% pond ash mix specimen. It is also observed that 20% to 50% pond ash, the dry density decreases with increasing the percentage of pond ash. The shear strength is also decreases from 10% to 50% pond ash mix specimen but 30% pond ash mix specimen gives better results to all other mix specimen of pond ash.

V CONCLUSIONS

The following conclusions are prepared after performing the experiments.

- The differential free swell index decreases by increasing the percentage of pond ash. When 50% pond ash is added in black cotton soil, the differential free swell decreases about 58.33%
- The swelling pressure of black cotton decreases by 27.73% by adding 50% pond ash.
- The optimum moisture content and maximum dry density decreases with increasing the percentage of pond ash.
- The UCS value decreases with increasing the percentage of pond ash. The shear strength of mix specimen is 86.77% which is not worth for improving the engineering properties of black cotton soil.
- The all results are inappropriate, so the pond ash is not useful to improve the engineering properties of black cotton soil.

VI ACKNOWLEDGEMENTS

I would like to express my profound gratitude and indebtedness to Er. Jitendra Khatti and my best friend Er. Amit Kumar Jangid who have always been a constant motivation and guiding factor throughout the research time in and out as well. Er. Jitendra Khatti is PhD. Scholar, who is doing PhD. from civil engineering department of University Teaching Department, RTU, Kota. It has been a great pleasure for me to get an opportunity to work under them and complete the research work successfully.

REFERENCES

[1] Cokca, E. (2001), "Use of Class C fly ash for the stabilization of an expansive soil", ASCE Journal of Geotechnical and Geo - environmental Engineering. Vol. 127, Issue 7, pp. 568–573.

[2] Phanikumar, B.R. and Sharma, R. S. (2004), "Effect of Fly Ash on Engineering Properties of Expansive Soil", Journal of Geotechnical and Geo - environmental Engineering. Vol. 130, Issue 7, pp. 764-767.

[3] Satyanarayana P. V. V, Rama Rao R and Krishna Rao C V (2004), "Utilization of Lime Fly Ash Stabilized Expensive Soil in Roads and Embankments". Proceedings of Indian Geotechnical Conference, Warangal (India). 465-467.

[4] Baytar, A. (2005). "Effects of fly ash and desulphogypsum on the geotechnical properties of cohesive Soil". A Master of Science thesis submitted to the graduate school of natural and applied sciences Of Middle East technical university.

[5] Brooks M. Robert (2009) "Soil Stabilization with fly ash and rice husk ash" international journal of research and reviews in applied science, volume 1, Issue 3, PP-209-217

[6] Jakka, R.S., Ramana, G.V. and Datta, M (2010), "Shear Behaviour of Loose and Compacted Pond Ash".

[7] Saran, A.(2011). "Strength characteristics of Fibre reinforced Compacted Pond ash."Mtech Thesis, National

[8] Dr. B. C. Punamia, Ashok Jain, Arun Jain, Soil Mechanics and Foundations, Laxmi Publications, New Delhi.

[9] Dr. K. R. Arora, Soil Mechanics and Foundation Engineering, Standard Publications, New Delhi.

[10] Indian Standard Code : IS 1498 – 1970, Classification and identification of soils for general engineering purposes (first revision).

[11] Indian Standard Code : IS 2720 (Part 5) – 1985, Determination of liquid limit and plastic limit (second revision).

[12] Indian Standard Code : IS 2720 (Part 7) – 1980, Determination of water content, dry density relation using light compaction (second revision).

[13] Indian Standard Code : IS 2720 (Part 10) – 1973, Determination of unconfined compressive strength (first revision).

[14] Indian Standard Code : IS 2720 (Part 40) – 1977, Determination of free swell index of soils.

[15] Indian Standard Code : IS 2720 (Part 41) – 1977, Determination of swelling pressure of soils.