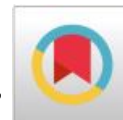




EFFECT OF FLY ASH ON GEOTECHNICAL PROPERTIES OF SOIL

Abhishek Dixit ^{*1}, Manish Nigam ², Rahul Mishra ³

^{*1, 2, 3} Assistant professor, Civil Engineering Department, PSIT College of Engineering Kanpur, INDIA



Abstract:

This paper investigates the effect of fly ash (generated from thermal power plant, Panki, Kanpur) on geotechnical properties of local soil, Bhauti Kanpur (U.P), INDIA. The fly ash used in the experimental work was of Class 'F' and soil was clayey in nature. Fly ash collected from the hopper attached to an electrostatic precipitator when coal was changed at a coal fired power plant. Concerning the major challenges regarding the safe reuse, management and disposal of these wastes an attempt has been made to mix fly ash at 5, 10, 15, 20, 25, and 30% on the basis of dry weight with local clay soil. To understand the behavior of fly ash with soil, numbers of laboratory experiments were performed on the local soil (clay) and contaminated soil with varying percentage of fly ash. As the result, it is shown that all the investigated properties were decreased except CBR value and optimum moisture content.

Keywords:

Fly ash, Hazardous waste, Land Contamination, Soil.

Cite This Article: Abhishek Dixit, Manish Nigam, and Rahul Mishra, "EFFECT OF FLY ASH ON GEOTECHNICAL PROPERTIES OF SOIL" *International Journal of Engineering Technologies and Management Research*, Vol. 3, No. 5(2016)7-14.

1. INTRODUCTION

Any country's economic & industrial growth depends on the availability of power. In India also, coal is a major source of fuel for power generation. About 60% power is produced using coal as fuel. Indian coal is having low calorific value (3000-3500 K cal.) & very high ash content (30-45%) resulting in huge quantity of ash is generated in the coal based thermal power stations. fly ash is under the manufacturing hazardous waste category. Presently in India, there is reported 7.2 million tone hazardous waste generation from more than 40,000 registered industries according to Controller and Auditor General's report (CAG-2012)[1] and there is no estimate of unregistered hazardous waste generating industries. This industrial hazardous waste has recyclable, landfill able and incinerable components.

According to Dixit et al. (2016)[2], Contamination of land may be due to the disposal variety of wastes and chemicals on or in the soil. Sources of land contamination could be several. Some contamination sources are listed as follows:

1. Industrial hazardous waste
2. Electronic waste

3. Municipal waste
4. Disposal of coal ash
5. Construction and demolition waste
6. Agricultural practices
7. Accidental disasters and oil spills
8. Chemical and nuclear plant waste
9. Chemical waste due to dismantling of ships
10. Illegal importing hazardous waste
11. Oil refineries

The scope of this study is limited to fly ash waste generation and its effect on soil.

In India, During 2005-06 about 112 million tone of ash has been generated in 125 power stations and the ash production is expected to be about 72 million tone by 2012 and about 100 million tone by 2017[3]. Any coal based thermal power station may have the following four kinds of ash:

- Fly Ash: This kind of ash is extracted from flue gases through Electrostatic Precipitator in dry form. This ash is fine material & possesses good pozzolanic property.
- Bottom Ash: This kind of ash is collected in the bottom of boiler furnace. It is comparatively coarse material and contains higher un burnt carbon. It possesses zero or little pozzolanic property.
- Pond Ash: When fly ash and bottom ash or both mixed together in any proportion with the large quantity of water to make it in slurry form and deposited in ponds wherein water gets drained away. The deposited ash is called as pond ash.
- Mound Ash: Fly ash and bottom ash or both mixed in any proportion and deposited in dry form in the shape of a mound is termed as mound ash. As per the Bureau of Indian Standard IS: 3812 (Part-1)[2] all these types of ash is termed as Pulverized Fuel Ash(PFA).
- The best way of disposing fly ash is to utilize it with some additives and converting it into a non-hazardous material and apply them in eco-friendly way. Fly ash have some good pozzolanic property and when it mix with the soil the water content present in the soil react with the fly ash and form a gel ,which act as good binder. so it is better way to utilize fly ash in soil stabilization. Erdal Cokca (2001)[5] Effect of Fly Ash on expansive soil was studied by Erdal Cokca(2001),his experimental findings confirmed that the plasticity index, activity and swelling potential of the samples decreased with increasing percept stabilizer and curing time and the optimum content of Fly Ash in decreasing the swell potential was found to be 20%. The changes in the physical properties and swelling potential is a result of additional silt size particles to some extent and due to chemical reactions that cause immediate flocculation of clay particles and the time dependent pozzolanic and self-hardening properties of Fly Ash.

Pandian et al. (2002)[6]. Studied the effect of two types of Fly Ashes Raichur Fly Ash (Class F) and Neyveli Fly Ash (Class C) on the CBR characteristics of the black cotton soil. The Fly Ash content was increased from 0 to 100%.The low CBR of BC soil is attributed to the inherent low strength, which is due to the dominance of clay fraction. The addition of Fly Ash to BC soil increases the CBR of the mix up to the first optimum level due to the frictional resistance from Fly Ash in addition to the cohesion from BC soil. Further addition of Fly Ash beyond the

optimum level causes a decrease up to 60% and then up to the second optimum level there is an increase. Thus the variation of CBR of Fly Ash-BC soil mixes can be attributed to the relative contribution of frictional or cohesive resistance from Fly Ash or BC soil, respectively.

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 comp active 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. Phanikumar and Sharma (2004)[7].

2. MATERIALS AND METHODS

In this study the local clay soil and Indian class F fly ash are used to study the geotechnical properties. The locally available clay soil, Indian fly ash samples and soil-fly ash mixed samples containing fly ash of 5, 10, 15, 20, 25 and 30% on the basis of dry weight and total seven numbers of samples are used for present investigation. The following laboratory test was carried out as per IS-2720[8].The test were carried out on both normal soil and soil fly ash mixed sample:

1. Atterbergs limits
2. Grain size analysis
3. Specific gravity
4. Proctor compaction
5. California bearing ratio test

3. RESULT AND DISCUSSION

The experimental results of different geotechnical properties of soil with different percentage of contamination with fly ash were presented in Table 1.

Table 1: Variation of geotechnical properties with different percentage of contamination.

% of fly ash as a contaminant	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	Shrinkage Limit (%)	Specific gravity	Optimum moisture content (%)	Maximum Dry Density (Kg/m ³)	California Bearing Ratio Value(%) @ 5 mm
0	36.95	24.44	12.51	10.57	2.63	19.33	16.48	3.10
5	36.80	24.88	11.92	10.51	2.60	20.08	16.45	3.10
10	36.50	24.97	11.53	9.28	2.58	21.03	16.44	3.12
15	35.66	24.19	11.47	8.56	2.55	21.43	16.40	3.13
20	35.01	24.15	10.86	7.30	2.53	21.83	16.53	3.16
25	34.92	24.39	10.53	7.02	2.40	21.97	15.75	3.22
30	34.72	24.60	10.12	6.30	2.33	22.37	14.93	3.11

Fig. 1 to Fig. 8 presented the variation of different geotechnical properties with respect to varying contamination percentage. Table.1 shows that liquid limit and plasticity index of the soil with increase in percentage contamination of fly ash decreasing(fig.1 and fig.3).

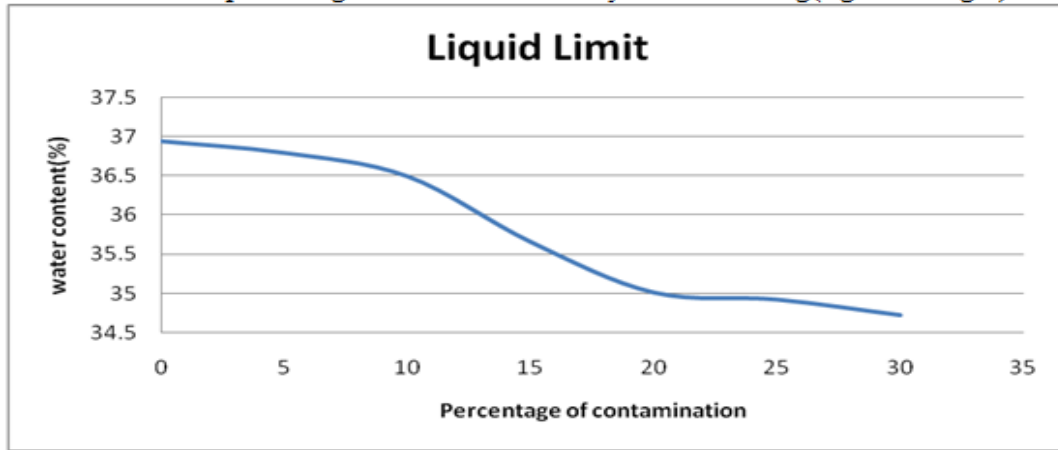


Figure 1: Variation of liquid limit with different percentage of fly ash contamination.

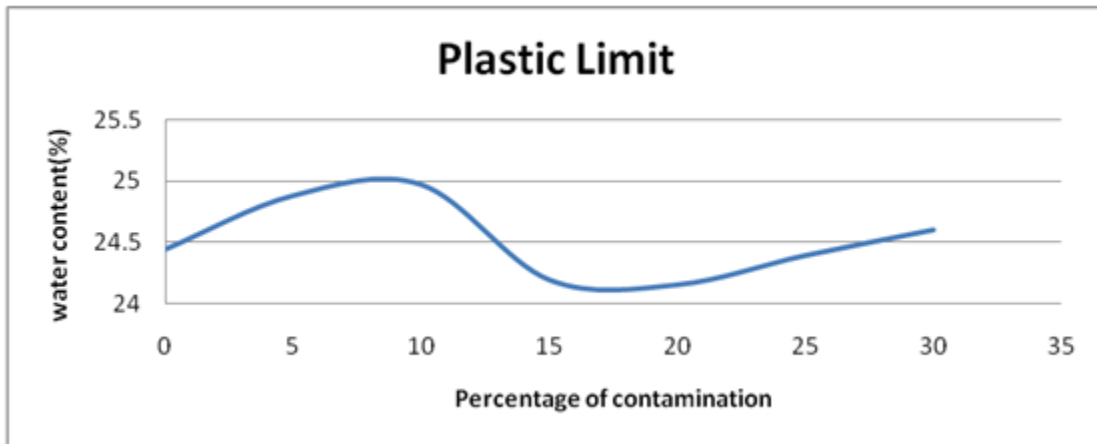


Figure 2: Variation of plastic limit with different percentage of fly ash contamination.

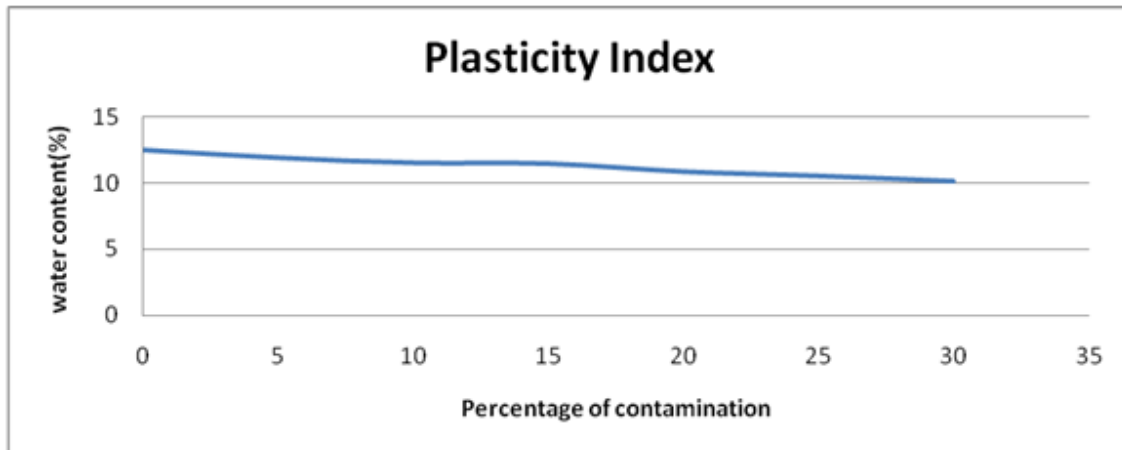


Figure 3: Variation of plasticity index with different percentage of fly ash contamination.

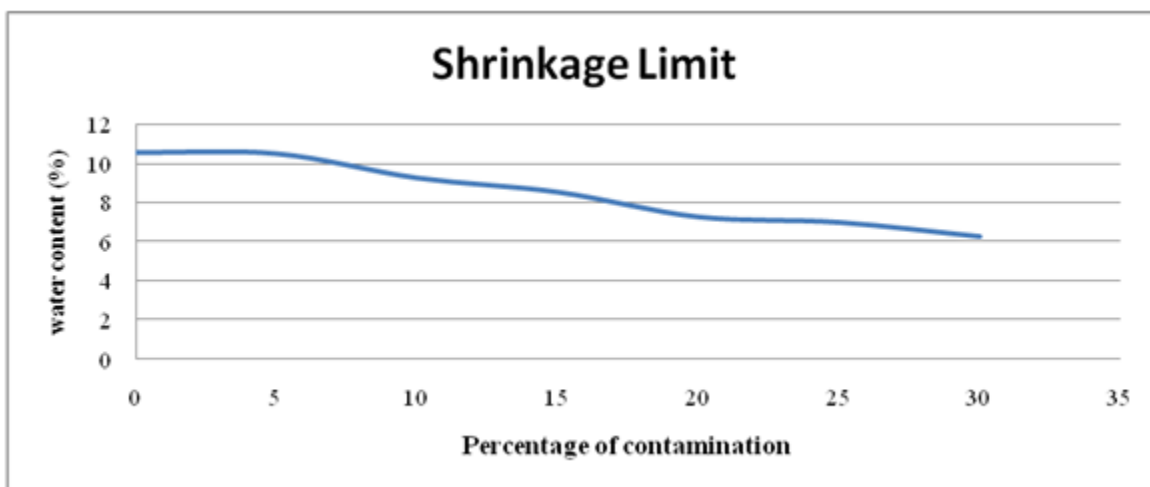


Figure 4: Indicates that shrinkage limit of soil was decreasing with increase of contaminant quantity.

Fig.4. Variation of shrinkage limit with different percentage of fly ash contamination.

- Discussion on shrinkage limit: With the increase of fly ash contents in mixed samples, the shrinkage values are decreased. The addition of non-shrinking and cohesion less fly ashes in local soil decrease the tendency of the mixed samples to shrink. The reductions in linear shrinkage may be due to the ingress of comparative less percentages of water which can be viewed from liquid limit values.

The specific gravity values were decreases as the fly ash content increases in the soil (fig.5).

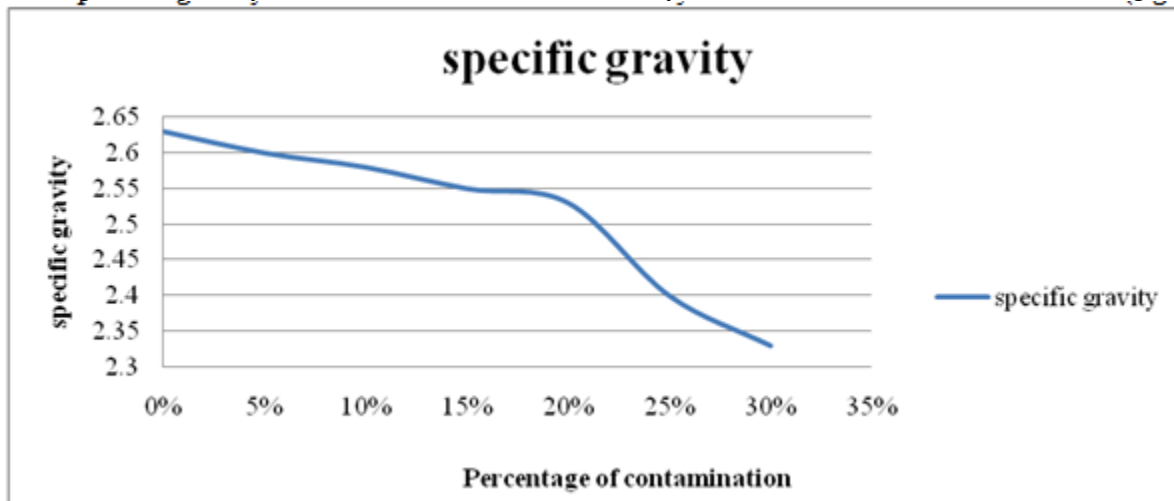


Figure 5: Variation of specific gravity with different percentage of fly ash contamination.

- Discussion on specific gravity : Fly ash particles are hollow, thin walled cenosphere, having low weight than conventional soil, so in mixed samples the overall weight become less. The similar trend was observed for fly ash and bottom ash mixed samples (Kim et al. 2005)[9], for pond ash

was amended with locally available soil (Kumar 2004)[10] and for coal ashes as better alternative materials of construction (Prakash and Sridharan (2009)[11].

Compaction effort is one and only parameter that controls the compaction characteristics i.e. dry density and moisture content at optimum state. Moisture content and dry density relation from standard Proctor compaction tests for the local clay soil and soil-fly ash mixed sample are shown in table 1.

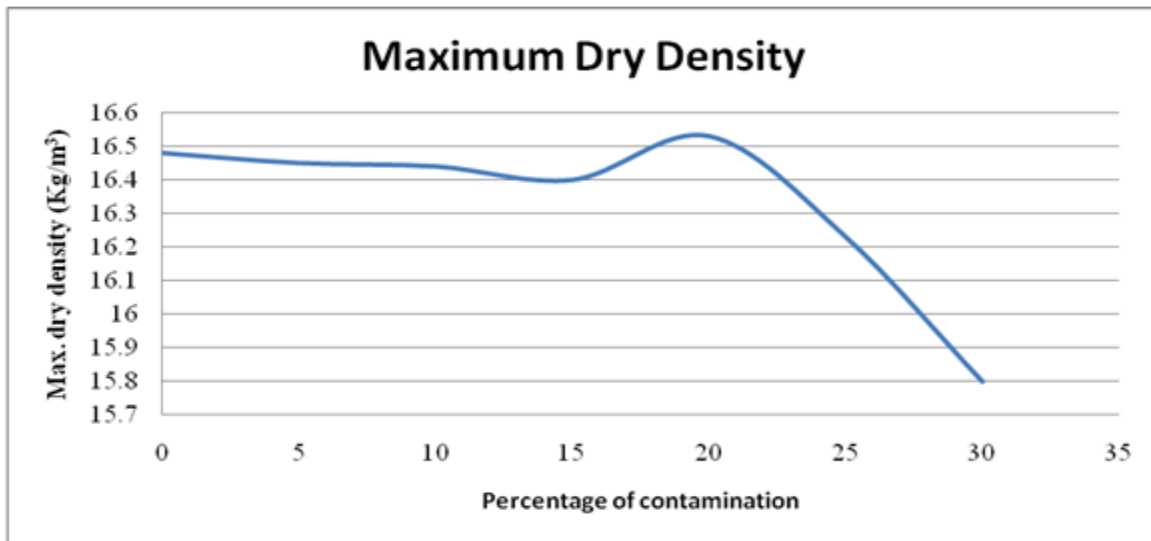


Figure 6: Variation of maximum dry density with different percentage of fly ash contamination.

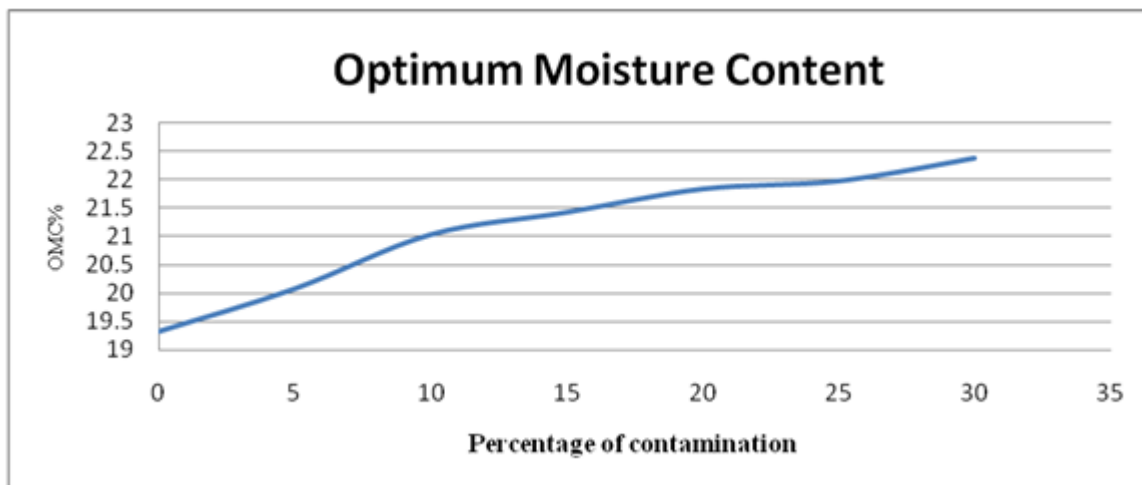


Figure 7: Variation of optimum moisture content with different percentage of fly ash contamination.

- Discussion on optimum moisture content: The inclusion of low weight and coarser fly ashes in local soil can make the mixed samples comparatively coarser and decrease the overall weight. The significance of these changes depends upon the amount of ash added and the chemical composition of the clay minerals and ash. The decrease resulted from the flocculation and

agglomeration of clay particles in presence of sufficient water leading to increase in voids and corresponding decreases in dry densities. The reason for the increasing OMC may be attributable to the affinity of the soil-fly ash mixed samples for more water to complete the cat ion exchange reaction and with application of compaction effort the voids are occupied by more water. The Similar trend was observed by Osinubi (1998)[12] in case of compaction delays on lime-treated lateritic soil with compaction delay and no compaction delays. It was also observed similar result in application of silica fume for natural clay liners. The results show more conformity with the present trend when evaluated the efficiency of fly ash as an additive in improving the engineering characteristics of expansive soils, compaction characteristics of pond ash amended locally available soil.

CBR value is used as an index of soil strength and bearing capacity. This value is broadly used and applied in design of the base and sub base material the local soil CBR value for 5mm penetration is 3.10 % as the fly ash content increased the CBR value increases till 25% mix and then start decreasing. The decrease in CBR value after the 25% because the pore water filled in the flocks.

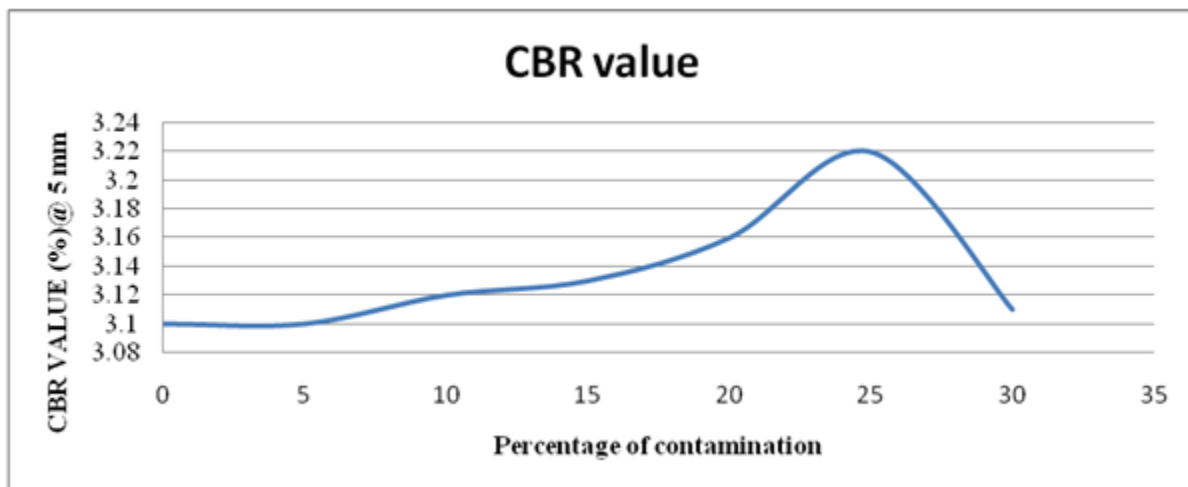


Figure 8: Variation of CBR (%) with different percentage of fly ash contamination.

4. CONCLUSIONS

The following conclusions are made based on the above results and discussions.

- In general, decrease in values of specific gravity, plasticity index and shrinkage limit in the soil-fly ash mix samples irrespective of fly ash mix.
- With the increase of ash content in the soil-ash mix samples, MDD decreases and OMC increases irrespective of fly ash mix.
- With the increase of ash content in the soil-ash mix samples, CBR value increases at 25% it gives maximum value which is more suitable for road construction.
- 30% of fly ash contents or above in local clay soil-fly ash mixed sample, this material may be used as land filling and embankments in the field of geotechnical engineering construction.

5. REFERENCES

- [1] *Controllor and Auditor General (CAG -2012), All India audit report on "management of waste India". (saiindia.gov.in/...Reports/...Reports/...Report_Environment.../Chapter_5)*
- [2] *A.Dixit, R.K. Srivastava, An Estimate of Contaminated Land Area due to Industrial Hazardous Waste Generation in India, International Journal of Advanced Research in Education & Technology 2016, vol.2 issue 3, pp.117-125.*
- [3] *Ash Utilization Division National Thermal Power Corporation (NTPC-2007), Resource For High Strength and Durability of Structures at Lower Cost.*
- [4] *E Cokca, Z Yilmaz, Use of rubber and bentonite added fly ash as a liner material, - Waste management, 2004, 24(2):153-64*
- [5] *KC Krishna, NS Pandian, California bearing ratio behavior of cement-stabilized fly ash-soil mixes Journal of testing and evaluation, 2002 Vol. 30, No. 6, pp. 1-5.*
- [6] *Phanikumar, B. and Sharma, R. (2007). "Volume Change Behavior of Fly Ash-Stabilized Clays." J. Mater. Civ. Eng., 10.1061/(ASCE)0899-1561(2007)19:1(67), 67-74.*
- [7] *Pandian, N. and Krishna, K., "California Bearing Ratio Behavior of Cement-Stabilized Fly Ash-Soil Mixes," Journal of Testing and Evaluation, 2002.*
- [8] *Standard Compaction Effort equivalent to IS light compaction (IS: 2720 Part VII, 1980*
- [9] *B Kim, M Prezzi, R Salgado, Geotechnical properties of fly and bottom ash mixtures for use in highway embankments, 2007; 133(7). 902*
- [10] *R Kumar, S Kumar, SP Mehrotra Towards sustainable solutions for fly ash through mechanical activation Resources, Conservation and Recycling, 2007, 52 (2007) 157–179*
- [11] *K Prakash, A Sridharan, Beneficial properties of coal ashes and effective solid waste management- Practice Periodical of Hazardous, Toxic, ..., 2009 Volume 13, Issue 4, 239-248.*
- [12] *KJ Osinubi, Permeability of lime-treated lateritic soil Journal of Transportation Engineering, 1998 Volume 124, Issue 5, 465-469.*