IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684, p-ISSN: 2320-334X
PP 36-40
www.iosrjournals.org

Influence of sand and fly ash on clayey soil stabilization

Chavali Rama Vara Prasad, Dr. R. K. Sharma
(Department of Civil Engineering, National Institute of Technology, Hamirpur, Himachal Pradesh, India)

ABSTRACT: *Clayey soils often exhibit undesirable engineering properties such as low strength, swelling and shrinkage characteristics etc., to improve these properties the common method followed is stabilization. In this paper an attempt was made to assess the effectiveness of clayey soil blended with Beas sand and fly ash for soil stabilization by studying the subgrade characteristics. It gives solution for proper disposal of fly ash and also provides good subgrade material for pavement construction. The results show substantial improvement in compaction and California bearing ratio of composite containing clay, sand and fly ash (70: 30: 10). The swelling nature of the clay also reduced up to 60% after stabilization. Thus the stabilized composite can be used for construction of flexible pavements in rural areas with low traffic.*
Keywords- *Beas sand, California bearing ratio, clayey soil, compaction, fly ash*

I. INTRODUCTION

For many years admixtures such as lime, cement and cement kiln dust are used to improve the qualities of readily available local soils. Laboratory and field experiments have confirmed that the addition of these admixtures can increase the strength and stability of such soils. However, the cost of introducing these admixtures has also increased in recent years. This has opened the door for researchers to find alternate admixtures such as plastic, fibers, liquid enzymes, micro bacteria etc. In view of this a lot of researchers working on utilization of fly ash in different construction operations. Jirathanathworn and Chantawarangul (2003) reported that by using fly ash mixed with small amount of lime, it is possible to improve some of the engineering properties of clayey soil including hydraulic conductivity as well as strength. Mathur et al (2003, 2005) have used fly ash in embankment with the technique of reinforced earth with a view to use this waste in road work. Bhuvaneshwari (2005) concluded that workability and maximum dry density was achieved at 25% of fly ash. Edil *et al* (2006) indicated the effectiveness of fly ashes for stabilization of fine grained soils. Kaushik and Ramasamy (2006) examined the various properties of coal ash to be used as good construction material in geotechnical applications. It is observed that fly ash exhibits high strength at compaction moisture content but poor shear strength characteristics under saturated conditions. Bhatta (2008) concluded that the addition of river sand to pond ash improved the CBR value so that it could be used for construction of sub grade. Chauhan et al (2008) observed that optimum moisture content increases and maximum dry density decreases with increased percentage of fly ash mixed with silty sand. Eskioglou and Oikonomou (2008) showed that the addition of ash increased the optimum moisture content in the compaction tests. The increase in optimum moisture content contributes to increase in the stabilization capacity of soil. Ravishankar et al. (2008) reported that addition of pond ash (PA) resulted in reduction of maximum dry density of blend with slight increase in optimum moisture content. Further addition of ordinary Portland cement resulted in improvement of strength characteristics. Prasad (2011) studied behavior of reinforced fly ash sub-base for flexible pavement and it was observed that with increase in reinforcement, CBR value improved. Bose (2012) reported that maximum dry density increases up to 20% fly ash mix, and then gradually decreases whereas the optimum moisture content decreased with increase in fly ash and also CBR values of clay-fly ash mixes tested under un-soaked conditions, shows peaks at 20% and 80% ash content. It was found that a clear optimum replacement level of 15% for all of these by products for medium and low plasticity type of soils. Supriya Saha and Sujit kumar pal (2013) achieved maximum unconfined compressive strength from the fly ash-soil-fly ash layers placed successively. Takhelmayum Gyanen *et al.* (2013) concluded that with percentage addition of fine, coarse fly ash improves the strength of stabilized black cotton soil and exhibit relatively well-defined moisture-density relationship, the peak strength attained by fine fly ash mixture was 25% more when compared to coarse fly ash.

This study has been undertaken to explore the possibility of stabilizing clay by using fly ash in combination with sand. The basic engineering properties of the composite material (clay: sand: fly ash) and their compaction and strength characteristics have been studied. The results have been discussed to bring out the possibility of using the composite in the construction of sub-grades for roads.

II. EXPERIMENTAL PROGRAM

Materials

The soil used in the study was locally available clayey soil and local sand. According to IS classification system, the soil was classified as clay with medium plasticity (CI) and the properties of clay are given in table 1. Sand was obtained from Beas river bed which can be classified as poorly graded sand (SP). The fly ash was obtained as residue left after electronic precipitation of the burnt gases. The particle size distribution curves for soil, sand and fly ash are shown in Figure 1 (IS: 2720 - Part IV). The geotechnical properties of various materials used in the study are shown in Table 1.

Table 1 Physical properties of materials used

Property	Clay	Sand	Fly ash
Specific gravity	2.627	2.637	1.947
Maximum dry density, MDD (g/cc)	1.910	1.592	1.159
Optimum moisture content, OMC (%)	12.6	7.3	31.8
Liquid limit (%)	43.6	-	41.6
Plastic limit (%)	23.4	-	-
Plasticity index (%)	20.2	-	-
Uniformity coefficient, Cu	-	1.73	-
Coefficient of curvature, Cc	-	1.02	-
Soaked CBR (%)	2.47	9.17	2.04

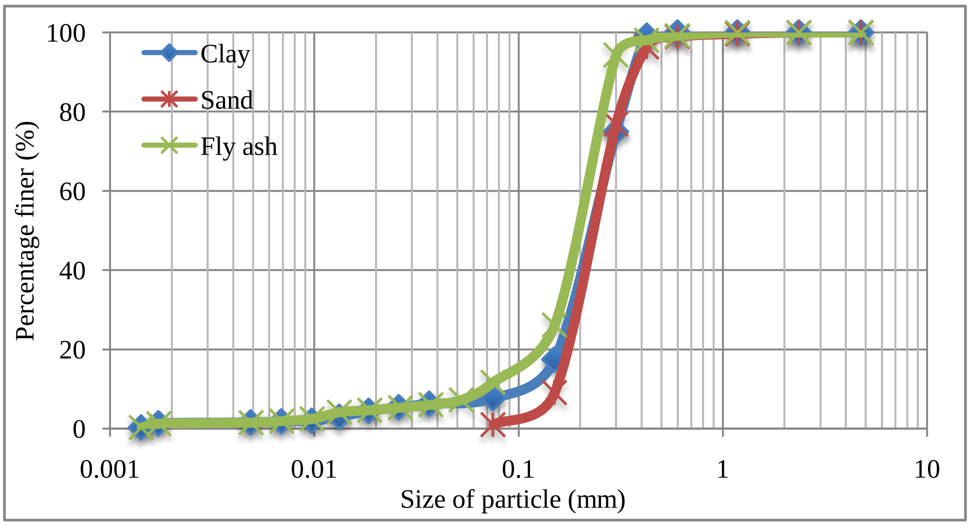

Fig. 1 Particle size distribution of clay, sand and fly ash

Method of Testing:

All laboratory tests were conducted in accordance with Indian standards. The specific gravity tests, consistency limit tests and the standard proctor tests were conducted in accordance with IS: 2720 (Part 3), IS: 2720 (Part 5) and IS: 2720 (Part 7) respectively. Particle size distribution curves (IS: 2720 (Part 4) show that clay and fly ash are uniformly graded with fly ash having higher range of finer particles and sand is poorly graded. Standard Proctor tests were conducted on specimens prepared from the clay, clay-sand and clay-sand-fly ash mixtures following IS: 2720 (Part 7). Test specimens were prepared by mixing dry materials with required quantities on basis weigh and further required amount of water is added. The materials were compacted in standard proctor moulds with standard compaction effort (25 blows from the 2.6-kg rammer dropped from a height of 310 mm) in three layers. The clay-sand mixes were obtained by varying percentage of sand from 10% to 40% in increments of 10% and standard proctor tests were conducted on the mixes. After selecting suitable proportion of clay-sand mix, fly ash content was mixed from 10% to 25% in increments of 5% and standard proctor tests were conducted on these mixes. Soaked and un-soaked California bearing ratio (CBR) tests were conducted in standard mould for samples with compactive effort (56 blows from the 2.6-kg rammer dropped from a height of 310 mm) compacted statically at maximum dry density (MDD) and optimum moisture content (OMC). Surcharge weight of 50N was used during the testing. A metal penetration plunger of diameter 50 mm and 100 mm long was used to penetrate the samples at the rate of 1.25 mm/minute using computerized CBR testing machine. Swelling was measured after 4days soaking from that expansion ratio is calculated.

III. RESULTS AND DISCUSSIONS

Compaction Tests:

Figure 2 shows the water content-dry density curves of clayey soil mixed with sand content varying from 10% to 40%. The above figure shows that optimum moisture content of clay decreases with the addition of sand. This is because sand particles are coarser and its surface area is less compared to that of clay. Coarser soils require lesser moisture content to obtain the maximum dry density. The dry density of mix increased due to better packing together of clay and sand particles leading to well graded nature of the mix and specific gravity of sand being more.

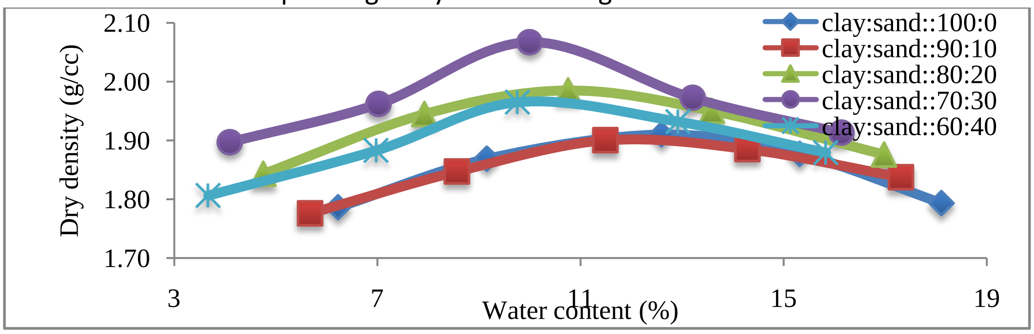

Fig. 2 Compaction characteristics of clay-sand mixes

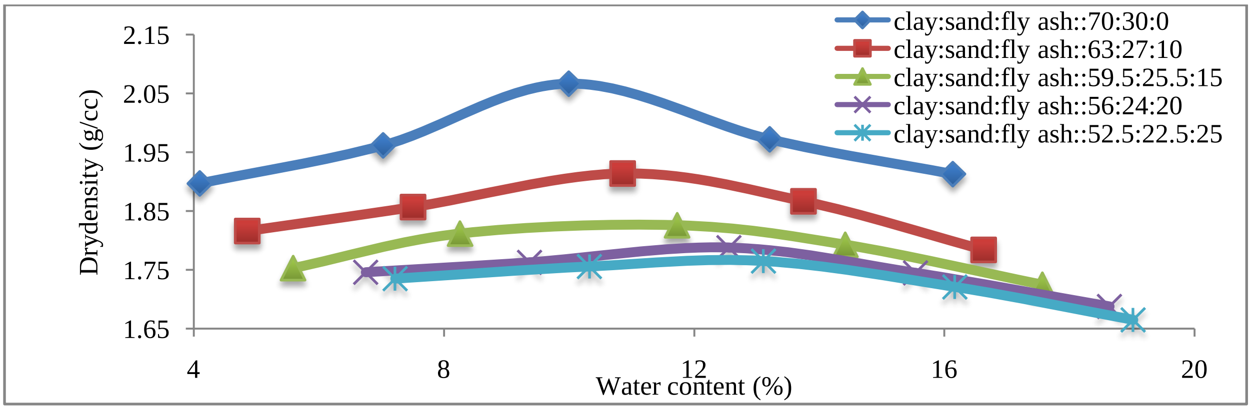

Fig. 3 Compaction characteristics of clay-sand-fly ash mix

Figure 3 shows the water content-dry density curves of the clay-sand composite with fly ash content increasing from 10% to 25%. The maximum dry density achieved after the addition of fly ash is lesser compared with that of clay-sand mix. This is due to the reason that the clay particles can fill most of the voids in the sand when mixed in the ratio of 70:30 and also due to lesser specific gravity of fly ash. Further, it is observed that as the fly ash content increases, the maximum dry density decreases but the optimum moisture content increases due to increase in the specific surface of the particles in the mix, because the fly ash particles are finer in nature.

California Bearing Ratio Tests:

The California bearing ratio tests were performed in laboratory in accordance with IS 2720: Part 16. The results of California bearing ratio (CBR) tests on clayey soil treated with sand and fly ash are shown in figure 4. It is observed that soaked CBR value of clayey soil increased with addition of sand and fly ash. The value of soaked CBR varies from 2.47% for unstabilized soil to 4.56% for stabilized soil and un-soaked CBR varies from 5.59% for unstabilized soil to 7.61% for stabilized soil. The improvement in CBR value may be attributed to better compaction and packing of the mix particles with addition of sand and fly ash. The California bearing ratio provides a basis of designing the sub-grades of flexible pavements. Figure 5 shows the variation of expansion ratio with the addition of sand and fly ash to the clay which shows stabilization decreased the swelling characteristics of clay. Thus, the clayey soil blended with sand and fly ash can be effectively used in the construction of sub-grades of roads with low traffic volume.

Table 2 IRC recommendations for pavement design based on soaked CBR values

Soaked CBR (%)	Subgrade strength	Recommendations
<2%	Poor	Need to be provide a capping layer of 150 mm thickness with materials having minimum CBR value of 10%
2%-5%	Moderate	Provide a cover of 80mm thick if needed
>5%	Good	No cover needed for 1-10msa traffic

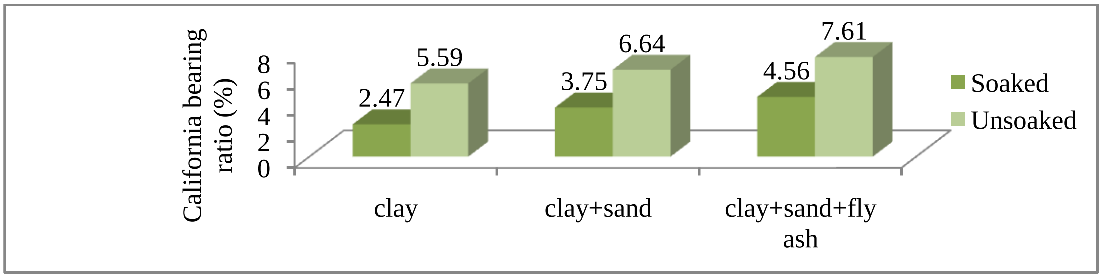

Fig. 4 Variation of soaked CBR and un-soaked CBR values for various optimum mixes

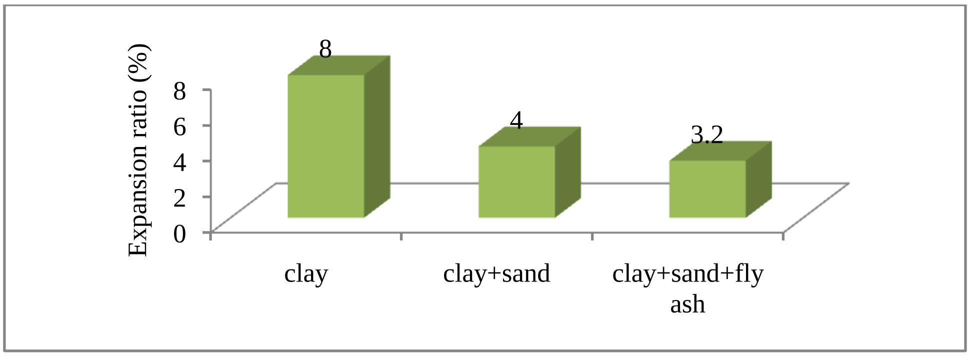

Fig. 5 Variation of expansion ratio in CBR samples after 4days soaking for optimum mixes

IV. CONCLUSIONS

The following conclusions can be drawn from the study conducted on clay-sand-fly ash:

1. The maximum dry density of clay-sand mix improved with the addition of sand up to 30% thereafter it decreased and the optimum moisture content decreased up to 30% sand content thereafter it increased slightly.
2. The maximum dry density of clay-sand-fly ash mix decreased with the addition of fly ash and optimum moisture content increased.
3. The California bearing ratio of the stabilized clay increased from 2.47% to 4.56% for soaked CBR and 5.59% to 7.36% for un-soaked CBR.
4. The expansion ratio of the stabilized clay decreased from 8% to 3.2% i.e., 60% of swelling was decreased with stabilization which can be used as a sub-grade material for construction of flexible pavements in rural roads with low traffic volume.

REFERENCES

[1] A.U. Ravishankar, S.N. Suresha and B. Kashinath, "Characterisation of lateritic soil modified with pond ash and cement", *Indian Highways*, June 2008, pp. 41-48.
[2] B. Bose, "Geo engineering properties of expansive soil stabilized with fly ash," *Electronic Journal of Geotechnical Engineering,* Vol. 17, Bund. J, 2012, pp. 1339-1353.
[3] Bureau of Indian Standards (1973). Methods of Tests for Soil, Part 2, Determination of Water Content of Soil, IS 2720, B.I.S, New Delhi.
[4] Bureau of Indian Standards (1985), Methods of Tests for Soil, Part 4, Grain Size Analysis, IS 2720, B.I.S, New Delhi.
[5] Bureau of Indian Standards (1985). Methods of Tests for Soil, Part 5, Determination of Liquid Limit and Plastic Limit. IS 2720, B.I.S, N. Delhi.
[6] Bureau of Indian Standards (1980). Methods of Tests for Soil, Part 3/Sec1: Determination of Specific Gravity, IS 2720, B.I.S, New Delhi.
[7] Bureau of Indian Standards (1992). Methods of Tests for Soil, Part 7, Determination of Water Content-Dry Density Relation using Light Compaction of Soil, IS 2720, B.I.S, New Delhi.
[8] Bureau of Indian Standards (1987). Methods of Tests for Soil, Part 16, Laboratory Determination of CBR, IS 2720, B.I.S, New Delhi.
[9] D.S.V. Prasad, "A study on flexible pavement performance with reinforced fly-ash sub base", *International Journal of Earth Sc. and Engg*. ISSN 0974-5904, 4(6) SPL, 2011, pp. 403-408.
[10] G. Takhelmayum, "Laboratory study on soil stabilization using fly ash mixtures," *International Journal of Engineering Science & Innovative technology*, Vol.2, Issue 1, 2013, pp 477-482.
[11] M.S. Chauhan, S. Mittal, and B. Mohanty, "Performance evaluation of silty sand sub-grade reinforced with fly ash and fiber," *Geotextiles and Geomembranes,* Vol. 26, Issue 15, 2008, pp 429-435.
[12] N. Bhatta, "Engineering properties of pond ash and pond ash sand mixtures", *Indian Highways*, July 2008, pp. 49-59.
[13] N.P. Kaushik and G. Ramasamy, "Strength characteristics of compacted coal ash", Unpublished thesis, Department of Civil Engineering, Engineering College Kota, 2006.
[14] P. Eskioglou and N. Oikonomou, "Protection of environment by the use of fly ash in road construction", *Global NEST Journal*, Vol. 10, No 1, 2008, pp. 108-113.
[15] S. Bhuvaneshwari, R.G. Robinson, and S.R. Gandhi, "Stabilization of expansive soils using fly ash," *Fly Ash India,* Fly Ash Utilization Programme (FAUP), TIFAC, DST, New Delhi, 2005.
[16] T.B. Edil, H.A. Acosta and C.H. Benson, "Stabilizing soft fine grained soils with fly ash," *Journal of Materials in Civil Engineering*, ASCE 18(2), 2006, 283-294.
[17] S. Mathur, U.K.G. Vittal V. Havangi and A.K. Sinha, "Design and construction of reinforced approach embankment using pond ash", *CBIP-3rd International Conference on Fly Ash Utilization and Disposal*, New Delhi, 2003, pp. 39-55.
[18] S. Mathur, U.K.G. Vittal and S.K. Soni, "Construction of road embankment and reinforced earth wall using fly ash", *Proceedings of National Seminar cum Business Meet on Use of Fly-Ash in Road and Embankment*, Allahabad, 2005.
[19] S. Saha, and S.K. Pal, "Influence of Fly Ash on Unconfined Compressive Strength of Soil and Fly Ash Layers Placed Successively," *Electronic Journal of Geotechnical Engineering,* Vol. 18, Bund. H, 2012, pp. 1593-1602.
[20] T.S. Jirathanathworn Nontananandh and Chantawarangul, "Stabilization of clayey sand using fly ash mixed with small amount of lime", *Proc. of the 9th National Convention on Civil Engg*. Engineering institute of Thailand and Thammasat University, Petchaburi, 2: GTE, 2003, pp: 93-98.