Properties of Expansive Soils Treated By Fly Ash

Kiran Bhoot

ABSTRACT-- Expansive soils are highly problematic by virtue of their volume change behaviour corresponding to the changes in moisture regime. By the alternate swelling and shrinkage they undergo in monsoon and summer many civil engineering structures like residential buildings, pavements and canal linings are severely damaged. To mitigate this problem of expansive soils, many innovative foundation techniques have been devised. The chief of them which are in vogue are sand cushion method, CNS layer technique, and under reamed pile foundations. Many stabilizing agents have also been tried. This paper presents the efficacy of fly ash, an industrial waste the disposal of which has become a problem, in reducing the swelling characteristics of expansive soils. The swelling and plasticity characteristics of expansive soils have been determined at different percentages of fly ash. It has been found that fly ash could reduce the swelling properties quite effectively.

INTRODUCTION

Problems with expansive soils

The problems posed by expansive soils have been recorded all over the world. They undergo heave or increase in their volume on imbibitions of water. On evaporation of water, however, in summer they shrink or their volume decreases. In the process they lose their density and become slushy. By this alternate swelling and shrinkage, many civil engineering structures like residential buildings, pavements and canal linings etc. are severely damaged and develop unsightly cracks. To counteract this dual problem. many innovative foundation techniques have been devised.

Foundation techniques in expansive soils

Some of the innovative techniques employed in expansive soils are briefly discussed below.

Under reamed piles developed by CBRI. Roorkee are bored cast in situ piles with enlarged bases and connected at the top by plinth beams. Enormous uplift resistance is mobilized along the surface of the pile and reduces heave. They have been widely used in India.

Granular pile-anchors (Phani Kumar, 2005) are highly effective in arresting the heave of foundations in expansive soils. In this technique the foundation is anchored at the bottom of the granular pile to a mild steel plate with the help of a mild steel rod. Considerable shear resistance will be mobilized along the pile-soil interface and resists the uplift.

In mechanical alteration the top layers of expansive soil are replaced with non-expansive material. Sand cushion (Satyanarayana, 2006) and cohesive non-swelling (CNS) layer technique (Katti, 2008) are examples of this technique. The philosophy of the sand cushion is that, in monsoon, the saturated sand occupies less volume, accommodating some of the heave of the underlying soil and in summer partially saturated sand bulks and occupies the extra space left by the shrinkage of the soil.

In CNS layer technique, about top 1.0 m to l.20 m of the expansive soil is replaced by a cohesive non-swelling soil layer. 'This also has been found to be quite effective in reducing the heave.

In some techniques that bring' about a radical change in the nature of the soil are stabilization techniques using chemicals like lime and calcium chloride. Fly ash is an industrial waste which poses the problem of its disposal, and causes pollution. It is estimated that. in India, 100 million tonnes of fly ash is produced every year (Sridharan et al., 2006). This calls for a bulk utilization of fly ash through different means. It can be used as a back fill material, construction material in embankments replacing material in problematic soils like expansive soils, a base course material in pavements and in some other geotechnical applications. Hence, its characteristics and efficacy are to be studied from different angles before actually using it in the field. This paper presents the effectiveness of fly ash as an admixture in expansive soils by conducting a laboratory test programme using a highly expansive clay.

EXPERIMENTAL PROGRAMM'E

The soil used in the experimental programme for studying the efficacy of fly ash in reducing the swelling characteristics of expansive soils has been collected from Amalapuram in Andhra Pradesh, It is a highly swelling soil with a free swell index (FSI) of 120%.

Table 1. Index properties of the soil

SR. NO	INDEX PROPERTY	VALUE
1	Specific gravity, G	2.67
2	Clay %	50
3	Silt %	37
4	Sand %	13
5	Gravel %	0
6	Liquid limit	79
7	Plastic limit	30
8	Plasticity Index	49
9	Shrinkage limit	10
10	Free swell index	120
11	I.S. Classification based on plasticity	CH
12	I.S. Classification based on degree of expansion	High

The index properties if the soil are given in Table 1. The index .properties has been determined according to the relevant Indian Standard Codes.

The optimum moisture content and the maximum dry unit weight of the untreated soil are 24.40% and 15.80 kN/m3 respectively.

The fly ash used in this study has been obtained from the thermal power station at Vijayawada. It has a low specific gravity of 1.62, and is composed of non-plastic silt-sized particles.

The effect of fly ash ion plasticity, free swell index and unconfined compressive strength has been studied varying the percentages of fly ash by conducting relevant tests according to the standard codes of practice.The variables used in the test program are as follows:

Percentage of fly ash by weight of the soil: 0, 2, 4, 6, 8 & 10

For the determination of unconfined compressive strength (UCC), samples have been prepared at an arbitrary water content of 10% and a dry unit weight of 14.5 kN/m3, at different percentages of fly ash mentioned above. Other properties also have been determined at the above percentages of fly ash.

RESULTS AND DISCUSSION

Table 2 shows the values of FSI, Atterberg limits and unconfined compressive strength of the soil at different percentages of fly ash.

It can be seen from the table that, as the % of fly ash increases, liquid limit decreases and plastic limit increases, decreasing the plasticity index of the soil considerably. It is interesting to note that, at 10% fly ash, the plasticity index of the soil decreased by 50%.

The Free Swell Index also decreases with the increase in the % of fly ash. At 10% fly ash, it is reduced by about 35%, showing that the soil is rendered non-swelling at higher percentages of fly ash. The reason for reduction in FSI and plasticity is that fly ash is composed of non-plastic silt-sized ash particles.

The Unconfined compressive strength has been found to increase with increase in% of fly ash as shown in the table. This can be attributed to the angle of internal friction of the ash. At 10% of fly ash, the increase in UCC is about 20% at the given arbitrary placement conditions.

Table 2. Effect of fly ash on physical and engineering properties of the soil

Fly ash (%)	Liquid Limit	Plastic limit	Plasticiy index	FSI	UCC (kPa)
0	79	30	49	120	125
2	77	30.5	46.5	112	130
4	73	31	42	105	136
6	69	32	37	98	140
8	65	33	32	90	144
10	60	34	26	80	150

CONCLUSION

Based on the experimental study conducted, it may be concluded that addition of fly ash reduces plasticity index of expansive clays considerably. Free swell index, a very apt index property of expansive soils which reflects their potential expansiveness, also decreases. The unconfined compressive strength of the soil-ash mix increases considerably indicating stability of the expansive clays improved**.**

REFERENCES

1) Katti, RK. (2008), "Search for solutions to problems in black cotton soils", First IGS Annual Lecture, Indian Geotech Society at I.I.T. Delhi.

2) Satyanarayna, B. (2006), "Swelling pressure and related mechanical properties of black cotton soils' Ph. D Thesis, I.I.Sc, Bangalore.

3) Sridharan, A, Pandian, N.S. and Rajasekhar, C. (2006), "Geotechnical Characterization of Pond Ash", Ash Ponds and Ash Disposal Systems. Raju, V.S. et al (Eds) Narosa Publishing House., New Delhi.

4) Phani Kumar, B.R (2005), "A-Study of Swelling Characteristics of and Granular Pile-Anchors in Expansive Soils", Ph.D. Thesis submitted to JNT University, Hyderabad.