Study of Engineering Properties of Expansive Soil Stabilized with Quarry Dust and Fly-ash.

Dr. Manas Kumar Bhoi[1], Raghav Sharma[1] and Harshil kakadiya[1]
[1]School of Technology, PDPU, Gandhinagar-382007, Gujarat, India
manas.bhoi@sot.pdpu.ac.in`

Abstract

The expansive soils are problematic as a foundation soil and due to high swelling and shrinkage, these soils poses lots of problems for the structures found on them. In reference to that the fly ash is a waste product from thermal plant, which uses coal as fuel and quarry dust is a byproduct of crusher units used for stone cutting etc.; and when mixed with expansive soil separately they found to have improved the swelling and shrinking behavior of the soil. The present paper describes a study carried out to check the improvements in the properties of expansive soil with mixing of both fly ash and stone quarry in equal proportion and varying the overall percentage. There are some conclusions established based on the experimental observation, such as (a) The Liquid Limit and Plastic Limit values go on increasing with increase in percentage of flyash-quarry dust mix, (b) The Optimum Moisture Content (OMC) goes on decreasing with an increase in percentage of the mix and (c) The California Bearing Ratio (CBR) values increases with increase in percentage mix, although percentage wise it is quite significant and (d) The Free Swell Index(FSI) decreases with increase in mix from 10% to 50% , by 20%.

Keywords: Expansive soil, Fly ash and stone quarry mix, OMC, CBR, FSI.

1 Introduction

Certain types of clayey soil expand when they are wet and shrink when dried. These soils are called as expansive soil or swelling soils. The expansive soils are more problematic for construction and are predominantly available in the majority places in Gujarat. Due to high swelling and shrinkage, these soils pose lots of problems to the structures found on them. Stabilization of expansive soils using admixture, controls the adverse effects on the foundation soil structures.

Fly ash is a waste byproduct from thermal power plants, which uses coal as fuel In order to utilize fly ash in bulk quantities, ways and means are being explored all over the world to use it for the construction of embankments and roads. Till now, not much of the byproduct flyash is being used for construction purposes like brick making, cement manufacture, soil stabilization and as fill material [3]. Parallel to this in Gujarat, large number of crusher units are available, which produces huge quantities of quarry dust and it's safe disposal is a great problem. In the recent past some of the researchers have brought out interesting notes on utilization of the quarry dust [5] and fly ash for soil stabilization [4].The experimental findings confirmed that the plasticity index, activity and swelling potential of the soil samples decreases with increasing percent of stabilizer and curing time, and some cases the optimum content of fly ash helps in decreasing the swell potential upto 20%. Similarly, various other industrial wastes used as stabilization agents are reported in literature such flyash[2], recycled ashes and fibers[1],silica fumes[6] and steel mill dust[7].

The expansive soil tested for this research work is collected from the Green city, Surat. These soils show large volume changes of swelling and shrinkage with variation of seasonal moisture content. Theses soils when subjected vehicular traffic, the road pavement gets heaved and cracked; hence it has to be stabilized before constructing the roads over it. In the present work experimental studies have been carried out in the laboratory by adding combination of fly ash and quarry dust to the expansive soil at equal proportions.

2 Materials Used:

2.1 Expansive soil

The expansive soil used in the experimental program is from Surat, Gujarat. The geotechnical properties of the soil are given as in Table.1 and it is classified as CH (Clay with high plasticity).

Table.1 Geotechnical properties of the soil.

Grain size	Above 4.75mm	1%
	Between 4.75mm to 75 micron	12%
	Below 75 micron	87%
Atterberg's Limit	Liquid limit	56%
	Plastic Limit	28%
	Plasticity Index	28%
Compaction Characteristics	Optimum moisture content(OMC)	17%
	Maximum dry density	1.85gm/cc
California Bearing Ratio value	Soaked CBR	2.43%
Swelling behaviour	Free swell Index(FSI)	81.8%

2.2 Fly ash

The flyash used in the experimental program is a class-F flyash (Having CaO = 0.9%) and it is collected from GERI-Vadodara, Gujarat. The geotechnical properties of the flyash are given in below in Table.2.

Table.2 Geotechnical properties of the flyash

Grain size	Above 4.75mm	1.92%
	Between 4.75mm to 75 micron	81.52%
	Below 75 micron	16.56%
Compaction Characteristics	Optimum moisture content(OMC)	20.6%
	Maximum dry density	1.31gm/cc

2.3 Quarry dust

The quarry dust for laboratory testing program was collected from a crusher unit in Gujarat. The geotechnical properties of the quarry dust are given in the Table.3.

Table.3 Geotechnical properties of the quarry dust.

Grain size	Above 4.75mm	3%
	Between 4.75mm to 75 micron	81%
	Below 75 micron	16%
Compaction Characteristics	Optimum moisture content(OMC)	9.4%
	Maximum dry density	2.05gm/cc

3 Test Methodology

Fly ash and quarry dust in the proportion of 1:1 were added to an expansive soil up to 50% of its dry mass. Fly ash added were 0 to 25% at an increment of 5% and also, quarry dust 0 to 25% at an increment of 5% by dry mass of the soil. The mixes were prepared in such a manner that their percentages were 100%, like soil: fly ash: quarry dust: 70:15:15 etc. The different tests done on the expansive soil fly-ash-quarry dust mix samples are Liquid Limit test, Plastic Limit test, Standard Proctor Compaction test, California Bearing Ratio (CBR) test and Free Swell Index (FSI) tests. The standard proctor compaction tests were conducted to find Optimum moisture content (OMC) and Maximum dry density (MDD) and; the CBR test is conducted on soil samples maintaining the OMC and MDD.

The liquid limit and plastic limit tests were conducted as per IS: 2720(Part 5)-1985[8]; Heavy compaction test was carried out according to IS: 2720(Part 8) -1983[10]; OMC and

MDD as per IS: 2720 (Part 9) – 1991[9]; Free swell index (FSI) tests were conducted as I.S:2720(Part – 40) -1977[11]; The California Bearing Ratio (CBR) test were conducted as per IS: 2720(Part 16)-1987[12].

4 Results and Discussions:

Based on the experimental results conducted as per methodologies indicated in the previous segment, all the geotechnical parameters like liquid limit, plastic limit, OMC, MDD, CBR value and Free swell index are found out. In this section the variation of these parameters with respect to admixture proportion will be discussed.

4.1 Admixture Proportion Vs Liquid Limit:

For the different proportion of admixtures in the soil sample, the corresponding value of the liquid limit is calculated as per the relevant Indian standard code[8]. As per the data points shown in Fig.1 and the related trend line it is quite clear that in general, with increase in in admixture proportion there is a decrement in the liquid limit. There is aberration in the data like , the liquid limit corresponding to 10% admixture proportion has lesser value(49.3%) compared to that of at 20% admixture proportion(50.2%) and it can be attributed to the experimental error at such low proportion of admixture in the soil. The conclusion drawn in earlier line is more realistic considering that the liquid limit of pure soil is 56%. But over all there is a decrease in liquid limit of the soil with increase in the admixture proportion. The practical significance is that, as the percentage of admixture increases, the soil sample will start flow like liquid at lower moisture content also and thereby losing shear strength at lower water content compared to the virgin soil.

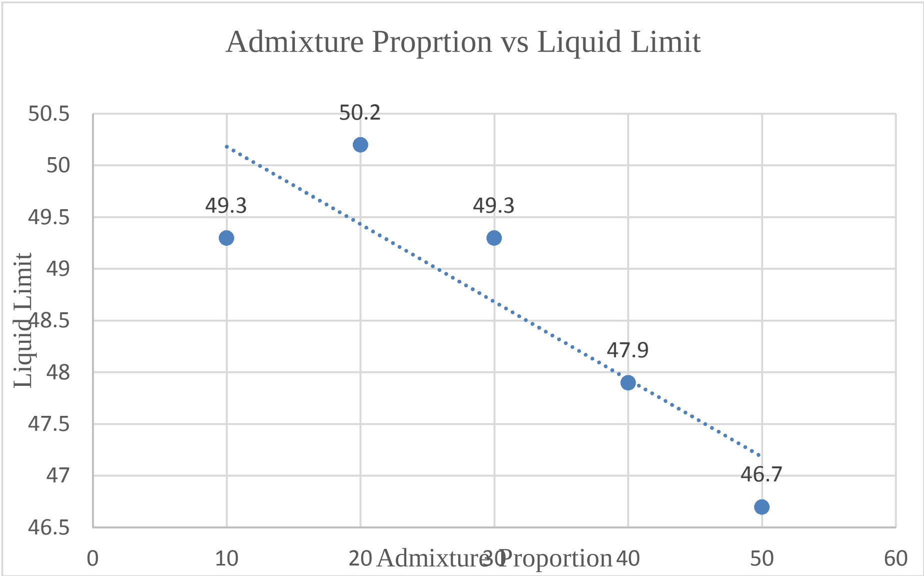

Fig. 1**.** Admixture Proportion (%) Vs Liquid Limit for the given soil sample.

4.2 Admixture Proportion Vs Plastic Limit:

For the different proportion of admixtures in the soil sample, the corresponding value of the plastic limit is calculated as per the experimental method given Indian standard code [8]. The data point and the corresponding trendline shows that, with increase in admixture proportion, there is a decrease the plastic limit value. Here the value of plastic limit for 10% admixture proportion is 27.83% and for 50% admixture proportion is 26.32% but percentage wise the decrease in the plastic limit is about 5%(as the plastic limit of the pure soil is 28%) and it's effect may not be that significant in changing the plastic nature of soil. But in general there will be a tendency to reach Atterberg's plastic limit at a lesser water content.

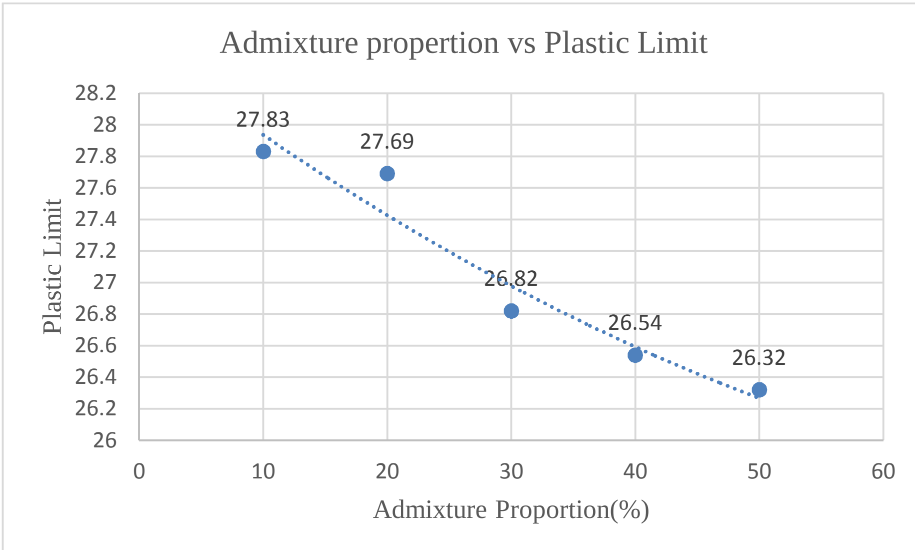

Fig. 2**.** Admixture Proportion (%) Vs Plastic Limit for the given soil sample.

4.3 Admixture Proportion Vs Optimum Moisture Content (OMC) and Maximum Dry Density (MDD):

For the given different proportion of admixtures in the soil sample, the corresponding value of the optimum moisture content (OMC) and maximum dry density (MDD) is calculated as per the experimental method given in the relevant Indian standard code [9]. The graph showing the variation of OMC with respect to proportion of admixture is shown in the Fig.3.a and the graph showing the variation of MDD with respect to proportion of admixture is shown in Fig.3.b. Considering the Fig.3.a, the OMC value is changing from 16.4% at 10% admixture proportion to that of 14.78% at 50% proportion and the general trend is decrease in OMC with increase in admixture proportion although the percentage of decrement is not so significant (around 10% considering the OMC of the original soil is 17%) to affect the behavior of the given soil sample drastically. In the Fig.3.b, the MDD value is increasing from 1.96 gm/cc at 10% admixture proportion to 2.17 gm/cc at 50% admixture proportion and overall trend is found to be increase in dry density with increase in admixture percentage. The percentage variation in the maximum dry density value is about 11% (Considering the MDD of the original soil is 1.85cc)for the variation of admixture proportion from 10% to 50%. This variation in MDD value, may not be that significant but it will still have some effect.

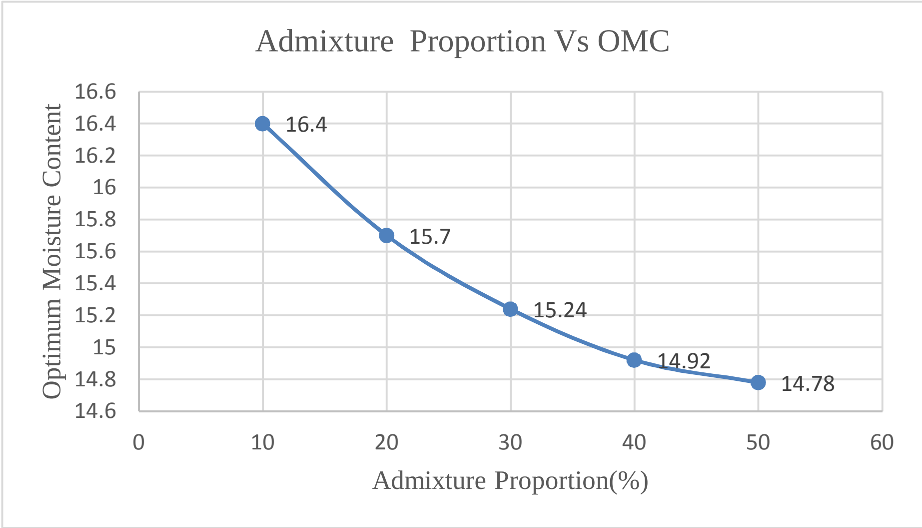

Fig. 3**.a.** Admixture Proportion (%) in the soil sample Vs Optimum Moisture Content (OMC).

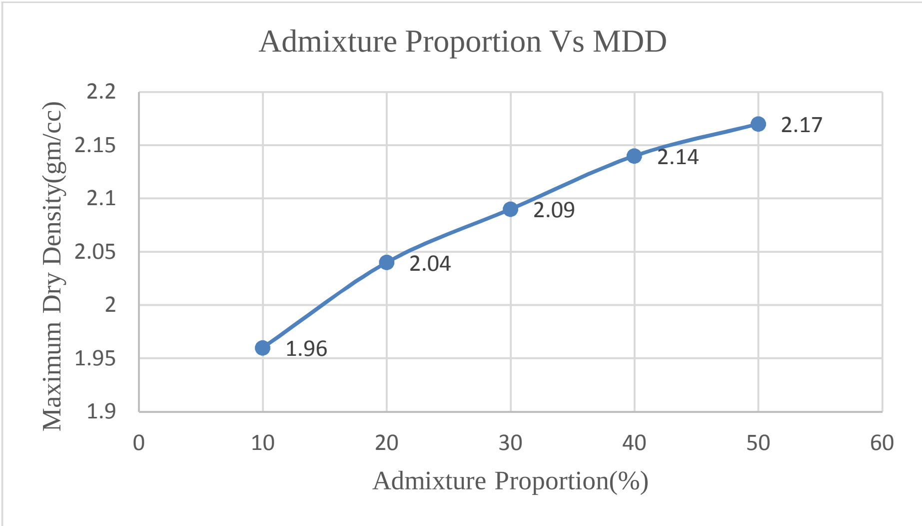

Fig. 3.b. Admixture Proportion (%) in the soil sample Vs Maximum Dry Density (MDD).

4.4 Admixture Proportion Vs California Bearing Ratio (CBR) value:

For the soil samples having different proportion of admixtures, the corresponding value of the California bearing ratio is calculated as per the experimental method given Indian standard code[12]. The Fig.4 shows the variation of CBR with respect to admixture proportion for both the plunger penetration value of 2.5mm and 5mm. The value of CBR is increasing with increase in admixture proportion for both the cases of 2.5mm and 5mm penetration. The percentage increase in CBR value is around 63% for 2.5mm penetration considering the original CBR value of the soil at 2.5mm penetration is 2.43%. The positive feedback that can be taken from this result is that, there is a more than 50% increase in CBR value for both the cases.

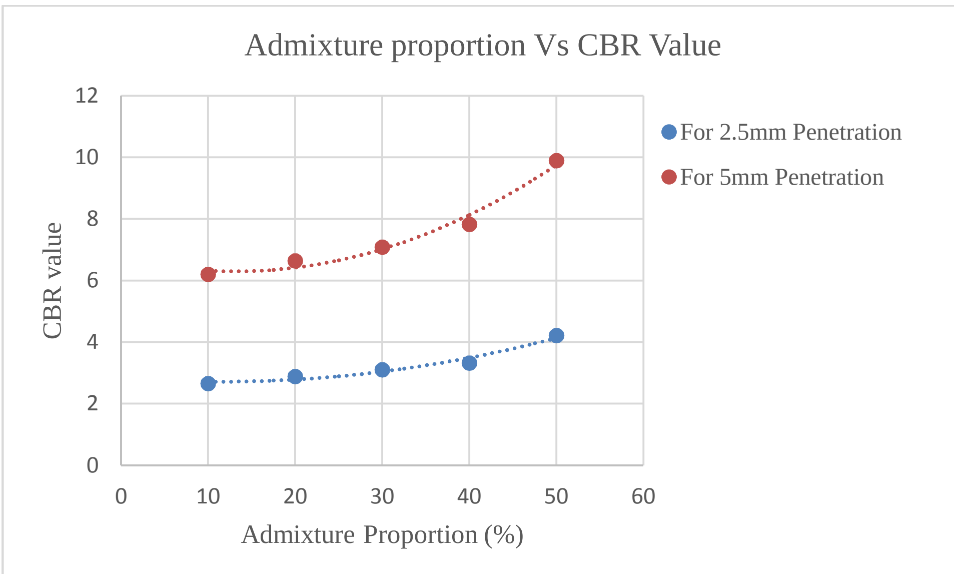

Fig. 4. Admixture Proportion (%) in the soil sample Vs CBR value at both 2.5mm penetration and 5mm penetration.

4.5 Admixture Proportion Vs Free Swell Index (FSI):

As per the experimental method given in Indian standard code[11], for the soil samples having different proportion of admixtures the free swell index(FSI) value was found out. As shown in fig.5, the free swell index value is decreasing with increase in the admixture proportion; FSI = 72.72% for 10% admixture content to FSI=59.09% for 50% admixture content. The percentage of variation of FSI value for the variation of admixture percentage from 10% to 50% is around 17%(Considering the original free swell index value of the soil is 81.8%) and it can be a significant value. So the swelling behavior of the soil sample is decreasing with increase in the admixture proportion.

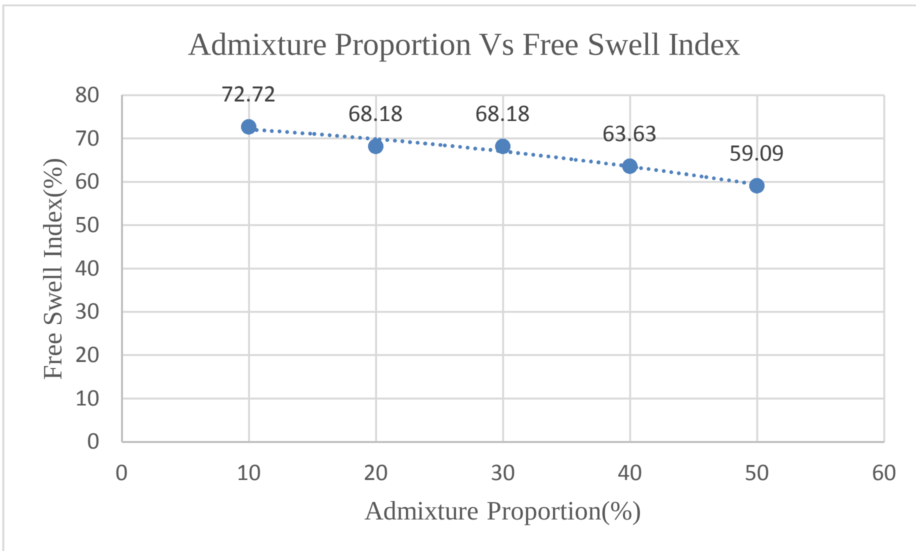

Fig. 5. Admixture Proportion (%) in the soil sample Vs Free Swell Index (FSI) of the same sample.

5 Conclusion

Based on the experimental results and analysis some conclusive points is stated in this section. The liquid limit and Plastic limit values go on increasing with increase in the percentage addition of fly-ash quarry dust mixes, although the increment is not so significant. The MDD value goes on increasing and the OMC value goes on decreasing with an increase in the percentage fly-ash quarry dust mixes. The CBR values goes on increasing with increase in the percentage admixture in the soil sample and it is a significant value of more than 50% and similarly the FSI value decreases by 17% with increase in the percentage admixture from 10% to 50%. Based on these experimental data points and corresponding trend line, respective parameter values corresponding to new admixture proportion can be established without conducting the actual experiment.

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