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EFFECT OF FLY ASH ON SOIL SUBGRADE STABILIZATION

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ABSTRACT : Soil stabilization has been found to be very effective in upgrading the bearing capacity of weak soil subgrade. The stabilizing agent, for cost efficiency, ought to provide a cheaper alternative to other possible processes. With the rapid industrialization efforts around the globe, enormous quantities of waste materials are generated and there has not been adequate mechanism for recycling and re-use of such wastes to reduce the consequent environmental problems and hazardous situations created as a result. The objective of the study is to upgrade subgrade soilfrom generally available in Haryana State using fly ash. The laboratory investigation carried out on the natural soils shows that these falls under silt of low plasticity (ML type) and silty sand (SM types) using Indian Standard Classification System, after that testing program conducted on natural soil samples and mixed with different percentages of fly ash included Atterberg limits, specific gravity, modified proctor test and CBR test. It was found that liquid limit of both soil decreased with addition of fly ashand plasticity index of ML type soil decreased also but SM type is a non-plastic soil. The results obtained show that the increase in fly ash content increase in OMC but decrease the MDD. Also, the CBR value of both soils is considerably improved with fly ash content. So in order to achieve both the need of improving the properties of soil subgrade and also to make use of the industrial wastes the present experimental study has been taken up.

Keywords: Materials, Fly Ash and Soil Stabilization.

1 INTRODUCTION

1.1 General

An extensive and good quality road network is one of the majorparameters for the development of a country's social and economic condition. The basic necessity for a good quality road structure is good and strong subgrade over which the road is constructed.But in many parts of the country, the sub-soil is of poor quality due to low strength and high compressibility. So there is a necessity for improving properties of soil subgrade which can improve the bearing strength of the subgrade soil by using admixtures like fly ash and lime etc. With the ever increasing demand and consumption of cement and in the backdrop of waste management, scientists and researchers all over the world are always in quest for developing alternate binders that are environment friendly and contribute towards sustainable management. Fly ash which is an industrial waste can be used as a stabilizer.

The main objective of this research paper is to perform CBR (California Bearing Ratio) test on natural soils and mixed with different percentage of fly ash in order to observe the effect of these admixtures on CBR values of soils

1.2 Soil Stabilization:

Soil Stabilization is the process of improving the engineering properties of the soil subgrade and thus making it more stable. In its broadest senses, stabilization includes increasing load bearing capacity of soil subgrade, to reduce permeability and to reduce compressibility of soil subgrade.

The simplest stabilization processes are compaction and drainage (if water drains out of wet soil it becomes stronger). The other process is by improving gradation of particle size and further improvement can be achieved by adding binders to the weak soils.

Generally the weaker subgrade soil can be tackled in two ways. In the first process weaker soil may be replaced by superior soil, this is not an engineered solution of the problem also this may be very expensive especially when fill material is borrowed from a distant place. Second alternative is to improve the engineering properties of the soil by means of stabilization using different admixtures.

Benefits of the stabilization process can include reduction in plasticity, reduction in pavement thickness, elimination of excavation materials hauling or handling and lower permeability.

1.3 Objective of Present Study:

The objectives of present study are determination the properties of the selected soil subgrade and admixtures, improvement in CBR value of soil subgrade usingfly ash which is a waste material and determination of performance stabilized soil subgrade with an optimum of fly ash and its suitability as a soil Stabilizer.

2 LITERATURE REVIEWS

Dr. Robert M. Brooks (2009) "Soil stabilization with fly ash and rice husk ash" The objective of this paper is to upgrade expansive soil as a construction material using rice husk ash (RHA) and fly ash, which are waste materials. Remolded expansive clay was blended with RHA and fly ash and strength tests were conducted. The potential of RHA-fly ash blend as a swell reduction layer between the footing of a foundation and subgrade was studied. In order to examine the importance of the study, a cost comparison was made for the preparation of the sub-base of a highway project with and without the admixture stabilizations. Stress strain behavior of unconfined compressive strength showed that failure stress and strains increased by 106% and 50% respectively when the fly ash content was increased from 0 to 25%. When the RHA content was increased from 0 to 12%, Unconfined Compressive Stress increased by 97% while CBR improved by 47%. Therefore, an RHA content of 12% and a fly ash content of 25% are recommended for strengthening the expansive subgrade soil. A fly ash content of 15% is recommended for blending into RHA for forming a swell reduction layer because of its satisfactory performance in the laboratory tests.

Laxmikant Yadu, Rajesh Kumar Tripathi and Dharamveer Singh (2011)"Study of Black Cotton (BC) Soil Stabilized With Fly Ash (FA) andRice Husk Ash (RHA)" the paper presents the laboratory study of black cotton (BC) soil stabilized with fly ash (FA) and rice husk ash (RHA). The samples of BC soils were collected from a rural road located in Raipur of Chhattisgarh state. The soil was stabilized with different percentages of FA (5, 8, 10, 12, and 15%) and RHA (3, 6, 9 11, 13, and 15%). The atterberg's limits, specific gravity, California Bearing Ratio (CBR) tests were performed on raw and stabilized soils. Results indicate that addition of FA and RHA reduces the plasticity index (PI) and specific gravity of the soil. The moisture and density curves indicate that addition of RHA results in an increase in optimum moisture content (OMC) and decrease in maximum dry density (MDD), while these values decrease with addition of FA. The addition of stabilizers (i.e., FA and RHA) increases UCS and CBR values, indicating the improvement in the strength properties of the soil. Based on the CBR and UCS tests, the optimum amount of FA and RHA was found to be as 12% and 9%, respectively. They Concluded that BC soil collected from shallow depth of rural road located at Raipur have been stabilized with FA and RHA. Addition of RHA results in an increase in OMC and decrease in MDD, while these values decrease with addition of FA. Cost analysis shows 14% and 20% saving per km length of the rural road with addition of optimum amount of RHA and FA. The study shows that fly ash is better additive as compared to rice husk ash. Key words: Black cotton soil, Fly ash, Rice husk ash, UCS, CBR.

M. Prakash and Dr. J. Jeyanthi (2013) "Effect of rice husk ash and fly ash on engineering properties of expansive soil" In this study, waste materials such as tice husk ash and fly ash are added to the expansive soil which resulted in considerable improvement in the strength characteristics of the expansive soil. Initially, the clay soil was obtained when mixed with FA and it was found that the maximum Unconfined Compressive Strength (UCS) of clay soil was obtained when mixed with 20% FA. Further, the optimum value of 20% FA was replaced partially with RHA in varying proportions by dry weight of soil with an increment of 5%. Atterberg's limits, maximum dry density (MDD), UCS and California Bearing Ratio (CBR) were the properties taken into consideration. UCS of clay soil after replacing by RHA increased by 30% and CBR increased by 10.5%. This increase in percentage was obtained for the proportion 15% RHA and 5% FA.

Gyanen Takhelmayum, Savitha A. L. and Krishna Gudi (2013) evaluate the compaction and unconfined compressive strength of stabilized black cotton soil using fine and coarse fly ash mixtures. The percentage of fine and coarse fly ash mixtures which is used in black cotton soil varied from 5 to 30%. From laboratory investigation it was observed that with the increase in water content the dry density decreases up to 20-30% and with further increase in water content the dry density decrease gradually. The decrease in dry density with increase in fine fly ash content is due alteration of gradation of soil mixtures. Whereas decrease in dry density with the increase in coarse fly ash mixture was attributed due to cat ion exchange between additives and expansive soil and it was also concluded that with percentage addition of fine or coarse fly ash improves the strength of stabilized black cotton soil. It was found that the peak strength attained by fine fly ash mixture was 25% more when compared to coarse fly ash.

Chavali Rama Vana Parsad and Dr. R. K. Sharma (2014) made an attempt to assess the effectiveness of clayey blended soil 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.

S.S. Rajput and R.K. Yadav (2015) utilize the industrial waste like fly ash to improve the engineering characteristics of the silty soil. Soil samples blended with fly ash from 0% to 50% of dry weight of the soil. Samples were prepared and results showed a significant increase in soaked California Bearing Ratio value. Liquid limit decreased from 30.66% to 23.31% and plasticity index decreased from 10.21% to 6.29%. DFS of silty soil reduced from 31% to 5%. From the compaction tests result decreased in maximum dry density (MDD) from 1.71 gm/cc to 1.55gm/cc and increased in optimum moisture content (OMC) from 20.4% to 24.31%. In this investigation it can be seen that fly-ash has a potential to improve the engineering characteristics of silty soil.

3 MATERIALS USED

3.1 Soil Samples

For the present study, soils are collected form two different places of district Jind (Haryana). The soil was excavated from a depth of 1.5m from natural ground level.

3.2 Fly Ash

Fly ash is a fine powder recovered from the gases of burning coal during the production of electricity in thermal power plants. Fly ash is pozzolana, a siliceous material which in the presence of water will react with calcium hydroxide at ordinary temperatures to produce cementitious compounds. So when fly ash mixed with soils gives pozzolanic properties in the mixture.The fly ash used in the present study was collected from Rajiv Gandhi Thermal Power Plant, Khedar (Hisar).

4 LABORATORY STUDIES

The testing program conducted on the selected soil samples included determination Atterberg's limits, grain size distribution, specific gravity of soil samples and admixtures, maximum dry density, optimum moisture content and CBR value mixed with different percentage of fly ash.

4.1 Liquid Limit: The liquid limit test was conducted on samples passing 425µ sieve; natural soil and soil mixed different proportions rice husk ash using casagrande's liquid limit apparatus as per the procedures laid down in IS 2720: Part 5: 1985.

4.2 Plastic Limit: The plastic limit test was conducted on samples passing 425µ sieve; natural soil and soil mixed different proportions rice husk ash as per specifications laid down in IS 2720: Part 3: 1985.

4.3 Grain Size Distribution: Grain size distribution method is used to evaluate the uniformity of soil particles, and to classify soil type. The soil sample passing through 4.75mm sieve is taken for sieve analysis. The sieve analysis method is used in the present study for grain size distribution as per the procedure laid down in IS 2720: Part 4: 1985.

4.4 Specific Gravity: The specific gravity test was conducted using pycnometer bottle on the soils and admixtures in accordance with IS 2720: Part 3: 1980.

4.5 Modified Proctor Test: The modified Proctor test was developed to represent heavier compaction than that in the standard proctor test. The test is used to simulate the field conditions where heavy rollers are used. The Indian Standard Code IS 2720: Part 8-1983 gives the specifications and guidelines for heavy compaction test.

4.6 California Bearing Ratio Test: The CBR test was conducted on samples passing 19mm sieve and retained 4.75mm sieve; natural soil and soil mixed different proportions rice husk ash using CBR test machine as per the procedures laid down in IS 2720: Part 16: 1987.

5 RESULTS AND DISCUSSIONS

The study explains the effect of different fly ash percentages on different selected soils. The results of this study with their discussions are presented in the following paragraphs.

5.1 Results of Atterberg's Limit Test:

5.1.1 Results of Atterberg's Limit Test on Jind City (ML type) Soil:

Soil index properties are used extensively by engineers to discriminate between the different kinds of soil within a broad category. The index properties of soil are obtained from Atterberg limit test results. The Atterberg limits are a basic measure of the nature of a fine grained soil. The test results of Atterberg limits of Jind City Soil is shown in Table 1

Table 1 Atterberg limit test results of JindCity Soil

Fly Ash %	Liquid Limit	Plastic Limit	Plasticity Index
0	26.45	23.07	3.38
4	22.87	19.88	2.97
8	19.23	17.11	2.12
12	16.34	15.28	1.06

Figure 1 shows the variation of liquid limit, plastic limit and plasticity index of ML soil with different proportions fly ash.

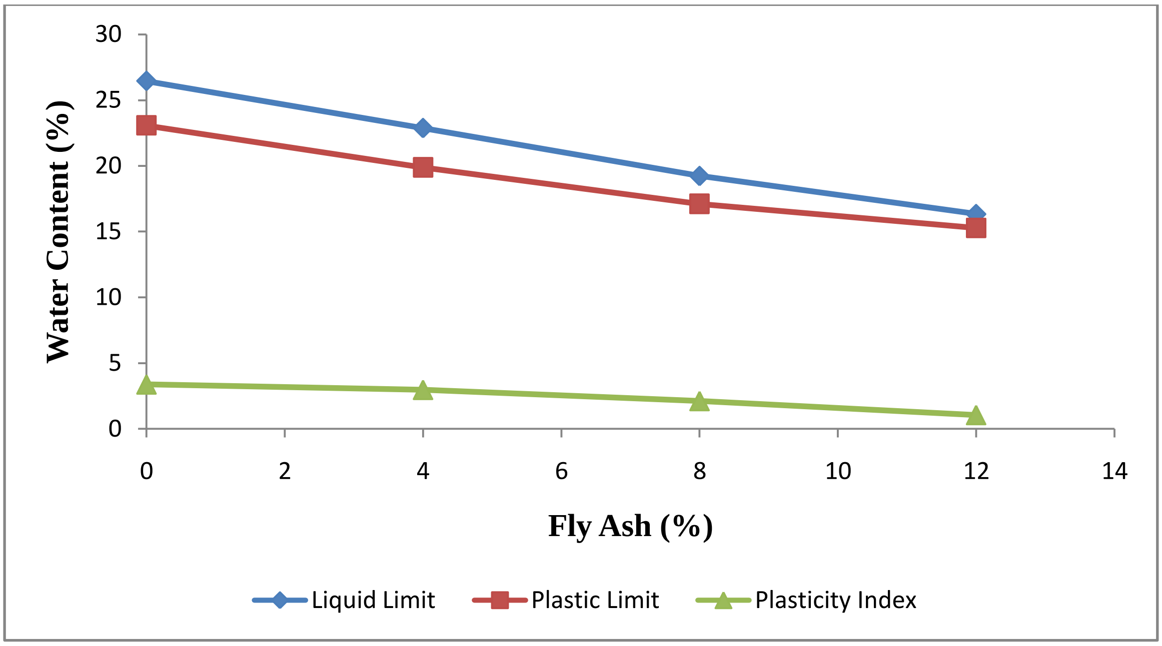

Figure 1 Variation of LL, PL and PI of ML Soil + fly ash mixes

5.1.2 Results of Atterberg's Limit Test on Uchana (SM type) Soil:

The test results of Atterberg limits of Uchana Soil is shown in Table 2

Table 2Atterberg limit test results of Unchana Soil

Fly Ash %	Liquid Limit	Plastic Limit	Plasticity Index
0	23.67	-	Non Plastic
4	24.78	-	Non Plastic
8	26.02	-	Non Plastic
12	27.83	-	Non Plastic

Figure 3 shows the variation of liquid limit and plasticity index of soil cannot be find out because soil is non-plastic with different proportions fly ash.

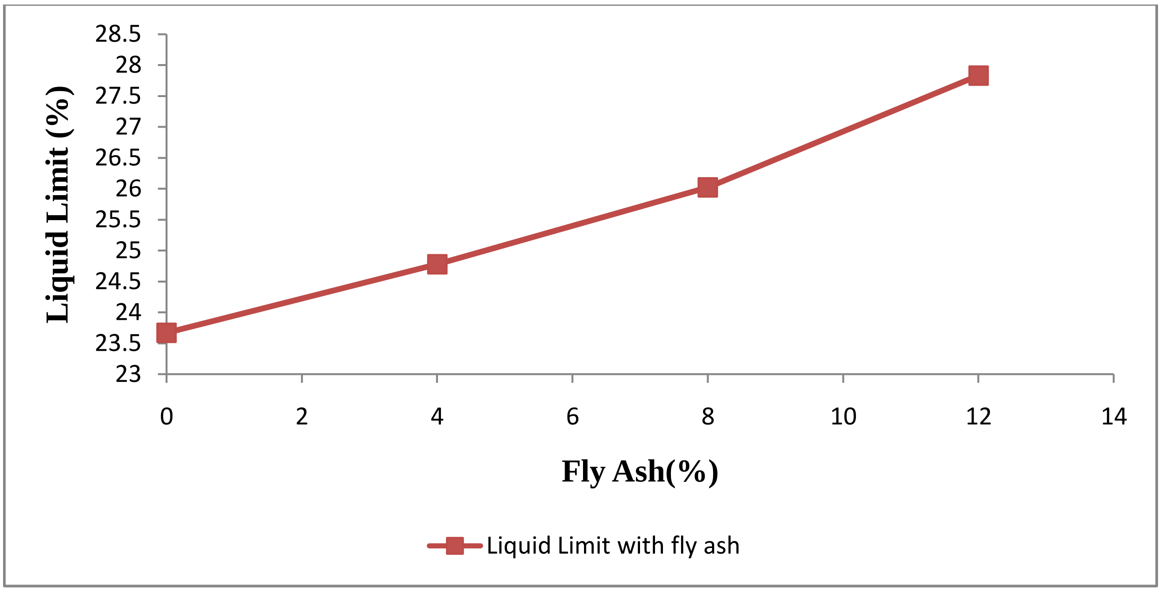

Figure 3 Variation of Liquid Limit of Uchana Soil + fly ash mixes

5.2 Result of Sieve Analysis

Grain size distribution of the soils is shown in Table 3. According IS classification system, the first soil classified as ML and second soil is classified as SM type.

Table 3 Grain size Distribution of soils and admixtures

Soil	Gravel Size (+ 4.75 mm)	Sand Size (4.75 mm – 0.075 mm)	Silt & Clay Size (<0.075 mm)
Jind City Soil	0	27.4	72.6
Uchana Soil	0	62.4	37.6
Fly Ash	0	23.4	76.6

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5.3 Results of Specific Gravity Test

The specific gravity is determined by pycnometer bottle and results are shown in Table 4.

Table 4 Specific Gravity of Selected Soils and Admixtures

Types of Soil/ Admixture	Specific Gravity
ML Soil	2.67
SM Soil	2.66
Fly Ash	2.25

5.4 Results of Modified Proctor Tests

5.4.1 Variation of MDD and OMC of ML soil mixes

In the present study a series of compaction tests were carried out on soil with varying proportion of fly ash and the variation in maximum dry density (MDD) and optimum moisture content (OMC) tabulate in Table 5

Table 5 MDD and OMC of ML soil mixes

Types of Soil Mixes	MDD (g/cc)	% decrease in MDD	OMC	% Decrease in OMC
ML Soil Only	1.947		12.4	
ML+ 4% Fly Ash	1.892	2.82	13.12	5.81
ML+ 8% Fly Ash	1.811	6.98	14.22	14.68
ML+ 12% Fly Ash	1.745	10.37	15.23	22.82

Figure 4 shows the variation of maximum dry density (MDD) and optimum moisture content (OMC) of ML type soil with different proportions of fly ash.

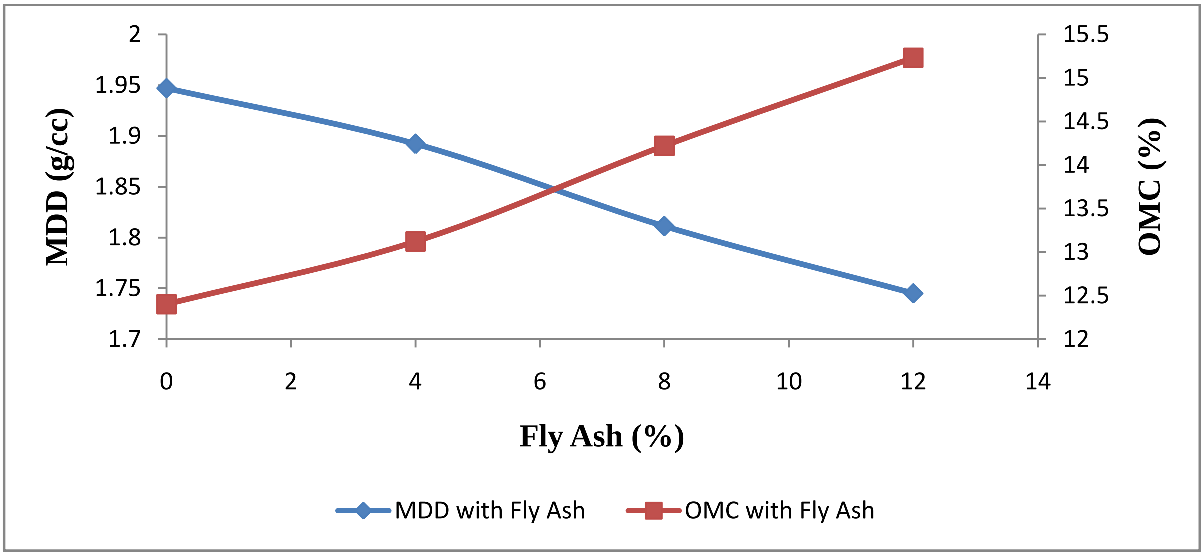

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Figure 4 Variation of MDD and OMC of ML type Soil with fly ash mixes

5.4.2 Variation of MDD and OMC of SM soil mixes

The variation of maximum dry density (MDD) and optimum moisture content (OMC) with different fly ash content mixed with soil is tabulated in Table 6.

Table 6 MDD and OMC of SM soil mixes

Types of Soil Mixes	MDD (g/cc)	% decrease in MDD	OMC	% Decrease in OMC
SM Soil Only	1.895		10.4	
SM+ 4% Fly Ash	1.848	2.5	11.38	9.4
SM+ 8% Fly Ash	1.793	5.4	12.23	17.6
SM+ 12% Fly Ash	1.763	6.7	12.89	23.9

Figure 5 shows the variation of maximum dry density and optimum moisture content of SM type soil with different proportions of fly ash.

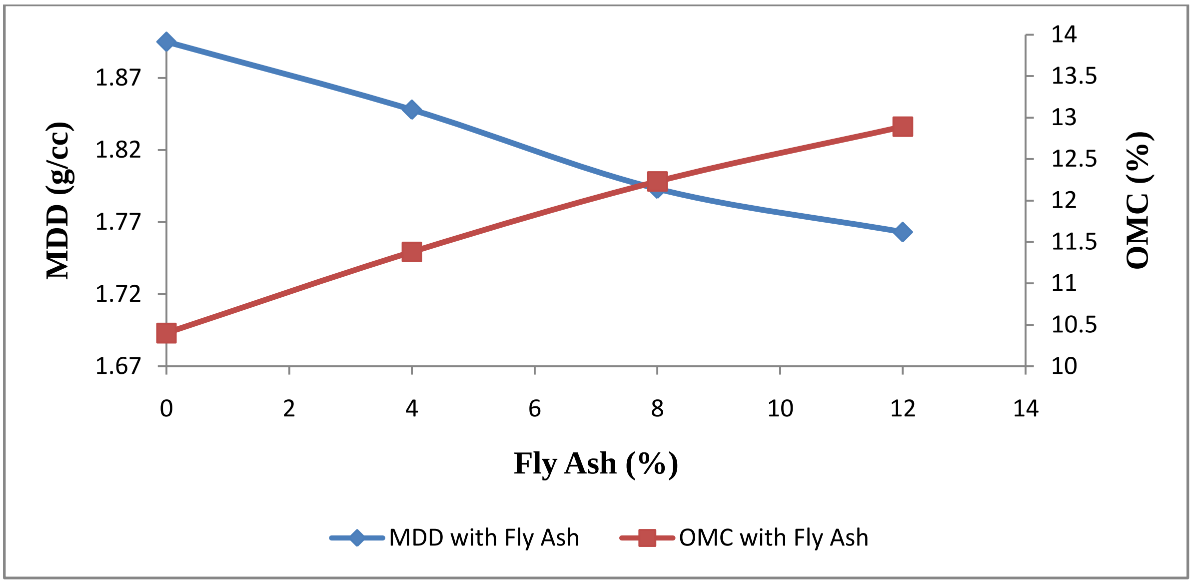

Figure 5 Variation of MDD and OMC of SM type Soil with fly ash mixes

5.5 Results of CBR Tests

California bearing ratio value for various proportions of fly ash are tabulated to determine the suitable proportion for the soil samples. The test results of CBR test are shown in Table 4

Table 4 Increase in CBR of soils with Fly Ash

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Soil Type	% Increase in CBR			
	Fly Ash (%)			
	0	4	8	12
ML	5.94	6.94	7.75	8.59
SM	9.57	10.4	11.07	11.55

Figure 6 and 7 shows the variation in CBR value of ML type and SM type soil with different proportions of fly ash.

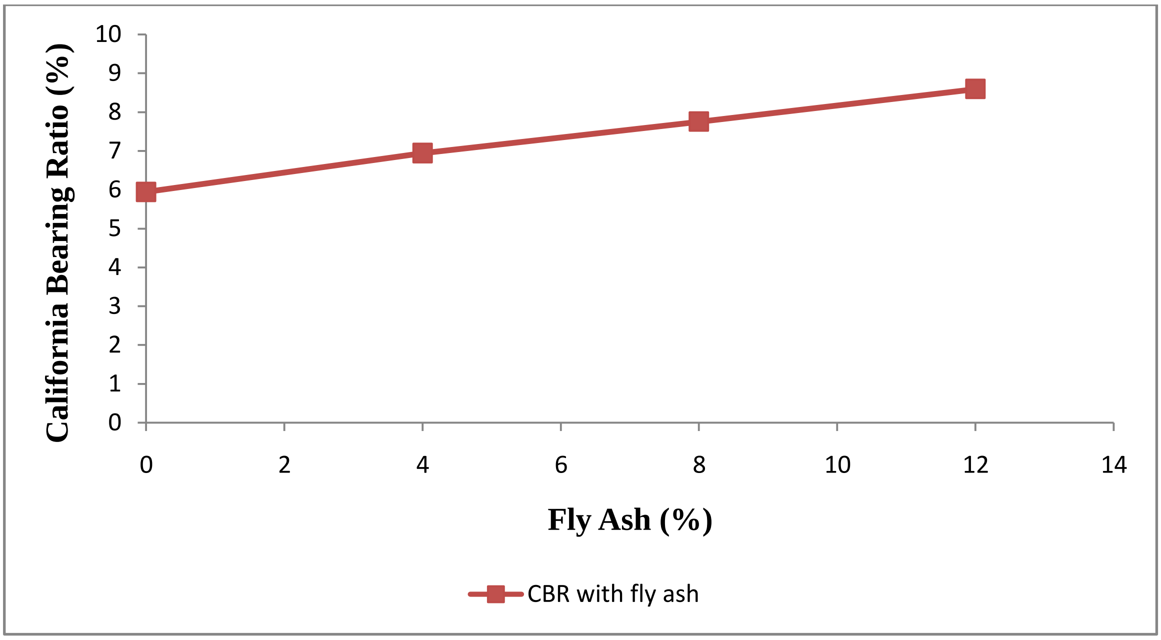

Figure 6 Variation of CBR of ML type Soil + fly ash mixes

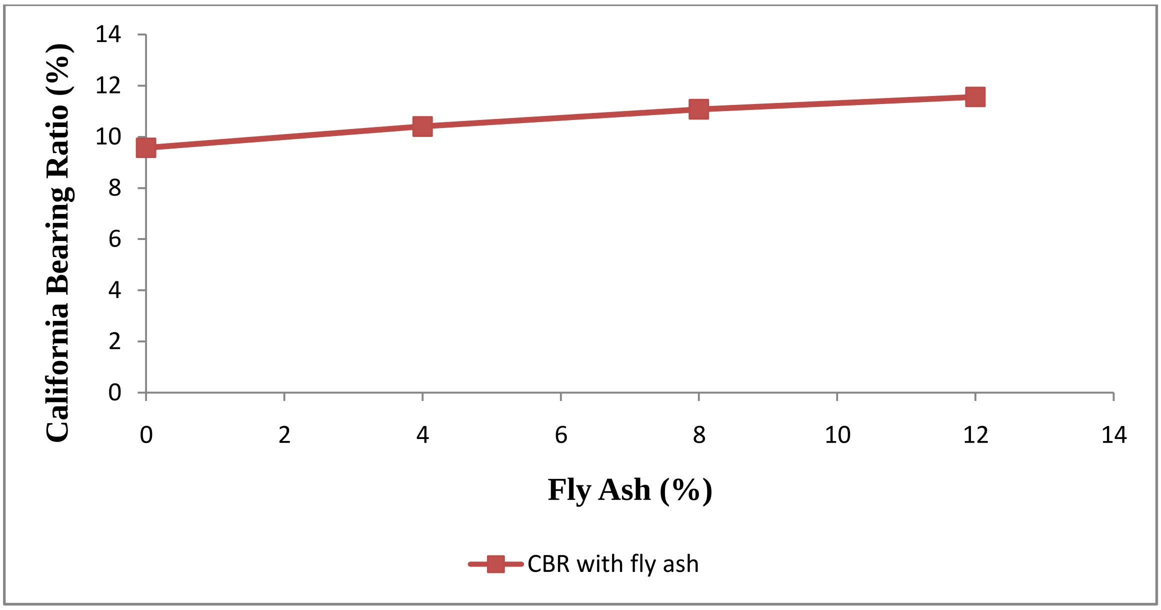

Figure 7 Variation of CBR of SM type Soil + fly ash mixes

6 CONCLUSIONS

From the results of the investigation carried out within the scope of the study, the following conclusions can be drowned.

1. From the results of grain size distribution soils are classified as ML type and SM type according IS classification system.

2. It is observed with addition of fly ash liquid limit of ML type soil decreases but liquid limit SM type soil increases and plasticity index of ML type soil also decreases but plasticity index of SM cannot be determined.

3. With addition of fly ash maximum dry density of both soils decreases and OMC increases.

4. CBR value of ML type and SM type increase with increase in proportion of fly ash.

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