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Effect of Fly Ash on the Strength Characteristics of Soil

Anniamma Chacko[1], Andrew Fernans Tom [2], Lovely K. M[3]
Professor, Department of Civil Engineering, M A College of Engineering, Kothamangalam[1,3]
Guest Lecturer, Department of Civil Engineering, M A College of Engineering, Kothamangalam[2]

Abstract:- The handling of fly ash has become an immediate concern due to its huge accumulation and lack of dumping yards. Flyash can be used in various civil engineering applications. Flyash in geotechnical constructions, embankments, soil stabilisations, geo polymers, subgrades etc. are some of the promising solutions for sustainable development. This paper highlights the importance of utilization of flyash in the stabilisation of soil subgrades. Attempts have been made to study the effect of flyash by conducting experiments on the samples collected from three different sites using various percentages of flyash. Introduction of flyash into the local soil has improved their geotechnical properties.

I. INTRODUCTION

About 570 million tonnes of coal is used every year in India, which produces about 100 million tonnes of flyash. About 65% of flyash produced from coal based power stations is disposed off in landfills and ash ponds. The accumulation of flyash has reached a very high level in the present scenario. Thus recycling and reusing of flyash has become an immediate concern in the recent years due to increasing landfill costs and current interest in sustainable development.Flyash is an effective material in the stabilisation of soft soils. Its low specific gravity, free draining nature, ease of compaction, insensitiveness to changes in moisture content, good frictional properties etc., can be gainfully exploited in the construction of embankments, reclamation of low lying areas, fill behind retaining structures etc. Stabilisation using flyash can increase the shear strength of soil and control shrinkage and swelling properties of soil, thus improving the load bearing capacity of a subgrade to support pavement and foundation. This method of stabilisation can be used to treat a wide range of subgrades. Many research results have indicated that flyash is an effective material and also has a potential application to stabilize soil subgrade.Sridharan, A., et al., (1997, 1998) have studied the improvement in California Bearing Ratio and Unconfined Compressive Strength of soil with addition of flyash. Gandhi, S. R., et al., (2005)conducted laboratory and field trials for stabilization of area covered with plastic clay at Ennore, north of Chennai city.Naik, H. K., et al., (2007) conducted tests on flyash samples mixed with lime and gypsum and reported significant increase in compressive strength.Tuncer, B.E., et al., (2007)has reported improvement in strength and stiffness of Road Surface Gravel with addition of flyash.Fabio Santos et al., (2011) reported improvement in the geotechnical properties of soil with addition of flyash for use in highways.

The properties of flyash vary widely from one plant to the other or even within the same plant over time, depending upon the type of coal used, method of burning and collection procedure. The results of researches carried out on soil at one site cannot be adopted in another place without a closer analysis. Hence this work aims to study the effect of flyash to stabilise soils in and aroundKothamangalam (Cochin) so that it can be used for construction of rural roads and their embankments.

II. MATERIALSAND METHODS

Samples were collected from three different sites inCochin and stored in plastic bags.The geotechnical properties of the soil samples were tested as per Indian Standard specifications and are shown in Table 1.1.

Table 1.1 Geotechnical properties of soil

PROPERTY	SAMPLE 1	SAMPLE 2	SAMPLE 3
Specific Gravity	2.68	2.62	2.75
Permeability	$2.2x10^{-3}$	$1.2x10^{-3}$	$1.3x10^{-3}$
Liquid Limit	44	40	42
Plastic Limit	40.3	17.7	31.7
Plasticity Index	3.7	22.3	10.3
Flow Index	8.2	15.5	11.7
Toughness Index	0.45	1.44	0.88

Uniformity Coefficient	6.5	5	4.5
Coefficient of Curvature	1.3	0.9	0.8
Maximum Dry Density(g/cc)	1.54	1.92	1.71
Optimum Moisture Content (%)	25	13	18
California Bearing Ratio (%)	16.6	8.78	8.78
Unconfined Compressive Strength (kg/cm^2)	2.62	2.37	0.34

The flyash sample was collected from Bhilai Steel plant in Chattisgarh. The chemical components and properties of flyash are listed in Table 1.2and Table 1.3respectively.

Table 1.2 Chemical Composition of flyash

CHEMICAL COMPONENTS	PERCENTAGE
SiO_2	58%
Al_2O_3	22%
CaO	1%
MgO	0.8%
Fe_2O_3	2%
Loss on Ignition(LOI)	8%

Table 1.3 Geotechnical properties of flyash

Specific Gravity	1.90 – 2.55
Plasticity	Non Plastic
Maximum Dry Density(g/cc)	0.9 – 1.6
Optimum Moisture Content(%)	18 - 38
Angle of Internal Friction	30˚ - 40˚
Cohesion(kg/cm^2)	Neglibible
Permeability (cm/sec)	10^{-3}– 10^{-5}
Compression Index	0.05-0.4
Uniformity Coefficient	3.1-10.7

Flyash was added to the soil samples in various percentages (0%, 15%, 30%, 45% and 60%). The required amount of flyash and soil were weighed and mixed together. Mixing was done manually and proper care was taken to prepare a homogenous mixture.Tests like Proctor's compaction, California Bearing Ratio and Unconfined Compression were performed to evaluate the variation of strength with the addition of flyash.

III. RESULTSAND DISCUSSIONS

Proctor's compaction Test:

The optimum moisture content and maximum dry density of the soil samples for various percentages of flyash were determined by performing Standard Proctor test as per IS 2720(Part VII)-1965. The variation of optimum moisture content and dry density is shown in Fig 1.1 and Fig 1.2 respectively.

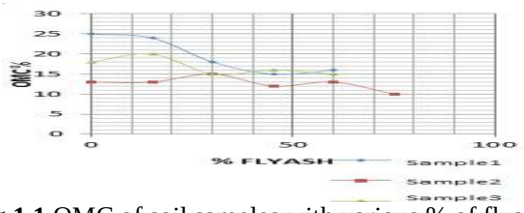

Fig 1.1 OMC of soil samples with various % of flyash

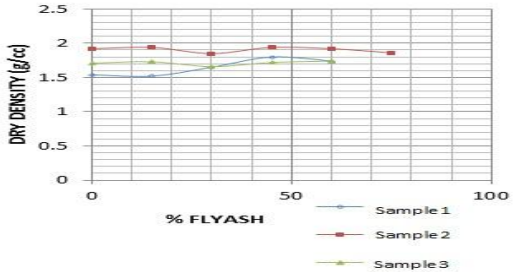

Fig 1.2 Max dry density of soil samples with various % of flyash

It can be observed that for all the three samples tested with increase in flyash content, optimum moisture content and dry density are getting reduced. Decrease in dry density is attributed to the low specific gravity.

California Bearing Ratio Test

CBR tests were conducted on soil samples prepared at OMC as per IS 2720(Part XVI)- 1979. The variation of CBR with increase in flyash content is shown inFig1.3.

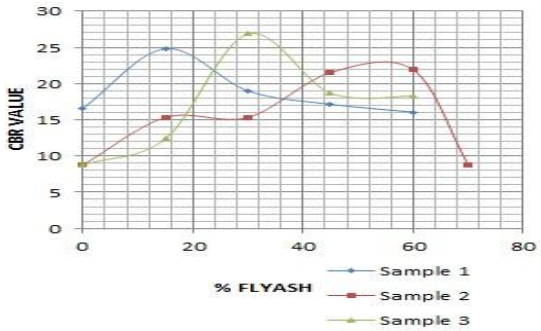

Fig 1.3 CBR values of soil samples with various % of flyash

It is found that, for all the three samples tested, with increase in flyashcontent, CBR value increases upto a certain limit and thereafter it tends to decrease. The optimum percentage of flyash is found to be in the range of 15- 30%.

Unconfined Compressive Strength Test.

UCC tests were conducted on soil samples prepared at OMC as per IS 2720(Part X)- 1991. The variation of Unconfined Compressive Strength with increase in flyash content is shown in Fig 1.4.

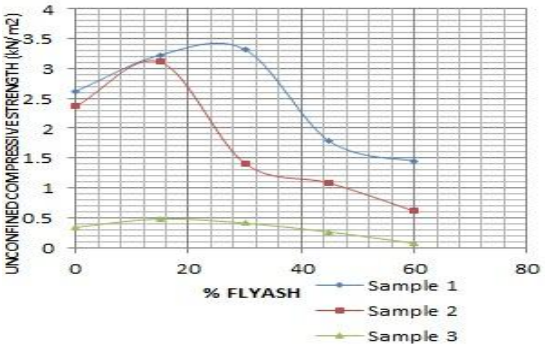

Fig 1.4 Variation of Unconfined Compressive Strength with various % of flyash

Here also it is found that for all the three samples tested, UCC strength value increases upto a certain limit and thereafter it tends to decrease and the optimum value is found to be in the range of 15-30%.

IV. CONCLUSIONS

The effect of flyash on three different soil samples was studied by conducting tests like Proctor's compaction, California Bearing Ratio and Unconfined Compression Test with various pecentages (viz. 15%, 30%, 45%, and 60%). It is found that strength increases with icrease in flyash content, reaches a maximum

value and thereafter decreases. The optimum flyash content for both CBR and UCC are found to be in the range of 15- 30%.

Based on the test results it can be concluded that substantial quantity of flyashimproves the soil properties. Hence this type of flyashcan be effectively used for the construction of local rural roads and their embankments.

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