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PERFORMANCE STUDIES OF LIME AND FLY ASH IN STABILIZATION OF BLACK COTTON SOIL

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ABSTRACT

The current work discusses a study conducted to evaluate the improvements in the qualities of expansive soil with varied amounts of fly ash and lime (5, 10, 20, 30, 40, and 50% by weight of soil). This research reports the findings of laboratory trials tests such as grain size analysis, specific gravity, Proctor Compaction Test (standard and modified), water content, permeability test, Atterberg's limits test (liquid limit, plastic limit, and shrinkage limit), and CBR test. One of the most challenging aspects of field application is thoroughly combining the two components (expansive soil and fly ash) in the proper proportions to produce a homogenous mass.

Keywords: B.C Soil, Flyash, Lime, Atterberg's limits, Compaction test, Permeability & CBR Test

INTRODUCTION

Soil is a critical component in civil engineering infrastructure development. It frequently directs the design and expense of building projects, which are typically lightweight and shallowly rooted structures. As a result, gathering proper soil geotechnical information is critical in infrastructure design and construction. Soil geotechnical inquiry is primarily focused on determining soil types and assessing their geotechnical properties and performance. Some soils, such as expansive soils, are known to be troublesome and need special treatment.

Expansive soils often show a high degree of volumetric swelling and shrinking in response to moisture content changes. This feature can have a negative impact on construction, performance, and life expectancy, particularly for lightweight civil engineering infrastructure. Major issues include volume changes caused by cyclic swelling and shrinkage during wetting and drying, which can cause differential heave, settlement, and creep, a decrease in soil bearing capacity and shear strength when saturated, high erosion susceptibility and instability when exposed in natural slopes, road cuts, or open excavations, and difficult workability conditions. The damage to civil engineering infrastructure is anticipated to be in the billions of dollars.

"Soil stabilization is the alteration of one or more soil properties, by mechanical or chemical means, to create an improved soil material possessing the desired engineering properties." In this paper Fly-ash and Lime are used for the stabilization of Black Cotton soil, for present study Flyash is taken from RAICHUR THERMAL POWER STATION, as fly ash is freely available, for projects near thermal power plants, it can be utilized to stabilize expansive soils for a variety of purposes.

LITERATURE REVIEW

Mehta A., et al. [1] India covers 51.8 million hectares of land with expansive soils, which are hard when dry but lose strength when wet. This problem affects civil engineers worldwide. To improve engineering characteristics, methods like replacing problematic soils with better materials or using additives are used. In Maharashtra, India, fly ash was used to stabilize black cotton soils at different proportions. The addition of fly ash made expansive soil less plastic and increased its workability by colloidal reaction and grain size change. The CBR values of clay with fly ash mixes were tested under unsoaked and soaked conditions, indicating fly ash's potential as an additive for improving expansive soil engineering properties.

J. Zhang et al. [2] The study examined the effects of lime and fly ash on expansive soil's geotechnical characteristics. Lime and fly ash were added at varying amounts, affecting chemical composition, grain size distribution, consistency limits, compaction, CBR, free swell, and swell capacity. The results showed that the addition of lime and fly ash altered expansive soil texture, increasing plastic limit and decreasing liquid limit, respectively. As the amount of lime and fly ash increased, maximum dry density, free swell, and swelling capacity

decreased under 50 kPa pressure, while coarse particles increased. The study concluded that lime and fly ash can successfully stabilize expansive soil.

Patel, P et al. [3] The study investigates the impact of Rice husk ash, Fly ash, and Lime on the engineering properties of black cotton soils. The properties of stabilized soil, such as compaction characteristics, unconfined compressive strength, and California bearing ratio, were evaluated. Various percentages of these ingredients were used to improve the engineering properties of expansive black cotton soil. The optimum content of each ingredient was determined, and it was found that adding any ingredient individually reduced the liquid and plastic limit of soil. However, the improvement in shrinkage limit was not substantial. The standard proctor perimeter was negatively influenced, and the maximum dry density (MDD) was reduced. The coefficient of permeability decreased with the percentage of Lime and Fly ash, and the plasticity index of soil decreased with the percentage of RHA, Fly ash, and Lime. The optimum percentage of RHA, Fly ash, and Lime was found to be 8%, 20%, and 20%. The study aims to determine the suitability of these ingredients for use as modifiers or stabilizers in the treatment of black cotton soil for roadwork.

Mishra, B et al. [4] The rapid growth of the population, rapid urbanization, and construction of buildings have led to a reduction in quality land, forcing people to use soft and weak soils for construction activities. These soils have poor shear strength and high swelling and shrinkage, making them difficult for engineering purposes. To improve their mechanical behavior, stabilization and reinforcement techniques are needed. One major issue in India is black cotton soil, which undergoes high swelling and shrinkage when exposed to moisture content variations. Lime is added to the soil, and pozzolanic reactions occur, forming a permanent strong cementation matrix. Experimental work was conducted with 3% and 5% lime content, analyzing changes in soil properties such as liquid limit, plastic limit, California Bearing Ratio (CBR), and maximum dry density.

Harish, G. R. et al. [5] Subgrade is a crucial component in pavement structures, transferring load over a larger area. The performance and durability of pavement depend on the type of subgrade soil and its engineering properties. Black cotton soil, also known as expansive soil, is problematic. Improvement of geomechanically properties is essential, and stabilization is a ground improvement technique. This study uses lime to stabilize black cotton soil, resulting in improved strength properties and a decrease in plasticity index. A substantial increase in CBR value was observed.

Kumar, K. A., & Bhavannarayana, C [6] The construction of pavement subgrades for roads and railways on black cotton soil (BC soil) is risky due to differential settlements, poor shear strength, and high compressibility. Chemical stabilization is an ancient method for stabilizing problematic soil. This project investigates the compaction and strength behavior of lime-treated BC soil reinforced with bamboo fibers. Different lime percentages were used to determine the optimum value of lime. Bamboo fibers were randomly added to BC soil at different percentages. Tests such as Atterberg's Limits, modified compaction test, California bearing ratio test, and unconfined compression test showed that the strength properties of the optimum combination of BC soil-lime specimens reinforced with bamboo fibers were significantly better than untreated BC soil.

Yin, Z., et al. [7] The study investigates the engineering properties of Black cotton soil (BCS) stabilized with natural lime and volcanic ash (VA). Results show that VA and lime significantly improve BCS's engineering properties. A mixture of VA and lime showed superior results, with 3% lime and 20% VA increasing natural CBR values, reducing plasticity by 29%, and reducing swell percent by 88%. Stabilized BCS meets minimum swell, plasticity, and strength requirements, making it an alternative to cutting and filling.

B. Pravallika and B. Rajesh [8] Black cotton soils, covering 20% of land, pose significant damage to infrastructure and buildings due to their fluctuating moisture content. These soils cause volume changes, causing severe damage to buildings, pavements, and canal linings. Stabilization, a process of improving soil properties, can be achieved using mechanical and chemical methods. Chemical stabilizers like cement, sand, silt, lime, and fly ash can be used for stabilization, particularly in projects near Thermal Power Plants. A study was conducted to assess the improvements in soil properties with fly ash in varying percentages (10%, 20%, and 30%).

TESTING PROGRAMME

Following laboratory tests were carried out as per IS: 2720. The tests were carried out both on natural soil and with different proportions of fly ash and lime mixed with soil i.e., (5, 10, 20, 30, 40, and 50% by weight of soil)

1. Grain Size Analysis
2. Specific gravity
3. Proctor Compaction Test (standard and modified)
4. Water content
5. Permeability Test
6. Atterberg's limits test (Liquid limit, Plastic limit & Shrinkage limit)
7. CBR Test

After removing impurities like vegetation, stones etc. the soil was mixed with fly ash in varying proportion by weight. Then soil was mixed with lime in varying proportion. The mixing was done manually, and the testing were carried out according to normal methods. The results of all of the tests listed above were collated and compared.

ENGINEERING PROPERTIES OF FLY ASH

1	**Specific gravity**	**1.90-2.55**
2	Plasticity	Non plastic
3	Proctor compaction	Maximum
4	Dry density (gm/cc)	0.90-1.60
5	OMC (%)	18-38
6	Angle of internal friction (o)	300-400
7	Cohesion (kg/cm^2)	Negligible
8	Compression index	0.05-0.4
9	Permeability (cm/sec)	103-105

RESULTS AND DISCUSSIONS:

The Results of B.C Soil, B.C Soil + Fly ash & B.C Soil+ Lime

Table 1 Shows Test Results on General properties of B.C.SOIL

SL.NO	EXPERIMENTS NAME	B.C.SOIL
1	Specific gravity	2.55
2	Moisture content (%)	21.03
3	Liquid limit (%)	67.00%
4	Plastic limit (%)	46.41%
5	Standard proctor test(MDD), N/cc	14.27
6	Modified proctor test(MDD), N/cc	14.98
7	Permeability(cm/sec)	6.04*10-7
8	Shrinkage limit	22.96%
9	CBR Test	3.88%

Table 2 Shows Test Results on B.C SOIL + % FLY ASH

B.C.Soil +%Fly ash	Gs	M.C in %	W_L in %	P_L in %	SPT (MDD) in N/cc	MPT (MDD) in N/cc	k in cm/sec	Ws in %	CBR in %
5%	2.12	19.19	52	45.36	14.64	15.72	$4.05*10^{-7}$	20.31	-
10%	2.10	19.02	45.13	43.51	14.68	15.80	$2.4*10^{-7}$	18.23	5.82
20%	1.99	18.45	37	41.81	17.41	17.41	$1.9*10^{-7}$	17.52	-
30%	**1.86**	**18.10**	**36**	**37.23**	**19.60**	**17.24**	$\mathbf{1.44*10^{-7}}$	**16.62**	**8.73**
40%	1.83	17.56	34	36.32	18.88	17.67	$1.18*10^{-7}$	14.10	-
50%	1.56	16.95	20	30.83	18.82	19.35	$0.88*10^{-7}$	17.82	-

The table-2 experienced the performances in the properties of soil after stabilization reflected well for replacing 30% of Fly Ash with weight of Black cotton soil compare to different percentages of Fly Ash. The result shows replacement of 30% of fly Ash is well performed.

Table 3 Shows Test Results on B.C SOIL + % LIME

B.C.Soil +% Lime	Gs	M.C in %	W_L in %	P_L in %	SPT (MDD) in N/cc	MPT (MDD) in N/cc	k in cm/sec	Ws in %	CBR in %
5%	2.52	19.62	57.23	44.81	12.89	17.00	$1.89*10^{-6}$	21.67	-
10%	**2.53**	**19.62**	**54.30**	**39.16**	**15.20**	**18.14**	$\mathbf{1.47*10^{-6}}$	**20.93**	**4.85**
20%	2.62	18.91	52.20	37.45	15.91	16.78	$0.81*10^{-6}$	18.85	-
30%	2.65	17.53	50.60	36.24	16.91	16.70	$0.60*10^{-6}$	16	9.15
40%	**2.70**	**17.31**	**46.60**	**34.30**	**17.18**	**16.58**	$\mathbf{0.51*10^{-6}}$	**10.25**	**-**
50%	2.77	16.06	40.32	33.06	15.53	16.31	$0.44*10^{-6}$	16.18	-

The table-3 experienced the performances in the properties of soil after stabilization reflected well for 40% of Lime with replacing Black cotton soil compare to different percentages of Lime. The result shows replacement of 40% of lime is well performed.

CONCLUSIONS

The present study can serve as an effective method to utilize Fly ash and lime in the stabilization of expansive soil. The conclusions are based on the tests carried out on soil-Fly ash and soil- lime mixes.

1. It has been seen that liquid limit & plastic limit decreases by adding fly ash and lime up to 30 % & 40% respectively.
2. The optimum value of maximum dry density (compaction) was achieved for 30% Fly ash and 40% Lime.
3. Maximum CBR value was achieved by addition of 30% fly ash and 30% lime.
4. Permeability of soil decreased at addition of 30% fly ash and 30% lime.
5. Shrinkage limit can be reduced by addition of 40% of fly ash and lime studied separately.
6. For 10% lime maximum dry density was achieved but shrinkage remained un altered.
7. Addition of 40% lime increased in Maximum dry density and reduced the shrinkage
8. 30% Fly ash and 40% lime was found to be the efficient input for stabilizing BC soil.

This helps to find an application for industrial waste fly ash to improve the properties of expansive soil both in embankments and pavement constructions. So, the optimum percentages of fly ash and lime were observed at

30% fly ash and 40 % lime for improving the properties of expansive soil. Fly ash and lime has good potential for use in geotechnical application of soils is a proven method to save time and money on construction projects. Lime drying of wet soils reduces weather-related construction delays and allows workers to return to work within hours. Lime alteration converts clay soils into friable, workable, and compactable materials. Fly ash and lime stabilization cause long-term chemical alterations in unstable clay.

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