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An Innovative Technique of Stabilization of Soil for Pavements Using Fly Ash and Steel Slag

Wajid Ali Butt

Research Scholar and Junior Engineer PWD(R&B) PMGSY Division Kishtwar, Jammu and Kashmir India, 182204

Abstract: ***The availability of materials for geotechnical application is becoming increasingly scare and there is a need to search for parsimoniously feasible substitute to these conventional materials. Fly ash and Steel Slag are such wastes which are produced in large quantity in India. The fly ash and steel slag being very light is easily carried by wind and water in its dry state thereby causing air and water pollution. The disposal of these wastes entails a large space. These wastes are available in abundance at a very low cost and can be easily used in stabilization of soil for the pavement sub-grade, embankments, landfill liners where in-situ mixing of soil and wastes are possible. However very limited information has been reported on steel slag in the literature. This paper presents some studies on the strength properties of soil mixed with fly ash and steel slag. The soil mixed with different proportions of fly ash and steel slag were tested for its engineering properties by performing a series of CBR tests on number of samples by using the different percentages of the fly ash and steel slag and comparing the results so obtained. The tests results have been analyzed and reveals that the strength increased considerably with the addition of these wastes. Also the optimum value of the wastes were found in terms of percentages where the strength was maximum.***

Keywords: Fly ash, steel slag, waste material, California Bearing Ratio (CBR), Compaction test

1. Introduction

Quite often, engineers may encounter situations where the selected site is not found suitable to take the load of the proposed structure. In such cases various methods of ground improvement can be used to improve the ground conditions. The main objective of the ground improvement is to improve the characterists of soil at the site. Soil stabilization is a rapidly developing field because good sites for construction are becoming limited day to day because of rapid industrialization and urbanization. The primary purpose of stabilizing a soil mass is to improve the stability by increasing its bearing capacity, reducing settlement and lateral deformation. The geotechnical Engineer has the challenge of construction of foundation at the sites which are previously considered unsuitable and objectionable. Though there are various soil stabilization techniques available, soil mixed with the wastes which creates environmental problems has been successfully used in recent times to improve the shear parameters of the weak soils. For the progress of any developing country like India, the proficient road network is the prime requirement. It has been observed that the investments in rural roads lifts the rural people above the poverty line. The Government of India has implemented the "Pradhan Mantri Gram SadakYojana" (PMGSY) for constructing the rural roads and is now almost in completion stage.As on now, India is looking for smart city concept, it is very much important to reuse waste materials. India is producing fly ash and steel slag in very large quantity every year. If these waste materials can be utilized in construction work, the aim of reuse of waste products and reduce the natural recourses can be achieved.Fly ash with steel slag stabilized sub-grade roads can provide a far better surface than conventional WBM roads due to higher strength.

2. Literature Review

Hossain, L. Mol(2011): Observed mechanical properties of clayey soil by incorporating cement kiln dust and volcanic ash.Dosage of volcanic ash and cement kiln dust varying from 0% to20% and the results shows that CBR, compressivestrength, tensile strength and modulus of elasticity increases. Kiran B. Biradar, V. K. Chakervarthi (2014): Studied the improvement of weak soil by adding admixtures through mechanical stabilization. A comparison is made based on results of tests on index and engineering properties of mechanically modified clayey soil with fly ash, crusherdustandsteelslag and found that CBR value considerably increases. Kiran B. Biradar, U. Arun Kumar, Dr. P V V Satyanaranyana (2014): A cooperative investigation carried out to observe an influence of steels lag and fly ash on strength of clayey soil. Steelslag and fly ash mixed with virgin soil in varying percentage to get optimum value. Theresults shows that the CBR value increased by 180% by addition of fly ash and also found that higher values of CBR obtained with addition of slag as compared to fly ash. Kalpana Patel, Adarsh Patel (2016): An experimental study was carried out to observe effects of steel slag on properties of different type of soils (clay, laterite, black cotton clay soil).Steel slag content was added in different percentage (0,5,8,10,15,20,25,30,40,50) and observed that at 40% steel slag MDD increased by 9.20% and CBR by 140%.

3. Experimental Investigation

3.1 Material Used

3.1.1 Soil

The soil used in the study was brought from Ramband Banihal area of Jammu and Kashmir. The soil was clayey in nature and all the requisite physical and mechanical properties were determined as per the relevant Standard tests (IS:2720). The physical properties are given in Table 1.

Table 1: Properties of soil

Clay content (%)	58
Specific Gravity	2.66
Liquid Limit (%)	38.7
Plastic Limit (%)	16.2
Plasticity Index (%)	22.5
Shrinkage Limit (%)	11.67
Maximum Dry Density (gm/cc)	1.84
Optimum Moisture Content (%)	14
CBR at OMC (%)	5.04

3.1.2 Fly Ash

Fly ash brought from Guru Gobind Singh Super thermal power plant Ropar Punjab India. The fly ash was sieved through 600 micron sieve to remove the lumps and other materials which are deleterious to soil.The fly ash passing through 600 microns sieve was used for the laboratory work.

3.1.3 Slag

The slag used in the study was brought from an industry of Mandi Gobindgarh Punjab India @ Rs 2.5 per kg

3.2 Laboratory Studies

In order to conduct the present study various experiments such as Atterberg's limits, Standard proctor test and CBR tests were conducted on the virgin soil samples and soil mixed with different proportions of fly ash and constant 2% slag content and then soil mixed with constant 20% fly ash and different proportions of steel slag. All the samples were prepared at optimum moisture content and maximum dry density. The addition of steel slag and fly ash was done manually, very carefully and percentage is calculated by weight. All mixing was done manually and proper care has been taken to prepare homogeneous mixture at each stage of mixing. Table 2 presents different combinations of the samples used in the present study.

Table 2: Proportions of materials

S. No	Proportion of Material in Percentage		
	Soil	Fly Ash	Slag
1.	100	0	0
2.	88	10	2
3.	78	20	2
4.	68	30	2
5.	58	40	2
6.	48	50	2
7.	70	20	10
8.	60	20	20
9.	50	20	30

(i) Liquid Limit and plastic Limit:- These tests were conducted on soil samples mixed with different proportions of fly ash and steel slag as per the procedure laid down in IS: 2720, Part V, 1985 reaffirmed 1995.

(ii) Compaction Proctor test:- The mould of capacity 1000ml with an internal diameter of 100 mm and height 127.3 mm was used. Compaction Proctor tests were conducted on soil samples mixed with different proportions of fly ash and steel slag as per IS: 2720 Part VII (Light Compaction), 1980, reaffirmed 1997.

(iii) California bearing ratio test: California bearing ratio (CBR) tests were carried out as per IS:- 2720, Part 16, 1987 reaffirmed 1997. All the CBR tests were conducted at optimum moisture content and samples were tested in unsoaked conditions. The mould for placing the CBR sample has inner diameter of 150 mm and height 175 mm and were kept for curing in moist sand for three days before testing.

4. Results and Discussion

Compaction Test: The variation and comparison of maximum dry density (MDD) and Optimum moisture content (OMC) with fly ash and steel slag is shone in Figs 1 and 2. From Fig 1 it is clear that the Maximum Dry Density (MDD) decreases with increase in fly ash content and constant 2 % steel slag because light weight fly ash content replaces the soil content, also there is increase in Optimum moisture content (OMC) with increase in fly ash content because of higher water absorption capacity of fly ash. Fig 2 clearly shows that the Maximum dry density (MDD) increases with increase in steel slag and constant proportion of 20% of fly ash because of higher pozolanic effect of steel slag. However Optimum Moisture content (OMC) decreases with increase in steel slag and constant proportion of fly ash (20%) because steel does not absorb so much water and implies that less water is needed in order to compact the soil, fly ash and steel slag mixtures.

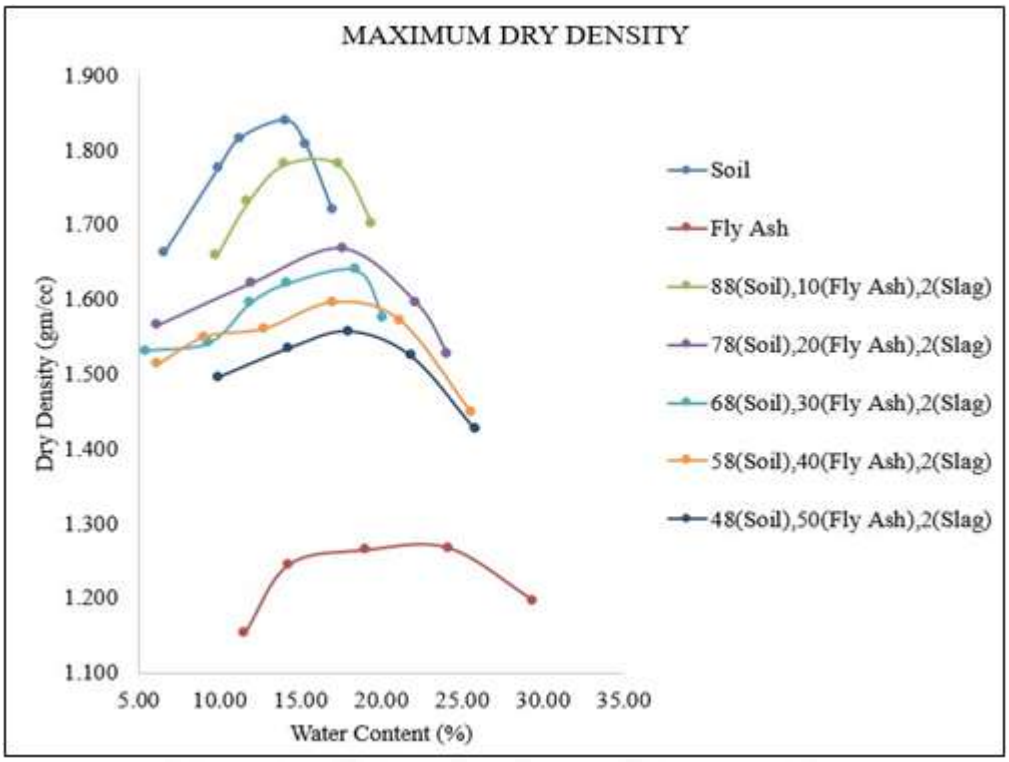

Figure 1: Comparison of MDD and OMC with different proportions of fly ash and constant steel slag

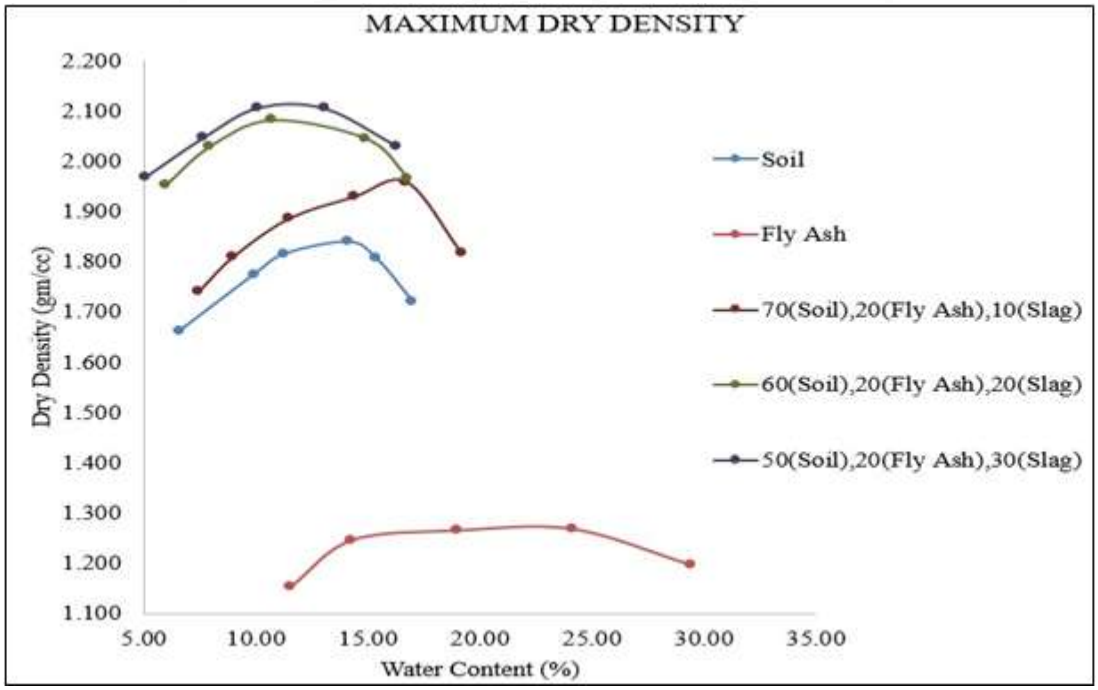

Figure 2: Comparison of MDD and OMC with different proportions of steel slag and constant proportion fly ash

California Bearing Ratio Test:-Of all the available methods of pavement design, the CBR methods has been found the most reliable and practical means of evaluating the strength of the sub-grade (bearing capacity of the soil) for estimating the required thickness of pavement to satisfied the given loading. CBR is measure of resistance to direct penetration of a rigid plunger and the load at penetration of 2.5mm and 5 mm were expressed as percentage of two standard loads (1370 Kg & 2055 Kg) the higher percentage was taken as the CBR value (which was 2.5 mm penetration) In the present investigation and attempt was made to conduct CBR test on soil stabilized with different proportion of fly ash and steel slag. Fig. 3 shows the results of the CBR tests for the stabilized soil with different proportion of fly ash and constants percentage of steel slag and Fig. 4 shows the results of CBR with different percentages of fly ash and constant proportion of steel slag. The increase in CBR value in comparison with virgin soil are presented in Table 3. From the results of CBR it is clear that when the slag content is constant (2%) and fly ash proportion is increasing there is increase in CBR value upto a maximum peak value and then starts decreasing again and even becomes very less as compared to virgin soil. When fly ash proportion is constant (20%) and steel slag is increasing there is also considerable

increase in the CBR value and the values are increasing. So the results obtained in the table 3 indicates that the CBR values increases more for the constant proportion of fly ash and increasing proportion of steel slag then the CBR values obtained by remaining the constant proportion of steel slag and increasing the proportion of fly ash. This shows that the steel slag has more pozolanic effect than the fly ash.

Table 3: California Bearing Ratio (CBR) Test Results

S.No	Percentage of soil	Percentage of Fly Ash	Percentage of Slag	CBR Value in %	Increase in CBR value in % in comparison with virgin soil
1	100	0	0	9.60	NA
2	88	10	2	13.10	36.46
3	78	20	2	15.40	60.42
4	68	30	2	15.38	60.21
5	58	40	2	12.98	28.96
6	48	50	2	6.20	-35.42
7	70	20	10	15.30	59.38
8	60	20	20	15.60	62.50
9	50	20	30	16.20	68.75

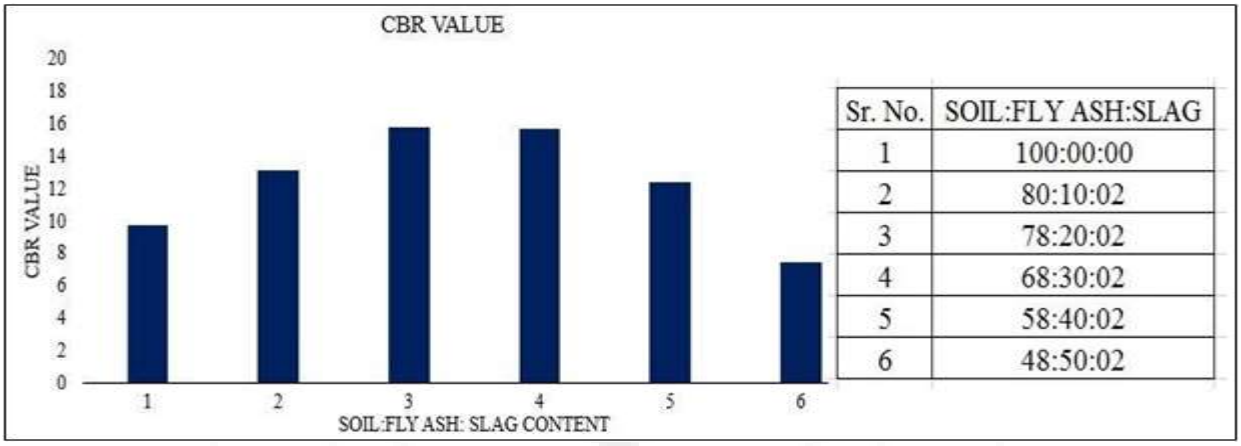

Figure 3: Comparison of CBR value with different proportion of fly ash and constant proportion of steel slag

The results shows that the CBR value increases with increases in fly ash content up to a peak value for 78:20:2 and 68:30:2 and thereafter again decreases with increase in the percentage of fly ash. Again for constant value of fly ash there is increase in CBR value and is maximum for 50:20:30 proportions.

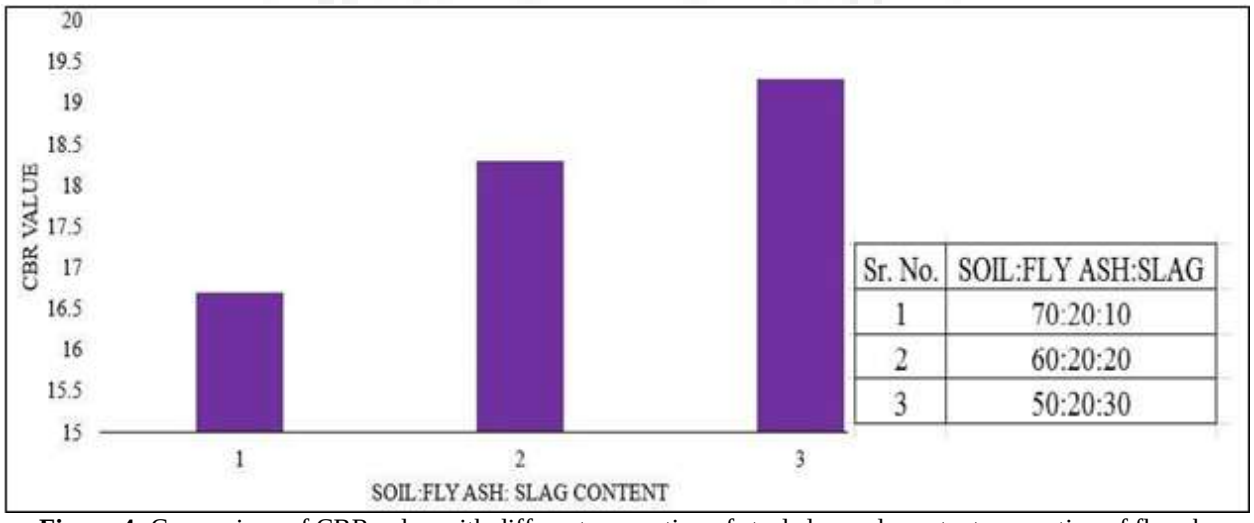

Figure 4: Comparison of CBR value with different proportion of steel slag and constant proportion of fly ash

5. Conclusions

On the basis of present experimental investigation, following conclusions are drawn.

- It has been found that maximum dry density decreased with increased content of flyash. Because proportion of soil decrease and soil has more dry density. Slag with 30% content in soil mix gave highest Maximum dry density and lowest moisturecontent.
- Maximum dry density improved by 70% in case of soil mix with Soil: Fly ash: Slag (50:20:30) as compare to fly ash specimen. On the other hand, 86 % moisture content

decreased.

- Value of California bearing ratioinitially increased with increment of fly ash and attained peak value of 60.42% with 78:20:2 ratio (Soil: Fly ash: Slag), but with increments of fly ash proportion CBR value decreased. CBR value has poorest results (-35.42%) with maximum fly ash in soil mix Soil: Fly ash: Slag (48:50:2). With increments of Slag percentage in specimens CBR value increasedcontinuously.
- Soil mix with Soil: Fly ash: Slag (50:20:30) gave 68.75% better results than virgin soil. It improves the results by9.37s% with slag content increased 30% from 10% in soil mix with fix amount of fly ash at20%.

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