



Characterization of waste material in the Construction of rural Roads

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Abstract

This paper apprehensive with the stabilization of sub grade dirt using deferent types of nearby available materials such as rice husk ash (RHA). Sugar cane ash (SCBA) and cow dung ash (CDA). RHA, SCBA and CDA were mixed in 0%, 2.5%, 5%, 7.5%, 10% and 12.5%. As intermediate plastic clay that reduces dryness and increases the optimum moisture content after stabilization. The trend of CBR and UCS increases and decreases, indicating a peak point showing an optimal ash content (7.5). CBR, UCS and CBR. We can easily protect our environment and we can design of economic roads.

Keywords: RHA, SCBA, CDA, CBR, UCS, DIRT ROAD

1. Introduction

The frequently available land of India is alluvial and is widespread in the northern plains and river valleys. The floodplain is about 43%, covering an area of 143 km², while in Bihar the most common terrain is the alluvial plain of the Indo-Gang tic plain. Most of the land is clayey and silt. The soil is porous due to its open nature. The proportion of iron oxide and lime varies within a wide range in this soil. This type of terrain has a low CBR value. Therefore, this will require a higher construction cost and a maintenance cost, which is too expensive.

India is an important agricultural country, so several crops are grown. India alone produces around 120 million Tons of rice fields a year, producing about 24 million tons of rice husks a year, for every 1000 kg of paddy rice, about 220 kg (22%) of husks are produced and when this husk burns in boilers, they are generated about 55 kg (25%) of RHA. Sugar production is estimated at around 26 million tons per year. Uttar Pradesh is the leading state of agricultural products and also the largest sugar cane producer in India. With a production of 1,333 Lakh Tons, Uttar Pradesh accounts for 39% of the total sugar cane production in the country. About 10-15 kg of cow manure is produced by a cow in a day. Therefore, cow manure can be used by burning it at a temperature of 450-500 LC as background material.

A rural road development project under Pradhan Mantri Gram Sadak Yojna (PMGSY) is still underway in India. The floor of the foundation is the base of the floor and its properties are important in the design of the flooring structure. The main function of the substrate is to provide adequate support for the flooring and, for this; the substrate must have a good load capacity, consistency limits, good drainage stability in adverse weather conditions and Load behavior conditions. Therefore, there is a require to design one of the appropriate methods of low cost road Consideration. The production cost can be considerably decreased by selecting locally available materials

for stabilization of the existing soil. This study includes the stabilization of sub grade soil using deferent locally available materials such as sugarcane bagasse ash, cow dung ash and rice husk ash.

1.1 Need to use locally available materials

Because most of northern India belongs to the alluvial region that has a soft soil and poor drainage conditions, a large amount of expense is spent each year to keep the pavements flexible on the spot. Pleasurable conditions this means that the type of terrain found in Bihar is poor for road construction. More thickness of the previous pavement layers was required, i.e. more consumption of the materials of the pavement layers. In Bihar, the production of road metals is prohibited, so these metals are transported from the quarry site of the neighboring state. This situation improves the advantage consequently; the additional burden of the construction costs of the project is lasting. In light of this, attempt has been made to use locally available materials that are generally establish in abundant amounts in rural areas.

1.2 Scope and objectives

This study aimed to improve the strength of clay soil by using locally available agricultural and geotechnical waste to reduce construction costs. Three different types of stabilizing agents are used, such as rice husk ash (RHA), cane sugar sack ash (SCBA) and cow dung ash (CDA). The present study was carried out with the following objectives:

1. Explore the possibility of using rural waste materials such as RHA, SCBA and CDA in soil stabilization.
2. To investigate the chemical and physical properties of stabilizing agents and their suitability.
3. Investigate the physical and engineering properties of natural soil and stabilized soil by adding 2.5%, 5%, 7.5%, 10% and 12.5% ash to soil.
4. To compare the thickness of the pavement with the

maximum value of CBR soaked obtained for soil stabilized with CBR value soaked in natural soil.

2. Survey of the Literature

Roy Aparna studied the effect of rice chaff ash (RHA) together with the cement on the characteristics of the lower grade clayey soil. It has been found that as the proportion of rice and cement ash increases, the moisture content and CBR increase, while the maximum dry density decreases. Kumar and Preethi [5, 8] studied the behavior of clayey soil mixed with rice husk and lime and was Observed that the maximum improvement in CBR value is with combination of 6% lime + 10% RHA. Shrivastava [7] had seen the effect of lime and RHA on engineering properties of black cotton soil and found that there is a major increase in CBR and UCS strength, whereas optimum moisture content increases and maximum dry density decreases. Basha *et al.* [1] replaced the soil with various extent of rice husk ash and cement. It was found that 6–8% of cement and 15–20% RHA shows the optimum value. Addition of rice husk ash to the cement stabi-lized soil shows the significant result in CBR. [2] Investigated the influence of agricultural wastes in soil stabilization. Agricultural wastes such as sugar cane bagasse ash, rice husk ash and groundnut shell ash are used to stabilize the weak sub grade soil [9]. And carried out experiments on stabilization of Actuate Lateritic Soil with Sugarcane bagasse ash and cement. Result of CBR showed tremendous improvement [3]. Kiran & Kiran had analyzed the strength characteristics of black cotton soil using bagasse ash as stabilizer. The strength parameters like CBR, UCS were determined. It was observed that the blend results of bagasse ash with deferent percentages of cement for black cotton soil gave change in density, CBR and UCS values.

Kiran *et al.* [4] studied the stabilization of lateritic soil using sugarcane straw ash and cement. Sugarcane straw ash was an effective stabilizer at 6% with 5% of cement for improving the geotechnical properties of local lateritic soil sample [6]. Investigated the pozzolanic potential of cow dung ash when used in concrete by partial replacement of cement at 0, 5, 10, 15, 20, 25 and 30%. It was found that not more than 15% of cow dung ash could be use to produce well and quality mortar and concrete.

3. Physical and chemical properties of the stabilizers

The rice husk was obtained from the nearest and burned mill at a temperature range of 600-700 LC in an open fire until it was transformed into amorphous silica. The bagasse obtained from the sugar cane in dry conditions was obtained from the oil mill (gur) and burned at a temperature of 800-1000 LC, while the cow dung pies were collected from the villages and burnt at a time. Temperature of 400-500 LC. These ashes were tested in the laboratory for chemical compositions as shown in Table 1. The physical properties of the stabilizers used in this study were determined in the soil mechanics laboratory shown in Table 2.

Table 1: Chemical properties

SL. No.	Component	Test result (% by mass)		
		CDA	RHA	SCBA
1	Silica (SiO ₂)	56.32	94.6	70.83
2	Aluminium Oxide (Al ₂ O ₃)	5.03	0.20	6.84
3	Iron Oxide (Fe ₂ O ₃)	2.76	1.22	4.87
4	Calcium Oxide (CaO)	13.2	0.30	3.41
5	Magnesia (MgO)	4.33	0.21	3.24

Table 2: Physical properties

Sl. No.	Property	Test result		
		CDA	RHA	SCBA
1	Colour	Grey	Grey	Grey
2	Specific gravity	1.765	1.89	1.90
3	Liquid limit	42.85	44.3	39.22
4	Plastic limit	Non-plastic	Non-plastic	Non-plastic
5	Optimum moisture content (%)	41.25	43.56	46.60
6	Maximum dry density (gm/cm ³)	1.18	1.17	1.26

Table 3: Atterberg’s Limits in percentage.

Different mixing proportions Soil: Ash (CDA/RHA/SCBA)	RHA		SCBA		CDA	
	LL	PL	LL	PL	LL	PL
100:0	36.06	23.7	36.06	25.10	36.06	23.70
97.5:2.5	35.20	24.92	36.61	25.86	33.79	23.33
95:5	35.06	25.27	34.50	24.60	38.03	27.76
92.5:7.5	34.87	26.32	33.24	25.76	41.63	31.87
90:10	34.52	27.96	32.37	26.25	39.3	29.62
87.5:12.5	34.49	28.33	31.85	25.97	42.81	33.44

As per ASTM (Class C) the combine percent composition of silica (SiO₂), aluminum oxide (Al₂O₃) and (Fe₂O₃) should be more than 70. This shows that, it is a good pozzolana that could help mobilize the calcium hydroxide (CaOH) in the soil for the formation of cementations compounds. The silica and alumina available in the ash reacts with the calcium present in the soil in the form of calcium hydroxide to form the calcium silicates and calcium aluminates which is very important

arameter for cementing behavior. RHA and SCBA have more than 70% oxides whereas CDA has 65% oxides for pozzolanic action.

4. Laboratory investigations

The soil sample used for this study is collected from proximity of Patna in Bihar at a depth of 1.5 m–2.5 m using the method of disturbed sampling. According to Indian Standard soil classification system, the soil was classified as intermediate plastic clay (CI). The particle size distribution of natural soil was carried by conducting both the sieve analysis and hydrometer analysis. The geotechnical properties of the natural soil are mentioned in the following subsequent headings. The guidance on proportioning was taken from the literature. The amount of ash was varied from 2.5 to 12.5% by weight of soil in steps of 2.5%.

4.1 Atterberg’s Limits characteristics

The Atterberg's Limits test of the natural soil and soil mixed with three selected ash were conducted as per IS: 2720 (Part-5)-1985. Liquid limit and plastic limit values are indicated in the Table 3. shows the variation in the plasticity index of the soil and soil-ash composites, the effect of adding the deferent ashes in varying proportions. It is observed that plasticity indexes (PI) of the natural soil is 12.36%. In ash stabilization the liquid limit of soil generally Decreases but the plastic limit increases. Thus the plasticity index of soil decreases. In general reduction in the liquid limit is the indicative of reduction in the compressibility and swelling characteristics. From the change in liquid limit it may be inferred that there is an overall improvement in the behavior of alluvial soil on the addition of RHA and SCBA. The general decrease in liquid limit at all soil-ash combination is attributed to the fact that the ash reaction forms compounds possessing cementation properties namely calcium silicate cement with soil particles. The general trend of plasticity index for ash stabilized soil declines. RHA and SCBA stabilized soil indicates almost same rate of decrease in plasticity index with an increase in percentage contribution of ash. But, CDA stabilized soil shows there is no significant change in plasticity index with an increase in percentage contribution of ash.

4.2 Compaction characteristics

Standard proctor test was conducted as per IS: 2720 (Part 7) to determine the optimum moisture content and corresponding maximum dry density. The variation in the optimum moisture content with a percentage increase in ash. On increasing the proportion of the different ash and decreasing the proportion of the soil in mix, the optimum moisture content increases. This may be due to the increase in mix proportion and decrease in quantity of free silt, clay fraction and coarser materials with large formation of surface area. This process needs water to take place which means more water is needed in order to compact the soil-ash mix. It shows the variation in the maximum dry density of the stabilized soil, with using different proportions of ashes. It has been seen that the dry density decreases and the optimum moisture content increases as the proportion of different ashes increases. The decrease in maximum dry density may be due to the addition of ash with a lower specific gravity than the soil.

4.3 Strength characteristics

4.3.1 CBR test

The CBR test for natural soil and stabilized soil was carried out as per IS: 2720 (Part-16) in both soaked and unsoaked conditions to evaluate their load bearing capacity. The unsoaked CBR. It has been observed that the unsoaked CBR increases then decreases with an increase in the proportion of the different ash. The increase in unsoaked CBR may be due to the formation of calcium silicates after reaction of silica from ash and calcium from soil. Afterwards the unsoaked CBR decreases as the excess of silica does not react with calcium. The maximum unsoaked CBR was achieved at 7.5% of ash. The maximum CBR value is 18.83%, 16.24% and 13.67% for RHA, SCBA and CDA respectively. Soaked CBR characteristics of natural soil as well as stabilized soil. It has been observed that the soaked CBR increases and then decreases with an increase in proportion of

the different ash. The increase in the soaked CBR up to 7.5% ash content can be attributed to the gradual formation of cementitious compounds between the ashes and calcium hydroxide contained in the soil. The decrease in the soaked CBR after 7.5% ash content may be due to excess ash that was not mobilized in the reaction, which consequently occupies spaces within the sample and therefore reducing bond in the soil-ash mixtures. Maximum soaked CBR is 7.68%, 5.88% and 4.87% for RHA, SCBA and CDA respectively at 7.5% of ash content.

4.3.2 Unconfined compressive strength characteristics

The unconfined compressive strength (UCS) of the natural soil and stabilized soil was determined as per guidelines of IS: 2720 (Part 10) 9. The variation in unconfined compressive strength.

It has been obtained that the UCS of the natural soil is 1.48 kg/cm². On replacing the soil with the deferent ash, initially the UCS of soil increases up to the mix 92.5% soil and 7.5% RHA/SCBA/CDA and then decreases. The subsequent increase in the UCS is attributed to the formation of cementations compounds between the calcium hydroxide present in the soil and ashes and the pozzolans present in the ashes. A further decrease in the UCS values after the addition of 7.5% ashes may be due to the excess ashes introduced to the soil and therefore forming weak bonds between the soil and the cementations compounds formed. The maximum UCS value recorded was 2.16 kg/cm², 1.88 kg/cm² and 2.05 kg/cm² for RHA, SCBA and CDA contents respectively just after preparation of samples. These values are slightly higher than the natural soil UCS of 1.48 kg/cm².

4.4 Thickness implications

Flexible pavement of rural roads is designed according to the chart given in the IRC-SP: 72-2015. The soaked CBR of unstabilized soil is 2.37%. The optimum soaked CBR for stabilized soil is 6.68%, 5.88% and 5.92% for RHA, SCBA and CDA respectively. Overall thickness of the pavement is evaluated while keeping CBR constant and varying traffic loads. Traffic load was considered from 10 to 2000 ESAL (Equivalent single axle load)

Single Axle Load in thousands) for showing the variation in thickness. There is a reduction in thickness that varies from 25% to 31.5% for RHA stabilized soil whereas it varies from 12.5% to 23.5% for SCBA and CDA stabilized soil.

5. Conclusions

On the basis of the present study following conclusions have been drawn:

The alluvial soil was identified as intermediate plastic clay (CI) on Indian Standard classification system. Three waste materials like RHA, SCBA and CDA were used to stabilize the soil for road construction. An enough cementations property was found in RHA and SCBA rather in CDA.

On addition of deferent ash in the soil, the plasticity index decreases with an increase in the proportion of ash from 2.5% to 12.5%. The percentage decreases in plasticity index value of soil from 13 to 24, from 16.8 to 50 and from 13 to 52.4 for RHA, SCBA and CDA stabilized soil respectively.

The compaction characteristic of stabilized soil found to be

dependent on the plastic nature of the soil. For medium plastic soil, addition of stabilizer to soil reduced the maximum dry density while increasing the optimum moisture content irrespective of stabilizer type.

The soaked and unsoaked CBR of the soil is found to be increasing and a peak point is achieved then decreasing. Therefore, an optimum CBR is obtained at 92.5% soil and 7.5% ash composition. The value of soaked CBR at peak point when stabilized with RHA, SCBA and CDA is increased by 134%, 79.81% and 48.92% respectively when compared to unstabilized soil.

A similar trend of the CBR was obtained for UCS. The value of UCS at peak point when stabilized with RHA, SCBA and CDA is increased by 45.94%, 27% and 38.51% respectively when compared to unstabilized soil.

On the basis of maximum CBR and UCS value, the ash content for stabilization is obtained as optimum value i.e. 7.5%. At this value there is relatively low dry density and high moisture content that will be helpful in controlling the volumetric changes. Hence, this optimum value may be considered for stabilization of soil for sub-grade construction. Thickness implication indicates that there is a significant reduction in thickness while using ash stabilized soil for sub-grade construction. Hence, this will economize the cost of construction.

Comparatively priority may be given in this sequence to RHA, SCBA and then CDA for stabilization of soil. CDA is not a very good stabilizer but can still be used to improve the engineering properties of alluvial soil.

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