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Soil Stabilization in Pavement Construction

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ABSTRACT

Soil is used as a material for road construction in sub grade and sub base region of the pavement. If the strength of soil is poor due to it being soft, has a high swelling tendency or low shear strength than soil stabilization is required. Its main advantage over soil replacement is most of the time it is done to reduce the cost incurred. There are numerous stabilizers available in the market like lime, cement, flyash, granulated slag etc. In this paper we will use rice husk and lime as stabilizer. Although the stabilizer is neutral, it requires a activator to start the reaction which is provided in form of lime. So the percentage of soil to admixture play a crucial role in soil stabilization as they have different specific density. The objective of the study is to improve the locally available weak soil with stabilizers. The test involved are Modified proctor test to find the maximum dry density of the sample mixture and CBR test to check whether adding admixture improves the soil, as higher the CBR it helps to reduce the crust thickness and helps in increasing the bearing capacity of the soil. Thus overall may help in reduction of cost incurred in the project.

Keywords; Lime , Rice husk

1.Introduction

It is seen that India facing the main challenge to give a network of full system of road, particularly in providing road connectivity to village and highway, expressways for development of industries. Construction and materials cost is increasing leaps and bound year after year. So, there is a need to obtained one suitable low cost road construction method by which we effectively utilize local materials without environmental hazardous.

The main objectives of soil stabilizing road constructions are

- To obtain economy in initial construction cost of pavement such as sub base course and sub grade.
- To upgrade the pavement structure to higher specifications at a later stage and it is easier to available raw material which is eco-friendly.

General application of soil stabilization techniques

In Sub grade of Pavement

Area where the soil is found low strength and used as a sub grade material is not fit forconstruction material in main road pavement.

- Find suitable soil from nearby and other areas that have suitable soil properties, transport the soil from the borrow pits to the construction sites, compact the samein layers by mechanical means and construct the subgrade of specified 500mm thickness.
- By adopting appropriate soil stabilization techniques and upgrade the properties of soil to suitable levels, compact in layers and construct the subgrade of pavement to required thickness.
- In Sub-base course

The method of Soil Stabilization by different material have been successfully adopted to improve available soil and soil aggregates mixes for construction of bottom layers of thepavement structures such as base course and sub base which are cost-effective.

Mechanics in Soil Stabilization

Modification in property of soil like the swelling and shrinkage of the natural soil by the use of complete compaction, proportion and/or submission of economical stabilizers and additivesis term as soil stabilization. Soil Stabilizers are used as physical, physiochemical and chemical method to ensure that the stabilized soil serves its intended purpose as the pavement component and their property upgraded. The basic principle is

1. Comparing the properties in given sample soil and examine in unuseful properties of the soil which are loose. By adopting the appropriate method of supplementing the weak properties by effective and economical method of soil stabilization hazardous to environments.
2. Along with the environmental aspects.

3. Analyzing the soil Stabilized mix for intended durability and stability values.
4. By adopting suitable construction procedure including addition of suitable stabilizer, mixing spreading and by adequate mechanical compaction.

Soil stabilization causes following changes

1. Increase in soil strength characteristics.
2. Increase in some properties of soil like plasticity,sewelling and shrinkage.
3. Chemical properties change in soil structure.
4. Gaining desired minimum strength even after subjecting the stabilization of soil.

Techniques in soil stabilization

- Mixing and proportioning different materials

  The strength property of a soil is gained by the cohesion component 'C' per unit area and friction components represented by 'phi'. Generally granular soils contain no cohesion. So, the stabilization of fine grained soil can be enlarged by addition of course grained soil at an appropriate proportion

- Cementing Agent

  It is most economical to increase the strength of soil by adding binding agent likeOPC, Lime or some bituminous binders.

- Modifying Agents

  If a stabilizer added in soil then undesirable properties of soil such as plasticity or swelling such as its reduction without adding to its strength it is called modifying agent. Lime is most common modifying agent which can be used in clayey soil.

- Water Proofing Agents

  Compacted Soil which is generally stable and becomes loose if there is an excessof water when subjected to soaking condition . If absorbtion can be stopped or reduced by any means of some water proofing agents it will be possible to make use of such an material with advantage, the most common method of water proofing is by use of bituminous binder.

- Water Retaining Agents

  Generally some non cohesive soil capable to stable when compacted in layers gives slight moisture content, by 'imparting apparent' to the soil. But the soil maybecome weak and unstable when purely dry In such cases utilization of deliquescent material is endorse like Calcium Chloride to hold some water or absorb water from the atmosphere and thus impart some obivous cohesion and retain the strength. This can also reduce the dust problems in un-surfaced roads which makes environment healthy. In low rainfall areas problem of low water content which rise to unstability in granular soil.

- Heat Treatment

  In the past decades the natural heat treatment of the soil or thermal stabilization results in some useful and undesirable changes in cohesive soil. The changes depend on temperature variation and time duration of heating. Manufacturing of brick is based on this principle. The desirable variation include reduction in swelling properties and heat treated soil may be used as aggregates in mechanical soil stabilization or as puzzolonic admixtures in soil lime stabilization.

Chemical Stabilization

It is very economical when several chemicals added as one chemical or in combination even in less proportion say .5% by weight of soil may impart desirable changes in different types of soil. However significant investigation and care is required before any costly chemical mixed. India is developing country and adopted chemicals under chemical stabilization. Some country have been found successful in curbing the significant properties of soil components and modifying strength and durability to stabilized mixes of certain type of soil.

Soil - Lime Stabilization

In road construction soil Lime works in both ways as a binder and as well as modifier for high plasticity clayey soil. Lime may be used in both fine grained and coarse grained soil to modify their property. The basic principle follow with lime soil stabilization was puzzolonic action. The puzzolonic reaction takes place when lime added is due to addition of hydrated lime with moist soil and it is defined as hydrated lime ($Ca(OH)$ + Water + Soil (SiO_2, Al_2O_3 and others). Cementious material in which lime present with stable silicate hydrates and calcium aluminates hydrates. The addition of lime creates improvement in workability of soil by increasing OMC wrt soil without lime, increase in all type of strength related properties by decreasing plasticity index, swell reduction and soil becoming hydrophobic. With suitable addition of rice husk it can be added to the gravel, sand and silt

2. Literature Review

General

(M. Harikumar et.al., 2016)[1] had studied that unartificial additive's use as rice husk & lime for soil stabilizing which is economical. When RHA, lime added the maximum dry density decreases and slight rise in optimum moisture content. RHA and lime addition results gradual rise in plastic limit and liquid limit of soil. Several soil samples tested with RHA, lime and by performing these laboratory test minimum content of RHA is determined. Several results are compared in practical lab test after finding strength parameter like optimum moisture content, maximum dry density, unconfined compressive strength. So instead of hauling soil from long distance, it was decided to use the locally available plastic clay stabilized using Fly ash. Fly ash is freely available in locality of a thermal power plant.

(P. N. Babaso H. Sharanagouda 2017)[2] rice husk contains like carbon, hydrogen, silicon, oxygen, silica. Bulk density of rice husk is 96-100 kg per metre cube. Rice husk is cheaper fuel then coal. Rice husk has binding ability which reduces the formation of crack in soil. It is seen that the local soil was highly plastic so the fly ash can be used up to 25% after which maximum dry density was increased 1.25 times the original.

(Ankit Singh Negi, 2013)[3] For highly active soil lime is used which takes less time for quick stabilization of soil. Lime improves various property of soil such as shrinkage, carrying capacity of soil, plasticity index, increase in CBR value and increase in compression resistance with time. Lime is good stabilizing material for cohesive soil. Lowweight material is used for better compaction of cohesive soil by filling voids between them.

(Aparna Roy 2014)[4], by using rice husk cost of stabilization may be minimized and this agricultural waste will be disposed. So that environmental hazards get down. Small percentage of cement and rice husk the soil get stabilized by adding them gradually. Several observation are taken after changing percentage of rice husk and cement which gives good performance of optimum moisture content and maximum dry density. The MDD was decreased while OMC increased with increased in RHA content. By increasing 10% of RHA and 6% of cement content the maximum improvement in strengthand this percentage are also applicable to practical purpose.

(Koteswara Rao D 2011)[5] Rice husk when mixed with lime and gypsum it gains potential to stabilize. It reduces the cost of road construction in rural areas and also reduces the environmental waste like rice husk ash. Rice husk when mixed with lime (5%) it increased the CBR value to reduce the effect of swelling and shrinkage of cohesive soil. Rice huskgives significantly result.

(Sharma and Sivapuliah, 2015)[6] for old usual method of soil stabilization are to remove the soft soil and change from a hard materials. Due to most economical method has driven the researcher to look for alternative method and one of these methods is process of soil stabilization. The primary benefits of using these additives for soil stabilization are cost saving. Slag is cheaper then cement then cement and their availability over across the country. For cohesive soil use of rice husk gives us better result in property of soil.

(B. Suneel Kumar & T. V Preethi 2014)[7], Studied that due to increased construction activities in highway sector the demands for sub grade material have increased. To fulfils the demand of sub grade material use of different alternatives waste material gen rate. These alternate waste materials do not cause environmental hazardous and depositional problem. By several investigation has been done after which agriculture waste material like rice husk ash which improve the sub grade properties. A chemical reaction in stabilization process is started when rice husk ash mixed with other cementious materialssuch as lime and cement.

(M Alhassan 2012)[8] maximum dry density decreases which is due to lower particular specific gravity (2.25) of RHA. RHA act as filler in soil voids. As the increase in RHA content also increase in PMC and unsoaked CBR. The main science was to use lime or cement with rice husk and to change it to take more load from foundations. BC soil was obtained from Bangalore in Karnataka and rice husk obtained from industry and were dry-mixed. The strength of specimen increased by 18% at 7 and 14 days of curing and at 38%for 28 days.

(A. Hossain, M khandaker 2011)[9] studied the cost of soil stabilization is high due to over dependency on the utilization of industrial additives such as cement, lime etc. So, by keeping soil stabilization economical the used of agricultural based product should be done. These agricultural based product also reduce environmental hazardous. In soil modification addition of a modifier (cement, lime etc.) which causes change in index properties, increase in strength, change durability. RHA stabilized the soil slowly when mixed with lime and gypsum.

Summary of Literature

The practical work has been done in field of soil stabilization, and mainly it depend on necessity of on field modification of soil stabilization like CBR, MDD, OMC, UCS and Atterberg limits. The fundamentals of soil stabilization with respect to lime and rice husk are studied. Sub grade of pavement is improved due to soil stabilization, and economy in construction is analysed and if possible reduced with help of lower cost of admixture, or lowering the crust thickness. Further this project study the effects of stabilization of soil related to rice husk, fly ash and its effect on MDD, CBR, Crust thickness and would checkif overall cost of 1km road using stabilized soil has positive or negative effect on the economy of the project.

3.Materials

Soil

The soil is obtained from taramandal area in Gorakhpur. There soil is mildly expansive due to some clay content in it. The soil is sieved through 4.75mm sieve followed by 2.36mm, 1.18mm, .600mm, .425mm, .075mm, finally .002mm and retained on pan) weighed and air dried. Once the soil is naturally air dried, it is tested for natural moisture content in a muffle furnace.

Lime

Quick lime was slaked, finely crushed with minimum moisture and sieve or grind to form a minor homogenous powder the material was known as hydrated lime. Quick lime obtained by burning limestone or $CaCl_2$ obtained from lime quarry, then water is sprinkle and shake for 10 minutes and powder form is obtained. IS: sieve is used for producing Slaked lime by sieving from 3.5mm. Use of slaked lime for various purpose such as plastering making mortars, white washing, and lime putty and when mixed with soil, helpsto reduce its swelling and helps to gain strength. Above procedure is also called as hydration of lime.

$$Cao + H2O \rightarrow Ca(OH)2 + 15.6\ Kcal$$

Generation of high heat of hydration from above equation at a temperature of aprox 350^oC which is a exothermic reaction and generate heat. Energy generated from above reaction development of the lumps of quicklime which is split and convert to lime. The heat causes excess water to evaporate. When lime reacts with water the heat of hydration liberated and lime is then broken due to insufficient heat of hydration by mechanical means to a nominal shape and pulverized before heat of hydration and thus fine powder is produced by mechanical grounding. Extraction of lime from coarse grained stone,

Table 2.1 Properties in lime

Chemical Formula of lime	$Ca(OH)_2$
Appearance	Whitish powder
Molar mass	74.093 g/mol
Odour	Odourless
Melting point	580^0c
Density	580^OC 2.211g/cm^3
Solubility	• Soluble in acids and glycerol • Insoluble in alcohol
Solubility in water	• 1.89 g/L (0^OC) • 1.73 g/L (20^OC) • 0.66 g/L (100^OC)
Refractive Index	1.574
Magnetic Susceptibility	$-22*10^{-6}$ cm^3/g

Rice husk

Rice husk Ash was grinded in XOM-20 ball mill of vertical plane made in form of powder. After grinding rice husk Ash, it was simultaneously packed. After grinding break into small particles RHA it was seen that these particles in which most of them are less then 10micro meter. The specific surface area and particles size analysis of RHA was tested by using laser size analyzer was tested for specific surface area and particles size analysis of RHA was tested. Area of specific surface was approx. 5910cm2/g.

The pozzolonic reaction between lime & RHA liberates property of hardening and strength development. A phenomenon found that when RHA-lime is tested, the coarse particles correspondingly increased and expensive soil of fine particles is reduced. Sometimes specific surface area of mixture was

lowered and particles of lime RHA become larger. On the same time, medium particle size D50 was improved. Big amount of silicate mineral is generated when soil is cured for a certain period. The soil which is used for pavement construction should be capable to make bond with admixtures.

4.Methodology

Modified Proctor Test (IS 2720 Part 8- 1983, Reaffirmed May 2015) Modified proctor test is mainly analyzed and the properties of sample soil and the compaction of different types of soil sample with the increase in water content. This also gives us a relation between water content and dry density. Compaction densification (by mechanical means) is due to reduce in volume of voids of unsaturated soils filled with air and water, water content and volume of solids remains same.

The main aim for compaction of unsaturated soil is to increase dry density, shear strength, reduce compressibility, control shrinkage, reduce permeability & bulking of soil. Dry density is determined by degree of compaction. Mainly optimum moisture content is found by maximum dry density.
Modified proctor test is very useful for designing any pavement design for long lifeperiod. This test gives accurate value for pavement design.
For modified proctor test, the soil is compacted in the prescribed mould in five equallayers with rammer of 4.5kg with a fall of 45cm.

California bearing Ratio

For design and construction of rigid and flexible pavements and for analyzing the strength of sub grade soil and another form of pavement material California state highway department developed CBR method. Flexible pavement thickness requirement in highway and airfields is directly related with CBR test results. In empirical test method, CBR test result directly related with basic property of natural soil or material of pavement which is tested. CBR method is also standardized by Bureau of Indian Standards (BIS).
CBR test is done by 50mm diameter cylindrical plunger to penetrate in the soil sample at a rate of 1.25 mm per minute. Test are performed under normal condition of temperature and humidity. Test result are record for the load required for 2.5 mm and 5mm penetration of plunger in soil sample or tested pavement material.
Explanation of CBR soil testing in percentage of standard value of load in soil sample .
Graph is drawn between penetration and load. For the value of 2.5 mm and 5 mm the standard load value have been tested on large number of crushed stone aggregates. After this these tested sample are sieved through standard sieves. These standard load value given below maybe directly used to compute the CBR value of the tested material.

Penetration mm	**Standard load kg**	**Unit standard load kg**
2.5	**1370**	**70**
5.0	**2055**	**105**

Determination of CBR value in the laboratory.

CBR test apparatus in laboratory consist of a 150mm diameter mould with a base plate and collar. A cylindrical plunger at 50mm diameter attached with loading frame attached with a dial gauge to measure the expansion on the soaking and penetration curve value. The specimen in the mould is compacted to a dry density corresponding to the minimum state of compaction likely to be achieved in practice. In absence of the information the specimen may be compacted to dry density at the optimum moisture content.

Table 3.1 Crust thickness;

S.No	**Admixture**	**CBR**	**Sub grade Thickness in mm (Earth Work)**	**Crust Thickness**				
				Total crust in mm	**GSB in mm**	**WMM In mm**	**DBM in mm**	**BC in mm**
1	No Admixture	5.88	500	670	270	250	110	40
2	Soil+2% Ricehusk+ 1% Lime (Sample13)	10.13	500	570	200	250	80	40
3	Reduction in Crust Thickness	-	-	100	70	-	30	-

Quantity, Cost of Admixture and Net Savings

Cost of Admixtures

For Sample13, The maximum CBR and MDD was observed

Density of Stabilized Soil=1.92g/cc (ModifiedProctorTestSample13) MDD = 1.92g/cc = 1920 kg/m^3

For 1m^3soil,

Weight of Stabilized Soil=1920kgfor1m^3mix.

Quantity of Admixture Added in soil=2%Ricehusk+1%Lime

Weight of 2% Ricehusk= 1920*2/100 =38.40kg in 1m^3 of sample.
Weight of Rice husk in 6000 m^3 = 2,30,400 kg or 230.4 tonnes Cost of Rice husk = Rs 6per

kg or Rs 6000 per tonne.

Weight of 1% Lime in 1m^3 Sample=1920*1/100=19.20kg Weight of Lime in 6000 m^3 =

1,15,200 kg or 115.2 tonnes Cost of Lime = Rs 10.5 per kg or Rs 10500 per tone.

Table 4.1 Rate Analysis for preparation of subgrade using admixtures by mechanical means

S.No	Description	Unit	Quantity	Rate	Amount
1	**Labour**				
	Mate	day	0.360	351.00	126.36
	Skilled mazdoor for alignment and geometrics	day	1.000	351.00	351.00
	Mazdoor for spraying lime	day	8.000	338.00	2704.00
2	**Machinery**				
	Tractor with ripper and rotavator attachments@60cumperhourforripping and 25 cum per hour for mixing	hour	12.000	486.00	5832.00
	Motor Grader 110HP @50cumperhour	hour	6.000	2858.25	17149.50
	Vibratory roller 8-10tonne capacity	hour	6.00x0.65*	1838.90	7171.71
	Water tanker 6KL capacity	hour	12.000	28.86	346.32
3	**Material**				
	Lime at site	tonne	115.2	10500	1209600
	Ricehusk at Site	tonne	230.4	6000	1382400
	Water cost	KL	72.000	250.00	18000.00
4	**Overhead Charges(1+2+3)@10%**				264368.87
5	**Contractor's Profit(1+2+3+4) @10%**				267766.95
6	**Cost of6000m^3**				3175836.73
7	**Rateperm^3(1+2+3+4+5)/6000**				**529.30**

Rate of Subgrade Preparation with admixtures=Rs 529.30/m^3

Table 4.2 Bill of Quantity for Sub grade with No Admixtures for 1km road of 12m (2.5 + 7.0+ 2.5)

S.No	Description	Quantity(m^3)	Rate (Rs)	Amount(Rs)
1	Earth Work for Sub grade Preparation	1000*12*0.50=6000	120	7,20,000
2	GSB	1000*7.3*0.27=1971	3687	72,67,077
3	WMM	1000*7*0.25=1750	4124	72,17,000
4	DBM	1000*7*0.11=770	8805	67,79,850
5	BC	1000*7*.04=280	9664	27,05,920
-	**Total**	-	-	**2,46,89,847**

Table 4.3 BillofQuantityforSubgradewithAdmixturesfora1kmroadof 12m (2.5 + 7.0+ 2.5)

S.No	Description	Quantity(m^3)	Rate (Rs)	Amount(Rs)
1	Earth Work for Sub grade Preparation	1000*12*0.50=6000	529.30	3175836.73
2	GSB	1000*7.3*0.20=1460	3687	53,83,020
3	WMM	1000*7*0.25=1750	4124	72,17,700
4	DBM	1000*7*0.08=560	8805	49,30,800
5	BC	1000*7*.04=280	9664	27,05,920
-	**Total**	-	-	**2,3413,276**

Net Savings=Cost of Road without Admixture-Cost of Road With admixtures

= 2,46,89,847-2,3413276=12,76,571

Net Savings%=(Net Saving / Cost of Road without Admixtures)*100

=(12,76,571/2,46,89,847)*100= 5.17%

Table 4.4 Net Savingdue to stabilization

Cost of Road without Admixture(Rs)	Cost of Roadwith Admixture (Rs)	Change in Amount	Net Savings (Rs)	NetS avings%
2,46,89,847	**2,3413,276**	12,76,571	12,76,571	**5.17%**

5.Conclusion

The general study of admixtures shows that the stabilization is getting more and more popularity due to its cost efficiency, innovations, waste disposal problems and eco friendly. However in the present state the homogeneous soil should be made after design mix of soil with lime for stabilization and thus various studies are being carried out to find the efficiency of the stabilizer in terms of strength, cost, and its effect to surrounding areas and difficulty to incorporate into the mix.

Now a days flexible pavement expenditure in highway is much higher, which result the development of country become slow down. The stone ballast bitumen and grit are main constituents of flexible pavement in highway construction. Also a flexible pavement has a design life of 15 years whereas rigid pavement has 30 years design life. In India financial resources are limited and due tropic of cancer we are facing different natural problems to develop road infrastructure.

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