Soil Stabilization using Lime and Sugarcane Bagasse Ash

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***Abstract*— Soil stabilization is the process of changing soil properties to improve the strength and durability. It is the alteration of foundation soil to confirm desired characteristics or improvement of a less stable soil in compressive strength. It increases shear strength and controls shrink-swell property of soil, thus improving the load bearing capacity of a sub grade to support pavements and foundation. The soil improvement increases the bearing capacity of soil , tensile strength and overall performance of soil. The process of soil stabilization is accomplished using a wide variety of additives. When we consider a problematic soil , chemical stabilization is one of the common method used for improvement of engineering properties. Over the last few decades , lime has been used as a chemical stabilizer. At this era of energy utilization and resource depletion, there is an emerging trend in utilization of waste materials as soil stabilizer. Sugarcane bagasse ash is the burned product of sugarcane bagasse , which comprises high silica content. This sugarcane bagasse ash is a pozzolanic material which has the potential to be used as a soil stabilizer. In this project, the potential of sugarcane bagasse ash is evaluated and compared with the stabilization effectiveness of lime.**

Keywords— Soil stabilization, chemical stabilization, stabilization using lime, sugarcane bagasse ash.

I. INDRODUCTION

Soil stabilization is the process of modifying the properties of a soil to improve the engineering performance. It is the alteration of foundation soil to confirm desired characteristics or improvement of a less stable soil in compressive strength. It can increase the shear strength and control the shrink- swell properties of a soil, thus improving the load bearing capacity of a sub-grade to support pavements and foundations. It can be used to treat a wide range of sub-grade materials, varying from expansive clays to granular materials. The soil improvement increases the bearing capacity of soil, tensile strength and overall performance of soil. This process is accomplished using a wide variety of additives, including lime, fly-ash, and Portland cement. Over the last years, both earthwork researchers and engineers have paid considerable attention to use industrial and agricultural waste materials in soil stabilization and improving physical and mechanical properties of soil. While considering the economic aspects of soil stabilization, it is better to choose a stabilizer which is cost effective and widely available. Sugar cane is the largest crop by production quantity in the world. A large amount of wet bagasse is yielded and the management of this residue is of great importance from an environmental point of view. The combustion of this bagasse is one of the most common practices, resulting in the production of an additional residue, the sugarcane bagasse ash (SBA). Bagasse ash, comprising a high percentage of silica (Si02) is a pozzolanic material which has the potential to be used as a soil stabilizer. Lime is one of the most common stabilizer used over the past years. It is utilized as an effective way to modify soils- improving both workability and load bearing characteristics while increasing stability and impermeability. The application of lime can significantly improve engineering properties of soil. Due to the stabilization properties both lime and SBA can be effectively utilized in soil stabilization.

Objectives

- Replacement of cement with less energy intensive stabilizer
- Utilization of cost effective soil stabilizer.
- Utilization of an eco-friendly soil stabilizer.

Scope Of Study

The comparison of this method with conventional method is Stabilization of soil using less energy intensive materials, Development of a sustainable building unit using waste materials, Low cost and eco-friendly construction.

II. LITERATURESURVEY

Sujit Kumar Dash and Monowar Hussain (2016) In this study six different soil samples were reconstituted using two extreme types of soils, a montmorillonite rich expansive soil and a silica-rich non-expansive soil. The influence of lime stabilization on these soils was evaluated through determination of geotechnical properties such as liquid limit, plastic limit, swell, compressive strength, mineralogy, and microstructure. An optimum lime content beyond which the strength improvement decreased was found. This phenomenon is more prominently observed with silica-rich soils that form silica gel. As the silica gel is highly porous, when formed in large scale the strength gain from cementation is substantially countered by the strength loss from gel pores, giving rise to a visible reduction in overall strength. Additionally, the gel materials hold a large amount of water, leading to increased plasticity and swelling. They concluded that, excessive lime treatment should be avoided for silica-rich soils.

Ja'Afar Abubakar Sadeeq, Joshua Ochepo, A.B.Salahudeen and Tijjani (2015) The study was carried out to evaluate the effect of bagasse ash on lime stabilized lateritic soil. Laboratory tests were performed on the natural and lime/bagasse ash treated soil samples. Treated specimens were prepared by mixing the soil with lime and/or bagasse ash in variations of 0, 2, 4, 6 and 8% by weight of the soil. They found liquid limit value of 36.32, plastic limit of 21.30% and a plasticity index value of 15.02 %. The maximum dry density (MDD) of the soil was 1.69 kg/m3 and an Optimum Moisture Content (OMC) value of 16.8 %. Unconfined compressive strength (UCS) values of 269, 404 and 591 kN/m2 at 7, 14 and 28 days curing periods, respectively for the natural soil. Unsoaked and soaked California Bearing Ratio (CBR) values of 13 and 7%, respectively, were recorded for the natural lateritic soil. Peak UCS and CBR values of 698 kN/m2 and 43% were recorded for soil treated with 8% lime/6% bagasse ash. They concluded that in lateritic soil treatment, 8% lime / 6% BA contents will satisfactorily modify the soil.

Meron Wubshet and Samuel Tadesse (2014) The expansive soil was stabilized using 3% lime, 15% bagasse ash and 15% bagasse ash in combination with 3% lime by dry weight of the soil. The effect of the additives on the soil was investigated with respect to plasticity, compaction and California bearing ratio (CBR) tests. The result obtained indicated an increase in optimum moisture content (OMC) and CBR value and a decrease in maximum dry density (MDD) and plasticity of the soil for all additives. They found a tremendous improvement in the CBR value when the soil is stabilized with a combination of lime and bagasse ash. They concluded that combination of two locally available materials (lime and bagasse ash) can effectively improve the properties of expansive soil.

Amit S. Kharade, Vishal V, Bhikaji S. Gujar, Rohankit R. Deshmukh (2014) In this study laboratory experiments were conducted on black cotton soil with partial replacement by Bagasse Ash (3%, 6%, 9% and 12%). This paper highlights significant increase in properties of black cotton soil obtained at 6% replacement of Bagasse Ash without any chemical or cementing material. The results improved at 6% replacement are as follows – The maximum dry density increased by 5.8%, California bearing ratio (CBR) increased by 41.52% and Compressive strength increase by 43.58% The observations showed that, due to addition of bagasse ash CBR and Compressive strength increases almost by 40%, but density shows only significant change. The blend suggested from this research is Black cotton soil + 6% replacement by bagasse ash, without any addition of cementing or chemical material, this would be an economic approach.

Ankit Singh , Mohammed Faizan, Devashish Pandey and Rehanjot Singh (2013) This paper deals with the complete analysis of the improvement of soil properties and its stabilization using lime. Based on the test results, they found that lime can act immediately and improve various properties of soil such as carrying capacity of soil, resistance to shrinkage during most conditions, reduction in plasticity index, increase in CBR value and subsequent in the compression resistance with increase in time. They concluded that lime can be used as an excellent soil stabilizing materials for highly active soils which undergo through frequent expansion and shrinkage.

K.J Osinubi, V. Bafyau, A.O. Eberemu, and O. Adrian (2009) The study focused on the effect of up to 12% bagasse ash by weight of dry soil on the geotechnical properties of the deficient lateritic soil. Test specimens were subjected to particle size analysis, compaction, unconfined compressive strength (UCS), California bearing ratio (CBR) and durability tests. The compactions were carried out at the energy of the British Standard Light (BSL).The study showed changes in moisture – density relationships resulting in lower maximum dry densities (MDD), higher optimum moisture contents (OMC), reduction in fine fractions with higher bagasse ash content in the soil – stabilizer mixtures. A 2% bagasse ash treatment of lateritic soil yielded peak 7 days UCS and CBR values of 836 kN/m2 and 16%, respectively. They concluded that MDD and OMC generally showed trend of decrease and increase, respectively with higher bagasse ash content. The UCS increased from 366kN/m² for the natural soil to 836,842 and 973 kN/m² for specimens treated with 2% bagasse ash content and cured for 7, 14 and 28 days, respectively. The maximum CBR value of 16% was recorded with 2% bagasse ash.

MATERIALS

The major materials used are :

1. Laterite soil

Laterite is a type of soil which is very rich in iron and aluminium, and is commonly considered to have formed in hot and wet tropical areas. It is mainly developed due to prolonged process of chemical weathering . Laterite soil was collected from college premises.

Fig 1. Laterite soil

2. Sugarcane bagasse ash

Sugarcane is the largest crop by production quantity in the world. A large amount of wet bagasse is yielded and the management of this residue is of great importance from an environmental point of view.The combustion of this bagasse is one of the most common practices, resulting in the production of an additional residue called sugarcane bagasse ash or this project, sugarcane bagasse was collected from nearby juice shop and ash is produced by the combustion of bagasse after one week of air drying.

Fig 2.SBA

3. Lime

Lime is a calcium containing inorganic material which in composed of calcium oxide or/and calcium hydroxide. Lime can be used to treat soils in order to improve their workability and load- bearing characteristics.Soil stabilization occurs when the proper amount of lime is added to a reactive soil. Stabilization differs from modification in that the significant increase in strength over the longer term on- going pozzolanic reaction . Lime is produced throug the calcination of limestone, lime kiln at temperatures above 2000 degrees Fahrenheit. The product of calcination of high calcium limestone is quicklime or calcium oxide. Lime used for this project was collected from merchandise which is produced by kaveri lime industries.

Fig.3. Lime

EXPERIMENTAL INVESTIGATION

1.Specific gravity

Fig.4.Pycnometer

Procedure is followed as per IS 2720 part3

2. ATTERBERGS LIMITS AND INDICES

Whole procedure is followed as per IS 2720 part 5 and 6

2.1.Liquid Limit

Fig.5.Casagrande apparatus

2.2.Plastic Limit:

Fig.6.Plastic limit test setup

2.3.**Shrinkage Limit**

Fig.7.Shrinkage limit test setup

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 06, June-2021

3.Light Compaction

Fig.8.Light compaction equipment

All procedure is followed as per IS 2720 part 7

4.Unconfined Compressive Strength

Fig.9.UCC testing machine

Procedure is followed as per IS 2720 part 10

5. Hydrometer Analysis

The whole procedure is followed as per IS 2720 part 4

RESULTS AND DISCUSSIONS

Test on soil

Table.1.test conducted on soil

Test conducted	results
Specific gravity	2.52
Hydrometer analysis:	
Clay	21%
Silt	15%
Atterbergs limit and indices:	
Liquid limit	
Plastic limit	59%
Shrinkage limit	30%
Plasticity index	25.92%
	29%
Light compaction:	
Dry density	1.4g/cc
OMC	22.8%
UCC Test	
Compression test of soil ,qu	
	1.86kg/cm^2

Test on soil lime mix

Atterbergs Limits

1.Liquid Limit

- At 2% of lime content liquid limit of soil sample is 12 %.
- Liquid limit increased to maximum of 28.5 % for 4 % lime mixed soil.
- For 6 % and 8% lime mixed soil liquid limit is decreased and is of 24 % and 9.5 % respectively.

2. Plastic Limit

- At 2% of lime content liquid limit of soil sample is 7 %.
- Liquid limit increased to maximum of 18 % for 4 % lime mixed soil.
- For 6 % and 8% lime mixed soil liquid limit is decreased and is of 17 % and 6 % respectively.

3. Plasticiy Index

- At 2% of lime content plasticity index of soil sample is 5 %.
- Plasticity index reaches at a peak of 10.5 % for 4 % lime mixed soil.
- For 6 % and 8% lime mixed soil plasticity index is decreased and is of 7 % and 3.5 % respectively.

MDD and OMC with different proportions of lime

- Optimum moisture content (0MC) gradually increases with increase in lime content.
- At 2% lime content with soil OMC is 23.2%.
- OMC increased to 23.6% at 4% lime content mixed with soil.
- OMC reaches to a maximum of 25.8% at 8% lime content mixed with soil.
- Dry density increased from 1.59 g/cc to a maximum of 1.61g/cc then decreased to 1.59 g/cc.
- Maximum dry density of 1.61 g/cc attained at 6% lime content mixed with soil.
- Soil -lime mix shows an optimum moisture content of 24.4% at maximum dry density of 1.61 g/cc.

Unconfined compressive strength test with different proportions of lime

- At 2% lime content, soil sample shows UCC value of 3.64kg/cm^2.
- By increasing the lime content UCC value also increased and attained a maximum of 4.91 kg/cm^2 at 6% of lime content.
- UCC value decreased to 2.92 kg/cm^2 at 8% lime content.
- Based on the test results optimum lime content for soil stabilization is 6% by weight of the soil sample.

Test on soil- SBA mix

Atterberg's limits with different proportion of SBA

1.Liquid limit

- At 8% of SBA content, liquid limit of soil sample is 26 %.
- Liquid limit decreased to 20 % for 12 % SBA mixed soil.
- For 16 % and 20% SBA mixed soil liquid limit is increased and is of 44.6 % and 62.1 % respectively.

2.Plastic Limit

- At 8% of SBA content, plastic limit of soil sample is 50 %.
- Plastic limit decreased to 33.4 % for 12% of SBA mixed soil and then increased to 54% for 16% of SBA mixed soil.
- For 20% SBA mixed soil, plastic limit is decreased and is of 34.2 %.

3.Plasticity Index

- At 8% of SBA content, plasticity index of soil sample is 24 %.
- Plasticity index decreased to 13.4 % for 12 % SBA mixed soil.
- For 16 % SBA mixed soil, plasticity index decreased to 9.4 % and for 20% plasticity index is increased to 27.9%

MDD and OMC with different SBA

- 8% of SBA mixed soil sample shows an optimum moisture content (OMC) of 15.9%.
- OMC gradually decreased and reaches a minimum of 9.09% when the soil is mixed with 16% of SBA content.
- At 20% of SBA mixed with soil OMC increased to 12.2 %.¬ 8% of SBA mixed soil sample shows a maximum dry density of 1.59g/cc.
- Maximum dry density (MDD) gradually increased and reaches a maximum of 1.73 g/cc when soil mixed with 16% of SBA content.
- At 20% of SBA mixed with soil MDD decreased to 1.63g/cc.

Unconfined Compression Strength Test

- At 8% SBA content, soil sample shows UCC value of 0.44kg/cm².
- By increasing the SBA content UCC value increased and attained a maximum of 3.41 kg/cm² at 16% of SBA content.
- UCC value decreased to 2.92 kg/cm² at 20% SBA content.
- Based on the test results optimum SBA content for soil stabilization is 16% by weight of the soil sample.

CONCLUSION

From the analysis the following conclusions are made:

- From this study it is clear that both lime and sugarcane bagasse ash have significant strength improvement in laterite soil.
- With 2,4,6,8 % of lime content stabilization soil shows an unconfined compressive strength of 3.64, 4.31, 4.91.2.92 kg/cm² respectively. So, optimum soil content for the stabilization is 6% by weight of soil.
- At optimum lime content unconfined compressive strength of virgin soil is increased by 264%
- Plasticity index of virgin soil is 29% and it is decreased by 7% for the optimum soil- lime mix.
- With 8,12,16,20 % of SBA content stabilization soil shows an unconfined compressive strength of O.44, 2.53, 3.41, 2.92 kg/cm² respectively. So, optimum soil content for the stabilization is 16% by weight of soil.
- At optimum SBA content, unconfined compressive strength of virgin soil is increased by 183%
- Plasticity index of virgin soil is 29% and it is decreased by 9.4% for the optimum SBA- soil mix.
- On comparison it is observed that, though sugarcane bagasse ash is an eco-friendly and cost effective material it is not effective as lime as a stabilizer of soil.

ACKNOWLEDGMENT

Words cannot express our gratitude to the scholars we know, yet we would like to thank those who enabled the successful completion of this project. First and for most thank "**THE ALMIGHTY**" for his grace and mercy that enabled us to complete the work successfully.
We express our sincere thanks to **Prof. Dr. Abdul Gafur M**, Principal, Ilahia College of Engineering and Technology, Muvattupuzha for his kind patronage.
We express our sincere gratitude to **Prof. Dr. Abdulla P K** (Head of the Civil Engineering Department) for the encouragement and providing us the necessary facilities in the college for doing this project.
We express our sincere gratitude to **Ms. Rashida P K** (assistant professor in civil department) for guiding us to do this project.
We express our sincere thanks to our project co ordinators

Ms. Sreeja V and **Ms. Adhila Abdulla Kunju** (assistant professors in civil department) for constant encouragement during this project.
We also take this opportunity to thank all the personal associated with this project ideas and cooperation have helping in doing this project .

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 06, June-2021

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