DETERMINATION OF STRENGTH OF SOIL ANDIT'S STABILITY USING ULTRASONIC PULSE VELOCITY TEST

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Abstract – *Soil stabilization may be defined as alteration or modification of one or more soil properties to improve the engineering characteristics and performance of a soil. Utilization of industrial waste materials in the improvement of soils is a cost efficient and environmental friendly method. In this study density is found by ultrasonic testing method. This method can provide fast and simple approach for determining characteristics of compacted stabilized soil. This is a non- destructive method can be used as an alternative to existing methods to analyze laboratory or field compacted soils. In this study ultrasonic velocity measurements determine the compaction characteristics of stabilized soil. Variation of ultrasonic velocity with water content and density of compacted stabilized soils was analyzed. Effects of soil type and compaction conditions by velocity were analyzed.*

Keywords: soil stabilization, ultrasonic pulse velocity, non-destructive method, density

1. INTRODUCTION

By examining the relationship between soil's dry density (unit weight) and water content, compaction features of soil can be identified. In the lab, Proctor compaction tests (ASTM D 698) are frequently used to assess how dry density changes with water content. A compaction curve is used to show the relationship between the soil's dry density and water content. To ascertain whether construction methods are efficient,the compaction parameters of field soils arecompared to those of soils studied in a laboratory. When in-situ methodology is employed, additional time is required. This study work attempts to present an alternateapproach to decrease this time: the ultrasonic pulse velocity method. Determinethe characteristics of compacted soils quickly and easily with ultrasonic testing. To examine laboratory or field compacted soils, this non-destructive method might be employed in place of the ones now in use.

After performing conventional tests on soil samples with varying degrees of plasticity, such as clayey soil, the ultrasonic pulse velocity test was conducted on the samples,and a graph showing the relationship between density and velocity and water content was created. The association was then established by interpolating the outcomes of earlier conventional experiments, and an ultrasonic pulse velocity test brought the results to a conclusion. The standard values are obtained while the laboratory tests are performed, and the results are then confirmed using the laboratory ultrasonic pulse velocity result. [1].

2. SCOPE AND OBJECTIVES OF PRESENTSTUDY

The procedures call for core-cutting pavement samples to be taken for subsequent laboratory testing in order to do conventional quality control in the field.

This process is too time-consuming, expensive, and only valuable for official records; it cannot be used to correct errors discovered while laying and compacting soil subgrade in the field. Therefore quick on- the-spot measurements are required for thecontrol of the soil subgrade of the pavement layer. These factors contribute to the creation of the ultrasonic pulse velocity method. The purpose of the research is to assess the physical characteristics of clayey soil and the stabilization of clayey soil by stabilizers, utilizing an alternative in-situ testing method called ultrasonic testing The main objectives of the study are:-

- to research how stabilizers affectClayey soil's engineering performance and to determine whether they may be used as soilstabilizers
- if the soil stabilizer has good volumestability and durability which in turnalso increases strength and stiffnessof the soil specimen.

- To provide the soil specimen withvolume stability and durability through the analysis of the data acquired through the ultrasonic pulse velocity test

- To evaluate the project specimen through the non destructive tests toavoid damaging the thing

3. METHODOLOGY

The earth was dug up 1.5 metres below thesurface of the ground, rammed to break upany lumps, and then dried in the air.

Stabilizer that had been oven-dried was combined with clayey soil. The compaction and strength characteristics of mixes in accordance with IS were ascertained using avariety of soil and stabiliser combinations.

Four such combinations were created in all,and the laboratory tested the mixes' strength and compaction characteristics. In order to determine the P-wave velocity in the test compacted stabilised soil, two transducer arrangements—one for transmitting and the other for receiving— were used in the ultrasonic tests carried outfor this work.[1]

3.2 Ultrasonic Pulse Velocity Test [2]

The non-destructive ultrasonic pulse velocity test has been around for a while. The basic idea behind this test is the relationship between a material's density (ρ) and elasticity modulus(E), or square root of the ratio E/ρ, determines the velocity (V) of sound in that material (V).Following is the equation using Polish standards:

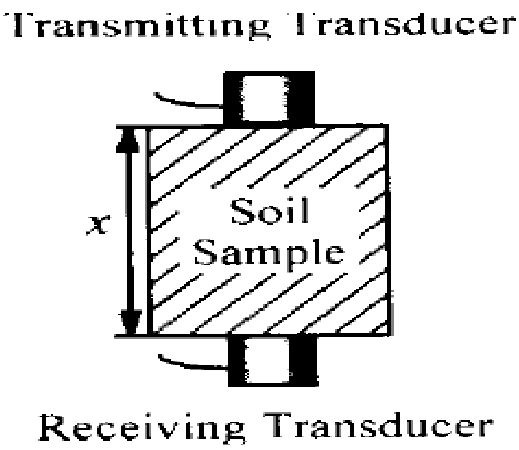
$$E = V^2 . P$$

This relationship can be used to calculate the elasticity modulus and, as a result, to assess the soil's quality. The test is therefore valuable for identifying voids, damage from fire or frost, and consistency of soil in related elements. The ultrasonic pulse velocity test measures the density of the soil and cantherefore be used to determine the strength of the soil. The time it takes for the ultrasonic pulse to pass through the soil and the aggregate determines the velocity of the pulse as it passes throughthe soil. The aggregate's modulus of elasticity and the amount of aggregate in the mix both affect the soil's pulse velocity.

3.3 About the equipment

- ❖ P-wave transducers,
- ❖ Pulser-receiver, and
- ❖ Data acquisition system.

For measurements, two transducers are utilised, one for transmitting ultrasonic waves and the other for receiving them after they have passed through the test sample. A pulse receiver that is attached to the data acquisition system for data digitization activates thetransducers.



Ultrasonic measurements are used to determine the first arrival time of the waves at the receiving transducer, which is the travel time for both test techniques. The delay between the time the transmitting transducer applied the pulse andthe time the waveform arrived in the receiving transducer was used to compute the initial arrival time. The digital data board and the pulse receiver were synced so that data collection began when the pulse was applied. The velocity of the waves as they travel from the transmitter to the receiver alongthe compacted earth is also measured along with their journey time. The data collected are helpful in analysing how soil characteristics and compaction conditions affect velocity.

Traditional compaction plots (dry density vs. water content) and compaction plots generated from ultrasonic measurements were compared (velocity vs. water content). Using normal and modified Proctor efforts, the soil that has been stabilised with stabilizer to an increasing proportion is compacted with varied water contents. The ultrasonic pulse velocity test is performed on the compacted soil mass. Samples were utilised to measure density, water content, and P-wave velocity during tests utilising the through-transmission test technique. Each sample that was utilised to assess the soils' compaction properties had its velocity determined. Dry density vs. water content and velocity vs. water content were used to create compaction plots.

4. EXPERIMENT DETAILS

4.1 Material

Soil

Engineers view soil as a complicated substance that results from the weatheringof solid rock. The ongoing geological cycle that occurs on the surface of the planet results in the development of soil. The cycle entails weathering or denudation, transportation, deposition, upheaval, weathering again,and so on.

Stabilizer

GGBS, (Ground Granulated Blast-furnace Slag) is a cementitious material whosemain use is in concrete and is a by-product from the blast-furnaces used to make iron. At a temperature of roughly 1500^{0}C to 1600^{0}C, molten slag floats above the molten iron as iron, ore, and limestone are permitted to fall into the furnace. After the molten iron is trapped off, the remaining molten slag is quickly cooled under water, leading in the creation of a glassy granule. The molten slag is composedof between 30% and 40% silicon dioxide (SiO2) and about 40% calcium oxide. The term "ground granulated blast furnace slag" refers to this glassy granulated that has been dried and ground to a specific size (GGBS). The degree of compaction in soil mixtures is influenced by the amount of GGBS added to the soil. Because GGBS has a greater specific gravity than expansive soil, the maximum dry unit weight increases as the amount of GGBS increases. Additionally, it was found that when the GGBS content increased, theideal moisture content decreased. [1]

4.2 Sample preparation

The field-received soil sample is dried in the air. To speed up drying, the clods were shattered using a wooden mallet. The sample is cleaned of any organic material, such as tree roots and fragments of bark. Similar to how oil is segregatedfrom the main soil mass, shells are another type of non-oil materials.

When samples are taken for estimation of organic content, limecontent, etc., the complete sample is taken for estimation without removing shells, roots, etc., and these removals are noted togetherwith their percentage of the total soil sample.[3]

4.3 Laboratory Tests to be conducted:

1. Specific Gravity test of soil
2. Grain Size analysis of soil
3. Hydrometer analysis of soil
4. FSI(Free Swell Index) test of soil

5. DATA ACQUISITION

The physical and chemical properties of thespecimen(soil and stabilizer) are given below

S.NO	PROPERTY	SOIL
1	Specific Gravity	
2	Grain size analysis	
	% of gravel	
	% of sand	
	% of silt and clay size	
3	Atterberg's limits	
	Liquid limit %	
	Plastic limit%	
4	Plasticity index	
5	Soil classification	
6	Free swell data	
7	Compaction characterstics	
	Max. dry density(kN/m^3)	
	Optimummoisture content(OMC)%	

TABLE 5.1 Physical properties of soil

S.NO	PROPERTY	SOIL
1	Specific Gravity	
2	Grain size analysis	
	% of gravel	
	% of sand	
	% of silt and clay size	
3	Atterberg's limits	
	Liquid limit %	
	Plastic limit%	
4	Plasticity index	
5	Free swell data	

TABLE 5.2 Physical properties of stabilizer

SL No	Chemical composition	Percent age
1	SiO2	40%
2	MgO	3.6%
3	CaO	39.2%
4	Al2O3	13.5%
5	Fe2O3	1.8%
6	SO3	1.7%
7	L.O.I	0.2%

TABLE 5.3 Chemical properties of stabilizer

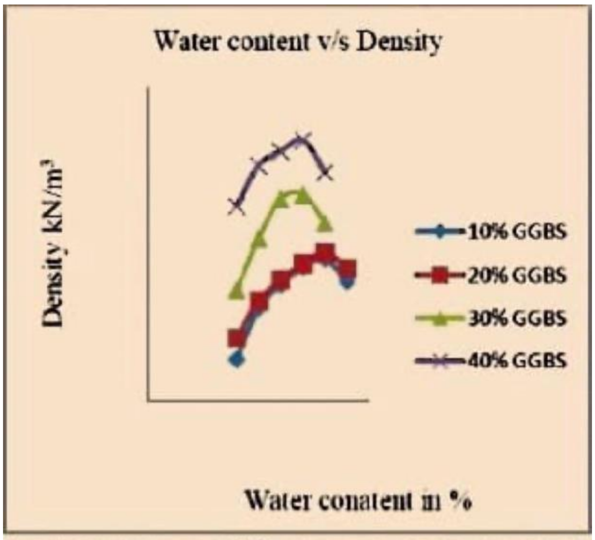
The results of the various tests to be conducted in the laboratory were also takeninto account while doing the analysis and drawing out the conclusions for the experiment.

5. DATA ANALYSIS

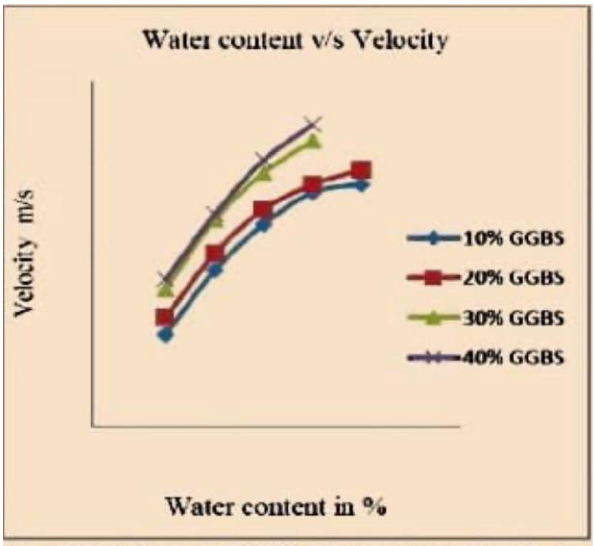
Through various tests that are conducted throughout the whole project, the effect onthe various properties of the soil with the influence of stabilizer at different percentages are obtained by evaluation and generating the relation between various parameters of stabilized soil.

The results are depicted using the nature ofthe graphs derived from data from various experiments,

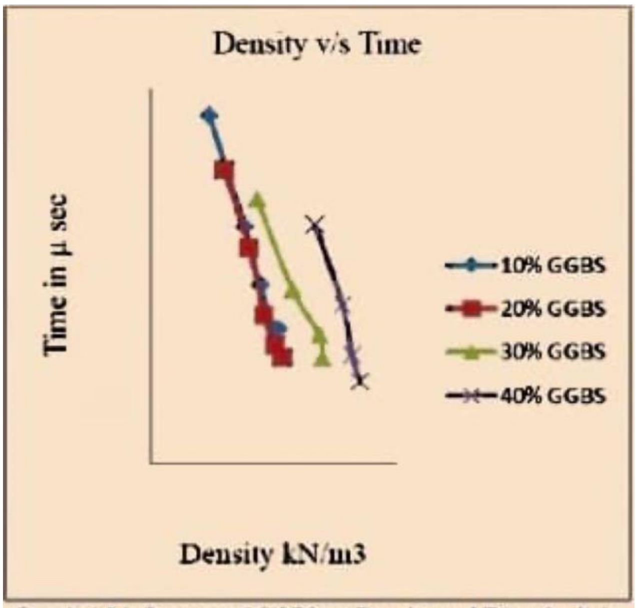
For light compaction,



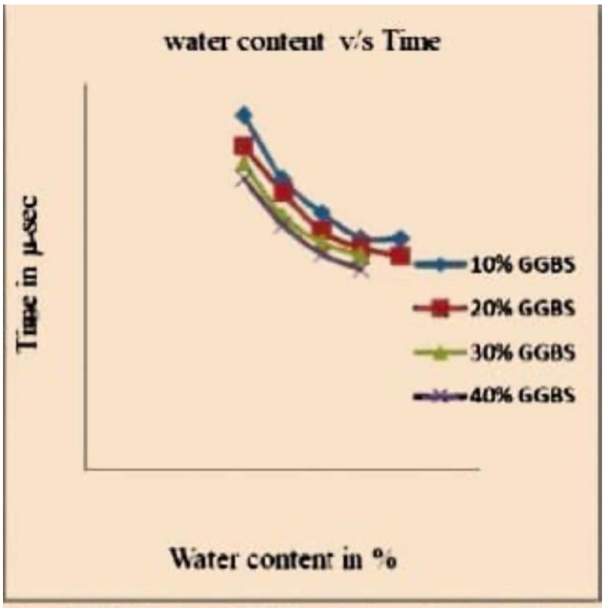
Graph 6.1 influences of GGBS on water content and density for light compaction



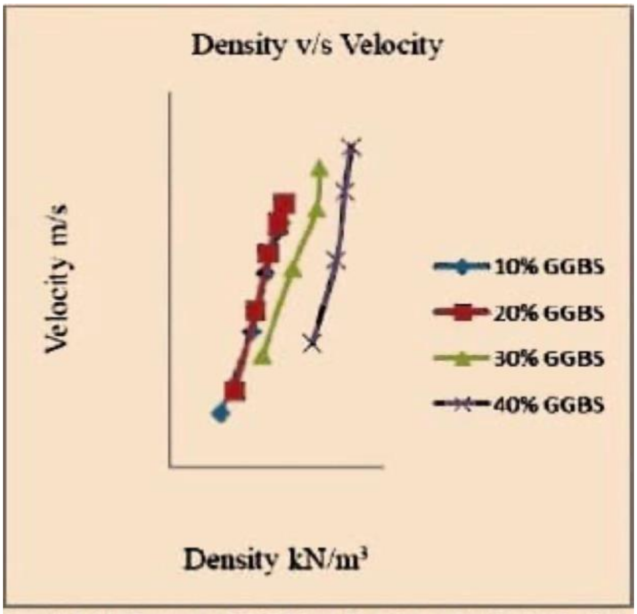
Graph 6.2 influences of GGBS on water content and velocity for light compaction



Graph 6.5 influences of GGBS on Density and Time for light compaction



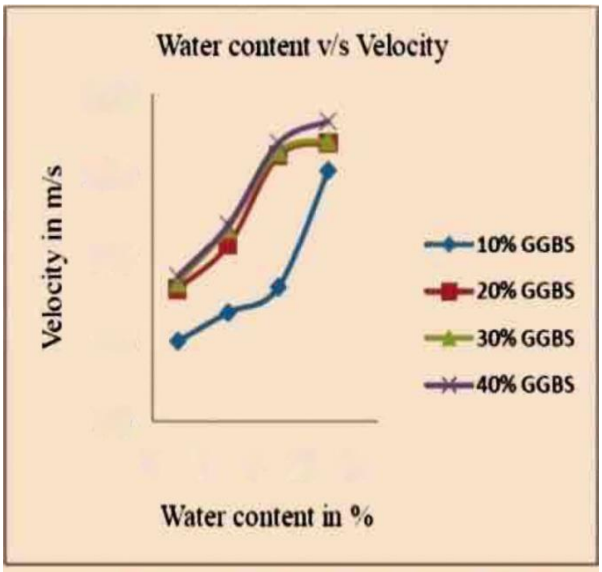
Graph 6.3 influences of GGBS on water content and time for light compaction



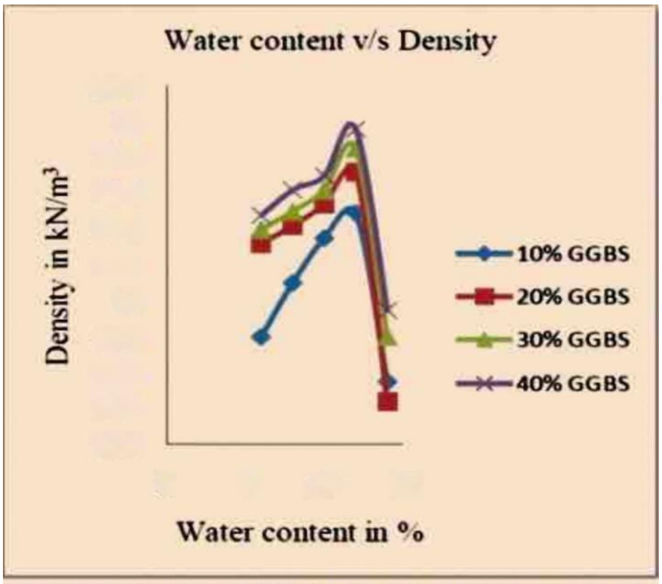
Graph 6.4 influences of GGBS on Density and velocity for light compaction

The different nature of graphs show the influence of different amount of stabilizer (GGBS) on the water content and density ofthe soil for light compaction on the soil.

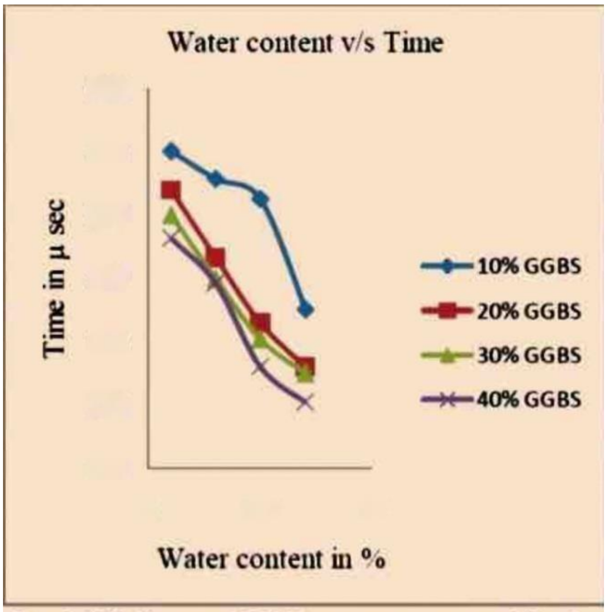
For heavy compaction,



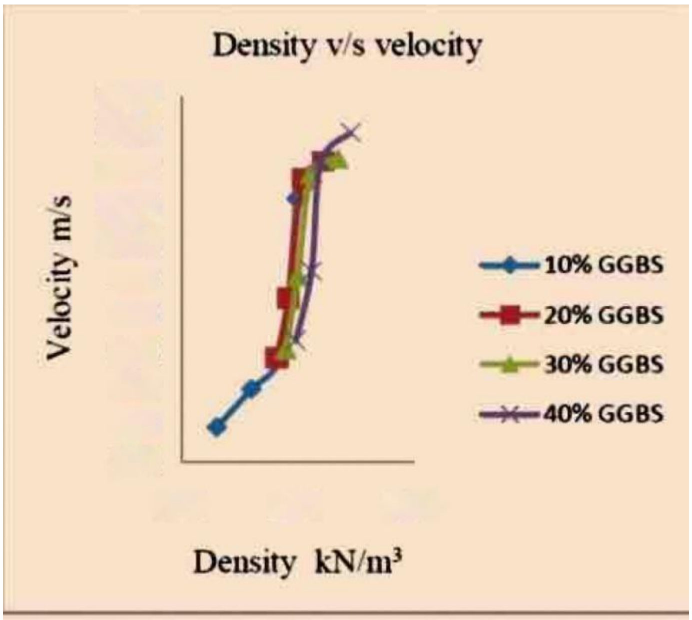
Graph 6.7 influences of GGBS on water content and velocity for Heavy compaction



Graph 6.6 influences of GGBS on water content and density for Heavy compaction



Graph 6.8 influences of GGBS on water content and time for Heavy compaction



Graph 6.9 influences of GGBS on Density and velocity for Heavy compaction

The different nature of graphs shows the influence of different amount of stabilizer (GGBS) on the water content and density ofthe soil for heavy compaction on the soil.

6. CONCLUSION

From the obtained analyzed results, thefollowing conclusions were drawn:

- Since stabilizer has considerablyimproved the geotechnical characteristics of soil, it can be utilized to stabilize clayey soil.

- With the addition of stabilizer to thesoil, maximum dry density increasedwhile ideal moisture content fell.
- The soil's tendency to swell hassignificantly decreased.
- Ultrasonic technology was used toexamine the compaction characteristics of soil with the addition of stabilizer.
- As stabilizer percentage increases,plastic limit, liquid limit, and plasticity index decrease. In the stabilized soil, p-wave velocity is measured using ultrasound measurements.
- With the same water content, it wasfound that there was no difference in the variation of either velocity or density.
- Compacted soil mass was examinedin several stages, and the results show that high solid contents, low water and air voids, and low solid contents and high water and air contents result in an increase in velocities, respectively.
- For varying percentages of stabilizer added to soil, different proportion of stabilizers, the rate of velocity increases with density was higher.
- The mixed dirt complies with the MORTH (Ministry Of Road Transportand Highways) sub grade criteria.

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