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An Evaluation of Compaction Characteristics for Expansive Clays by Using Ultrasonic Pulse Velocity Technique

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Abstract:

Preparation of Soil Grade Layer by achieving maximum dry density is most important in the construction of highway according to Ministry of Road, Transport and Highways. Therefore, determination of density for soil in the field is done by destructive methods such as core cutter or sand replacement tests. But these methods are tedious as well as require a lot of time. The present investigation aims at determining a non-destructive method of determining the density in the field.

Non-destructive testing by using ultrasonic pulse velocity method was performed on compacted clayey soil. The various physical properties of the soil were determined. Further laboratory specimens were prepared for varying percentages of GGBS and moisture contents by Standard Proctor method. Wave velocity by direct transmission was determined for all the specimens and optimum moisture contents for each of the percentages of GGBS was determined. Slabs were cast for soils with varying percentages of GGBS and their corresponding optimum moisture contents. Wave velocities were determined for both direct and indirect transmission. Cores were made and respective densities were determined. All the specimens tested exhibited an increase in pulse velocity with increase in dry density until optimum moisture content was obtained and a rapid decrease in velocity with further increase in water content. The observations made were in conformity to the research made earlier. The parameters investigated include water content, dry density, soil characteristics and the relationship between velocity and density.

Keywords **—Ultrasonic pulse velocity test, water content, wave velocity, p-velocity, dry density.**

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I. INTRODUCTION

In civil engineering various structures such as highways, buildings, bridges, dams etc. are founded on the soil surface. Hence, for their stability soils are compacted until required strength properties are achieved. These properties are directly related to the dry density and water content of the soil. Thus, these parameters are usually determined by using various destructive methods such as core cutter, sand replacement method etc. But these methods are usually tedious, time consuming and frequently halt the construction process.

Non-destructive testing methods such as nuclear density test, falling weight deflectometer, electrical resistivity tests can be used to determine the properties but not usually preferred because of accuracy and practical difficulties.

Ultrasonic pulse velocity (UPV) method is quite common amongst civil engineers and hence is being tried as an alternative to the above mentioned methods.

Additionally, since most of the soils don't possess the required strength and compaction characteristics inherently. Hence, to enhance their strength and compaction characteristics the soil has to be stabilized using soil stabilizers. Soil stabilization is defined as the process of improving the engineering properties of soil by mixing or adding some binding agents for example industrial wastes like ground granulated blast furnace slag GGBS, cement, lime, fly ash, etc., to the soil particles. Other materials like by-products granite dust, sodium hydroxide, lime-kiln dust and cement-kiln dust can also be used for stabilization. Stabilization process involves the methods used for altering the properties of a soil to enhance the improved engineering performance.

II. SCOPE AND OBJECTIVES

- To study the effect of GGBS on soil to be used as a stabilizer.
- To determine the optimum moisture content and dry densities.
- To analyse the variation of wave velocity with respect to varying percentages of GGBS.
- To analyse the variation of wave velocity with water content and density of compacted stabilized soils.
- To compare the variation in laboratory and field compacted densities of soils.

III. METHODOLOGY

First the soil was collected and brought from Davanagere. Next the soil was pulverized to break the lumps and then sieved by using an IS 4.75 mm sieve. GGBS was obtained from JSW, Peenya. The various physical properties of the soil such as soil type, specific gravity, Atterberg limits, OMC, maximum dry density (MDD), were determined. Next soil specimens for various percentages of GGBS were prepared using standard proctor test. For these specimens wave velocities were determined by direct transmission method using UPV method and optimum moisture content (OMC) was determined. Next slabs were casted using rolling compactor and rut analyser (RCRA) for varying percentages of GGBS and their corresponding OMC. For these slabs wave velocities were measured using direct transmission as well as indirect transmission method. Next cores were obtained from the slabs and densities were determined and compared to the densities of laboratory specimens.

IV. EXPERIMENTAL DETAILS

A. *Materials used*

1) *Black Cotton Soil*

The soil was brought from Davanagere, Karnataka. The soil is dark grey to black in colour and high clay content. The soil was pulverized by means of a rammer and then sieved by passing it through IS 4.75 mm sieve. The soil has high moisture retention properties. Sieve analysis and Atterberg's limits were determined to classify the soil as per IS: 2720 Part 5 (1985).

2) *Ground Granulated Blast Furnace Slag*

Ground granulated blast furnace slag or GGBS was brought from JSW, Peenya, Bengaluru. GGBS is produced in the iron and steel manufacturing industries as a by-product. The by-product is dried and pulverized into the size so as to produce GGBS. The addition of GGBS to clayey soil in varying percentages affects the compaction characteristics of the soil. It increases the dry density as well as aids in decreasing the optimum moisture content.

B. *Equipment used*

1) *Rolling Compactor and Rut Analyser (RCRA)*

Rolling compactor and rut analyser equipment is an equipment which is used to mimic the action of a road roller used for compaction in the field. First the soil with required GGBS% and water content is mixed and poured into the mould of dimension 650mm X 350mm X 300 mm is placed in the equipment and a plate of sufficient thickness with channels for the rollers is placed on top it. Then rollers which are connected to the loading frame are lowered electrically and placed on the channels of plate. Once firmly placed then the rollers move in a to and fro direction until the required thickness is achieved.

2) *Proceq Pundit Lab+*

Ultrasonic pulse velocity method is used to indirectly determine the compaction characteristics of the soil. In this method the p-waves are transmitted from the transducer and picked up by a receiver and the time taken and velocity readings are measured and noted. The ultrasonic waves have a frequency higher than 20 kHz. The transmission of these waves varies based on the material properties.

V. DATA ACQUISITION

TABLE I

PHYSICAL PROPERTIES OF CLAYEY SOIL

Sl No.	Property	For B.C Soil
1	Specific Gravity	2.25
2	Soil type	Well graded soil
3	Liquid limit %	36.53
4	Plastic limit %	26.78
5	Plasticity index	9.75
6	Max. dry density(g/cm^3)	1.67
7	OMC%	20

GGBS %	WATER CONTENT (%)	MDD (g/cm3)	VELOCITY (m/sec)	TIME (µs)
0	14	1.58	581	472
	16	1.62	596	460
	18	1.64	603	455
	20	1.67	615	447
	22	1.65	607	452
	24	1.62	596	460
5	14	1.62	602	468
	16	1.67	621	453
	18	1.68	625	451
	20	1.66	617	456
	22	1.63	606	465
10	14	1.65	843	346
	16	1.69	863	338
	18	1.71	874	334
	20	1.68	858	340
	22	1.66	848	344
15	14	1.69	881	261
	16	1.74	907	253
	18	1.78	928	248
	20	1.73	901	255
	22	1.71	891	258
20	14	1.71	967	192
	16	1.76	996	187
	18	1.79	1013	184
	20	1.77	1001	186
	22	1.74	984	189
25	14	1.78	1081	139
	16	1.81	1100	137
	18	1.79	1087	138
	20	1.75	1063	141

TABLE II

STANDARD PROCTOR TEST

Table III

UPV TEST FOR STANDARD PROCTOR SPECIMENSUSING DIRECT TRANSMISSION

GGBS%	OMC %	MDD (g/cm3)	VELOCITY (m/s)	TIME (µs)
0	20	1.67	615	447
5	18	1.68	625	451
10	18	1.71	874	334
15	18	1.78	928	248
20	18	1.79	1013	184
25	16	1.81	1100	137

Table IV

UPV TEST FOR SLAB USING DIRECT TRANSMISSION

GGBS%	OMC%	MDD (g/cm3)	VELOCITY (m/s)	TIME for 150mm(µs)	TIME for 650mm(µs)
0	20	1.67	584.25	500.38	2168.32

GGBS%	OMC%	MDD (g/cm3)	VELOCITY (m/s)	TIME for 125mm (µs)	TIME for 250mm (µs)	TIME for 375mm (µs)	TIME for 500mm (µs)
0	20	1.67	525.83	375.29	750.57	1125.86	1501.14
5	18	1.68	499.88	354.2	700.16	1050.24	1367.37
10	18	1.71	715.81	271.56	543.12	814.68	1086.24
15	18	1.78	751.31	201.44	407.46	597.46	805.76
20	18	1.79	884.35	156.11	312.21	468.32	624.42
25	16	1.81	930.6	117.45	234.89	352.33	469.77

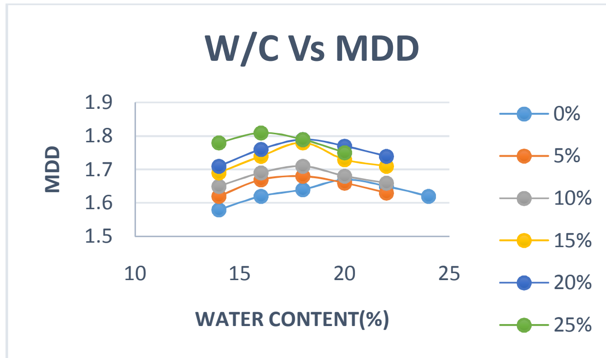
5	18	1.68	581.25	494.23	2141.67
10	18	1.71	795.34	362.08	1569.02
15	18	1.78	853.76	274.69	1190.33
20	18	1.79	982.61	208.14	901.94
25	16	1.81	1034	156.59	678.56

Table V

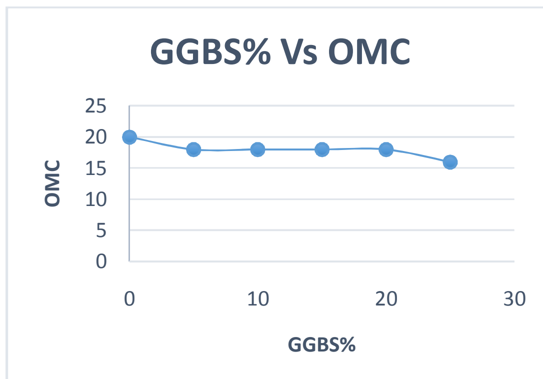
UPV TEST FOR SLAB USING INDIRECT TRANSMISSION

VI. ANALYSIS OF DATA

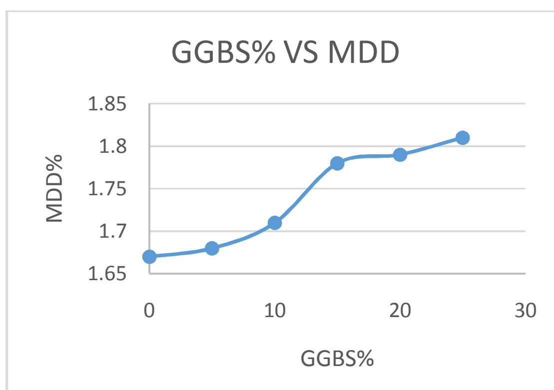
A. UPV Test for standard proctor specimens using direct transmission



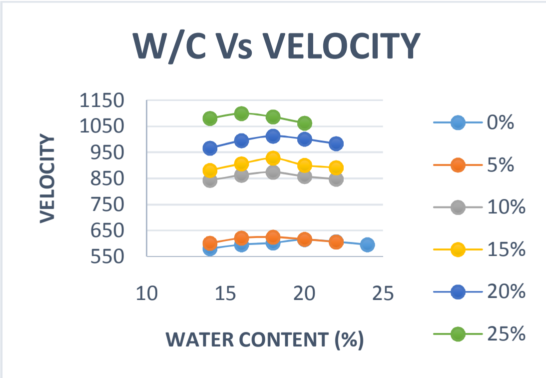
Graph 1. W/C Vs MDD



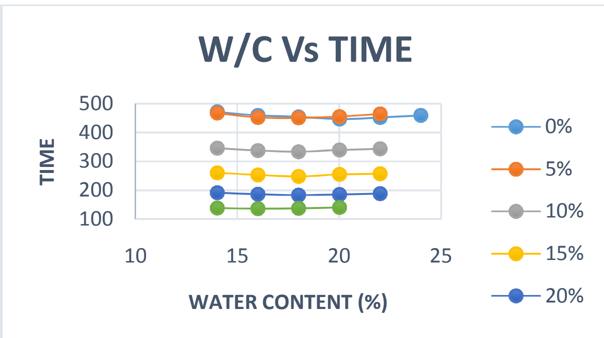
Graph 2. GGBS% Vs OMC



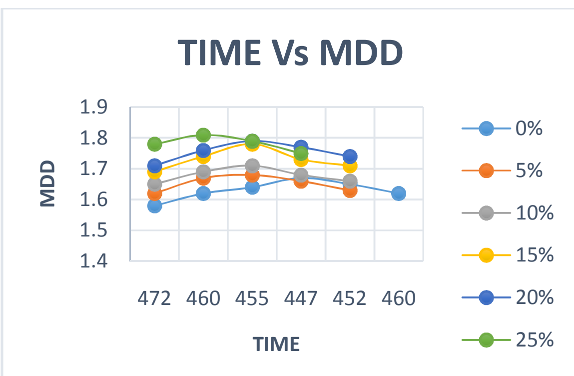
Graph 3. GGBS% Vs MDD



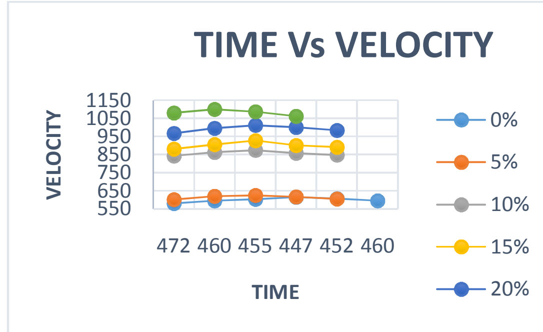
Graph 4. W/C Vs Velocity



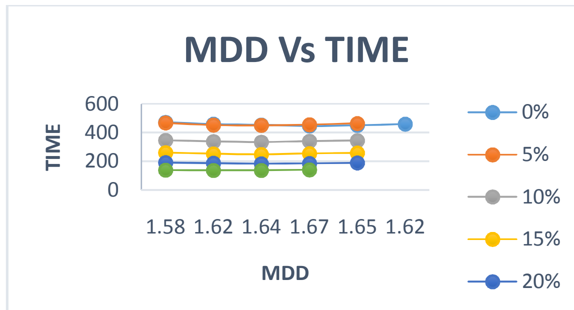
Graph 5. W/C Vs Time



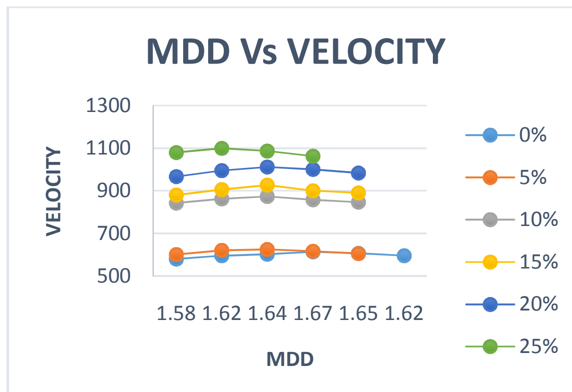
Graph 6. Time Vs MDD



Graph 7. Time Vs Velocity

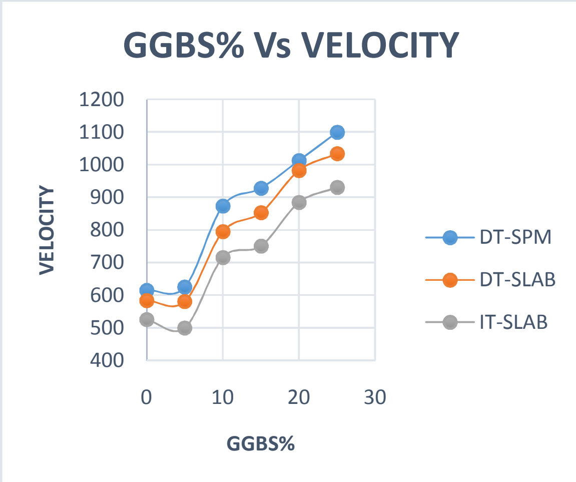


Graph 8. MDD Vs Time

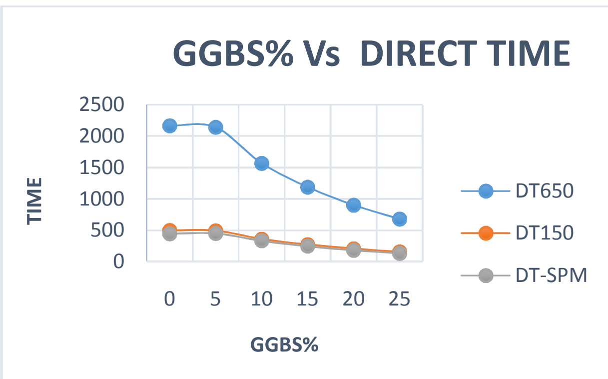


Graph 9. MDD Vs Velocity

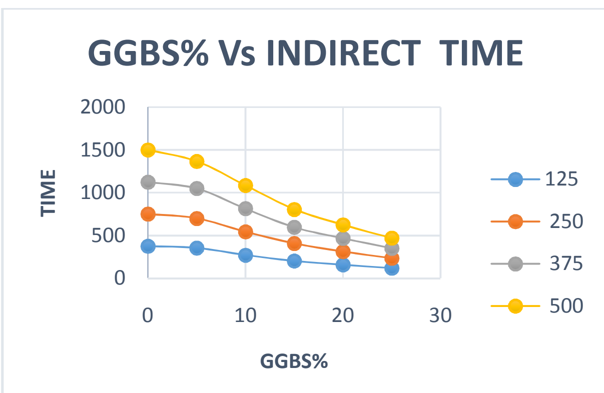
B. UPV Test for slabs using direct and indirect transmission



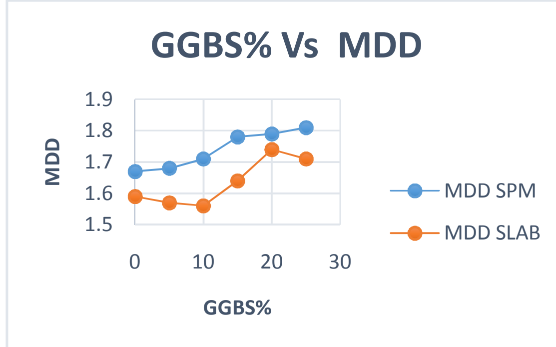
Graph 10. GGBS Vs Velocity



Graph 11. GGBS Vs Direct time



Graph 12. GGBS Vs Time



Graph 13. GGBS Vs MDD

VII. Conclusion

1) GGBS can be used as a stabilizing agent for clayey soil.
2) The maximum dry density increased and OMC% decreased with the increase in GGBS (5%, 10%, 15%, 20% and 25%).
3) Initially the compaction characteristics of standard proctor specimens were investigated by using UPV method. The p-velocity increased with increase in water content up to OMC and then decreased.
4) The p-velocity also increased with the increase in GGBS content.
5) In case of slabs as well the p-velocity readings are in good correlation with the standard proctor specimen readings but still less than the standard proctor specimen readings.
6) The density of the slabs obtained by core cutter method show that the compaction of slabs using RCRA varied slightly and thus explaining the decrease in velocity readings.
7) UPV method can be used as an alternative to the destructive methods of testing of density.

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References

[1] H. Ziari, H. Behbahani, A. Izadi and H. Divandary; “Field investigation of Non-destructive tests in measuring the pavement layers’ density”.

[2] IS: 2720 (Part 3)- 1980, "Determination of specific gravity of Fine, Medium and Coarse grained soils.
[3] IS: 2720 (Part 5)- 1985, "Determination of liquid limit and plastic limit".
[4] J.M. Raut, S.R. Khadeshwar, S.P. Bajad; "Interrelation of properties of soil with Ultrasonic Pulse Velocity".
[5] IS: 1498- 1970, "Classification and identification of soils for general engineering purposes".
[6] Sologyan, A. I, (1990); "Survey of methods and means for determining soil density in the field", Soviet Journal of Non-destructive testing, Plenum Publishing Corp; 25(7), pp 480-46.
[7] Nazli Yesiller, Gokhan Inci and Carol J. Miller; Ultrasonic testing for compacted clayey soils".
[8] Thomas B. Randrup and John M. Lichter; "Measuring soil compaction on construction sites (A review of Surface Nuclear Gauges and Penetrometers)".
[9] Nazli Yesiller, Gokhan Inci and Carol J. Miller (2000); "Ultrasonic testing for compacted clayey soils," Advances in Unsaturated Geotechnics, ASCE GSP 99, C. D. Shackelford, S. L. Houston, and N.-Y. Chang, Eds., ASCE, 54-68.

