A Study On Properties Of Compacted Stabilized Clayey Soil By Using Ultrasonic Pulse Velocity Method

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Abstract- *Infrastructure projects such as highways, railways, water reservoirs, reclamation etc. requires earth material in very large quantity In this experiment soil unconfined compression test clay samples are cast by adding (8%,10%,12%.14%.16%,18%.20%) of admixtures. for which the ultrasound testing is done for 0,1,3,7,14,21,28 day .The obtained velocities are such that an optimum dosage for each set is obtained where the velocity and hence the strength increase and later it starts decreasing.The different graphs for velocity versus curing period as well as percentage of admixture is plotted.The admixtures used are GGBS and Fly Ash+GGBS .The basic physical properties of the soil samples is also evaluated by using Liquit limit test plastic limit test ,specific gravity and sieve analysis is also done. 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.*

Keywords- Fly Ash ,GGBS, Velocity ,Ultrasound Testing ,Clayey Soil

I. INTRODUCTION

Ultrasonic testing is used for non destructive evaluation of materials and structures. Ultrasonic waves are stress waves with frequencies higher than 20 kHz that propagate in mass media. Propagation of ultrasonic waves in a material is affected by the properties and condition of the material. Transmission of waves in a material is quantified generally using two parameters: velocity and attenuation. Ultrasonic velocity can be correlated to elastic constants and mechanical properties of a material, whereas ultrasonic attenuation can be correlated to microstructural properties of a material .Clay soils are compacted for construction of various structures and facilities. Compacted clay soils are commonly used as liners for waste containment facilities; as embankments, sub grade, bases, and backfills for foundations and transportation facilities. Compaction characteristics of soils are determined by analyzing the relationship between water content and dry density (unit weight) of soils. Proctor compaction tests are commonly used in the laboratory to determine the variation of dry density with water content. The relationship between dry density and water content of soils is demonstrated using a compaction curve. Compactionproperties of field soils are compared with the compaction properties of the soils determined in the laboratory to verify the effectiveness of construction procedures. In-situ method is used in the field it is consuming more time. To reduce this time this research paper aims to introduce the ultra-sonic pulse velocity method as an alternative method. Ultrasonic testing can provide a fast and simple approach for determining characteristics of compacted clayey soils. This non-destructive method can be used as an alternative to existing methods to analyze laboratory or field compacted soils. Soils having various plasticity like clayey soil have been tested using conventional tests and then performed with ultrasonic pulse velocity test on these samples &An extensive investigation of the use of ultrasonic testing for compacted soils was reported in an early study by Sheeran et al. (. Velocities of P-waves were determined on three types of soils. It was observed that peak velocities and maximum dry densities occurred within ± 0.5% water content for laboratory compacted soils. The ultrasonic velocities increased with increasing dry density until the optimum water content. However, at water contents higher than the optimum water content, the velocities decreased with increasing dry density. Field tests were conducted on a low plasticity sandy silt. Velocities for laboratory compacted samples (Proctor compaction) of the soil varied between 300 m/sec and 1400 m/sec. Field velocities for the soil were within the range of laboratory velocities.
Significant

II.MATERIALS

2. CLAYEY SOIL (BLACK COTTON SOIL) :

In this experimental study Black Cotton soil is used which is obtained from Holalkere taluk ,near Davangere district.of Karnataka State.It is seived to 425 microns and used in mould that are further used in the destructive and Non destructive tests.

Table -1:Physical Properties of Black Cotton Soil

Sl no	Property / Parameter	For BC Soil
1	Specific Gravity	2.22
2	Atterberg"s limits	
	Liquid limit %	36.53
	Plastic limit	26.78
3	Plasticity index	9.75
4	Soil classification	Silty Clay

2.1 FLY ASH :

Fly Ash used in the study is obtained from the Raichur Thermal power Station,Shaktinagar, Raichur. Class F is used in the study. Fly ash, also known as "pulverised fuel ash", is a coal combustion product that is composed of the particulates fine particles of fuel that are driven out of coal-fired boilers together with the flue gases. but all fly ash includes substantial amounts of silicon dioxide ($SiO2$) aluminium oxide ($Al2O3$) and calcium oxide (CaO), the main mineral compounds in coal-bearing rock strata.Class F fly ash is used in this study.

Fig- 1: Fly Ash used as stabilizing Agent

2.2. GGBS

It was brought from Jindal, Hospet. GBBS which is produced by rapidly cooling red hot metal or other material especially in cold water or oil. The temperature of slag is in the range of 1300-1600^{o}C and is cooled rapidly to avoid crystallization. Molten slag which is the by-product of iron and steel-making from a blast furnace in water or steam produces a glassy, granular product and then later it was dried and then ground into a pure fine powder form. The physical properties and gradation of GGBS depends on the chemical composition of the Slag, its temperature at the time of rapid cooling hot metal, and the production method. Slag is composed of elements which include silica, alumina, calcium oxide, and magnesia .

Fig- 2: GGBS used as stabilizing Agent.

III. METHODS

3.1 PORTABLE ULTRASONIC NON DESTRUCTIVE TESTING INSTRUMENT (PUNDIT)

A pulse of ultrasonic (> 20 kHz) longitudinal stress waves is introduced into one surface of a concrete member by a transducer coupled to the surface with a coupling gel or grease.

The pulse travels through the concrete and is received by a similar transducer coupled on the opposite surface .The transit time of the pulse is determined by the instrument

The distance between the transducers is divided by the transit time to obtain the pulse velocity. The distance between the transducers is divided by the transit time to obtain the pulse velocity.

Fig- 3:Ultrasound Non Destructive Testing machine

3.2 CALIFORNIA BEATRING RATIO TEST (UNSOAKED CONDITION):

The California Bearing Ratio Method is used to find the CBR value of the Plain Soil sample and the Soil Sample prepared by addition of optimum amount of admixture in it accoding to the IS2720-part 16-1987.

Fig- 4: California Bearing Ratio Testing Machine

3.3 CASAGRANDE APPARATUS :

Soil is placed into the metal cup portion of the device and a groove is made down its center with a standardized tool of 2 millimetres width. The cup is repeatedly dropped 10 mm onto a hard rubber base at a rate of 120 blows per minute, during which the groove closes up gradually as a result of the impact. The number of blows for the groove to close is recorded. The moisture content at which it takes 25 drops of the cup to cause the groove to close over a distance of 12.7 millimetres is defined as the liquid limit.

Fig- 5: California Bearing Ratio Testing Machine

IV. RESULT AND DISCUSSION

4.1 SIEVE ANALYSIS OF SOIL SAMPLE

Table - 2:Seive analysis of Soil Sample

SL no.	Sieve Size (mm)	weight retained on each sieve (g)	% Retained	Cumulative % Retained	% Finer
1	4.75	0	0	0	100
2	2.36	58.27	11.65	11.65	88.35
3	1.18	143.15	28.63	40.68	59.72
4	0.6	40.29	8.05	48.33	51.67
5	0.425	110.2	22.04	70.37	28.63
6	0.3	28	5.6	75.97	24.03
7	0.15	74.09	14.8	90.77	9.23
8	0.075	31	6.2	96.97	3.03
9	PAN	15	3	99.97	0.03

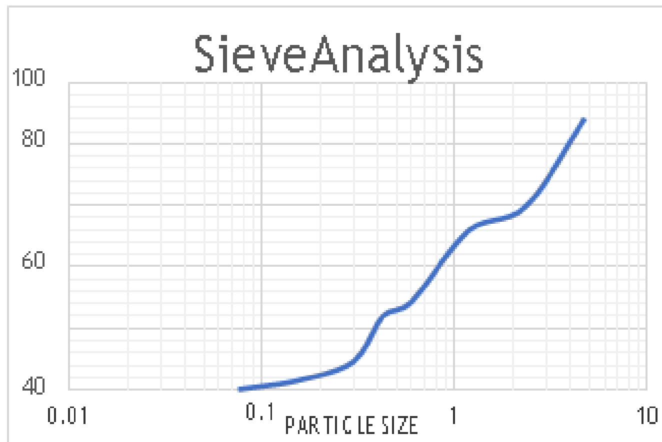

Fig- 6: Sieve analysis

From graph,
D10= 0.1578 mm
D30=0.4279 mm
D60=1.1915 mm

- Coefficient of uniformity = D60/ D10 = 7.550
- Coefficient of curvature= D30ˆ2/(D10 * D60) = 0.9738

K= C * D10ˆ2
Where, C=100 K= 2.49

4.2 SPECIFIC GRAVITY TEST

Table -3: specific gravity of clay soil

Sl.no	Particulars	Silty clay soil
1	Wt of empty density bottle, W1 (g)	0.690
2	Wt of density bottle + dry soil, W2 (g)	1.061
3	Wt of density bottle+water+soil, W3 (g)	1.724
4	Wt of density bottle + water W4 (g)	1.498
5	Specific gravity G	2.568

4.3 CONSISTENCY/ATTERBERG LIMITS

Table-4 :Consistency/Atterberg limits of clay soil

Sl No	Sample type	No of blows	Water content (%)	LL (%)	PL (%)	PI (%)
1	Norm al soil	31	34.78	36.53	26.78	9.75
2		14	39.75			
3		12	38.196			

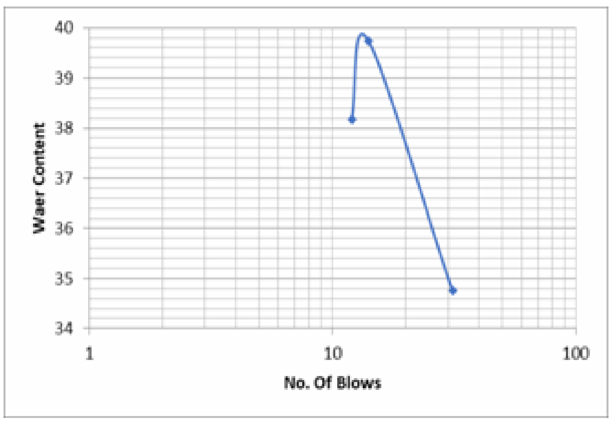

Fig-7: Liquid Limit graph for plain soil sample

Table -5 : Physical Properties of Soil used

SL No	Property / Parameter	For Soil
1	Specific Gravity	2.568
2	Atterberg"s limits	
	Liquid limit %	36.53
	Plastic limit	26.78
3	Plasticity index	9.75
4	Soil classification	
5	Free swell	
6	Compaction Characteristics	
	Max. dry density(kg/m³)	1770
	Optimum Moisture content (OMC)%	14%

4.4 SPECIFIC GRAVITY TEST FOR GGBS

Table 6 : Specific gravity of GGBS

Sl.no	Particulars	GGBS
1	Wt of empty density bottle, W1 (g)	690 g
2	Wt of density bottle + dry soil, W2 (g)	1010 g
3	Wt of density bottle+water+soil, W3 (g)	1705 g
4	Wt of density bottle + water W4 (g)	1498 g
5	Specific gravity G	2.83

4.5 CONSISTENCY LIMITS FOR GGBS

Table -7 : Consistancy limits of GGBS

Sl No	Sample	No of blows	Water content	LL (%)	PL (%)	PI (%)
1	GGBS	17	40.41	35	-	-
2		36	29.40			
3		25	36.04			

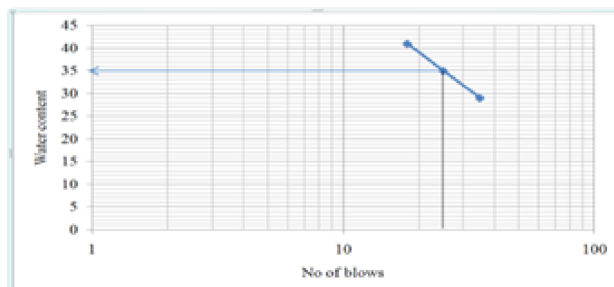

Fig- 8: Liquid Limit of GGBS

4.6 THE PHYSICAL PROPERTIES AND CHEMICAL COMPOSITIONS OF GGBS

Table -8: Physical properties of GGBS

SL No	Property / Parameter	For Silty clay soil
1	Specific Gravity	2.84
3	Atterberg"s limits	
	a)Liquid limit %	35
	b)Plastic limit	NA
4	c)Plasticity index	NP
5	Free swell index	0

Table -9 : Chemical properties of GGBS

SL No	Chemical composition	Percentage
1	SiO_2	40%
2	MgO	3.6%
3	CaO	39.2%
4	Al_2O_3	13.5%
5	Fe_2O_3	1.8%
6	SO_3	1.7%
7	L.O.I	0.2%

4.7 TESTS ON COMBINATION OF SOIL, GGBS & FLY ASH (SAC)

SAC

Table -10 : Chemical properties of GGBS

Sl. no	Type of Sample	Soil %	Admixture %	GGBS by weight of soil in (%)	Fly ash by weight of soil in (%)
1	S	100	0	0	0
2	SAC 1	92	8	30 of 8	70 of 8
3	SAC 2	90	10	30 of 10	70 of 10
4	SAC 3	88	12	30 of 12	70 of 12
5	SAC 4	86	14	30 of 14	70 of 14
6	SAC 5	84	16	30 of 16	70 of 16
7	SAC 6	82	18	30 of 18	70

SAC 1

SL no	Trials	No of blows	Water Content (%)	LL(%)	PL(%)	PI(%)
1	1	35	28.62	34.5	15.46	19.04
2	2	24	33.6			
3	3	14	45.77			
4	4	11	48.41			

SAC 2

SL no	Trials	No of blows	Water Content (%)	LL(%)	PL(%)	PI(%)
1	1	57	28.68	36.2	19.05	17.15
2	2	45	32.46			
3	3	27	36.4			
4	4	15	39.81			

SAC 3

SL no	Trials	No of blows	Water Content (%)	LL(%)	PL(%)	PI(%)
1	1	45	32.4	35.4	25.98	9.42
2	2	34	34.65			
3	3	20	36.27			
4	4	10	37.1			

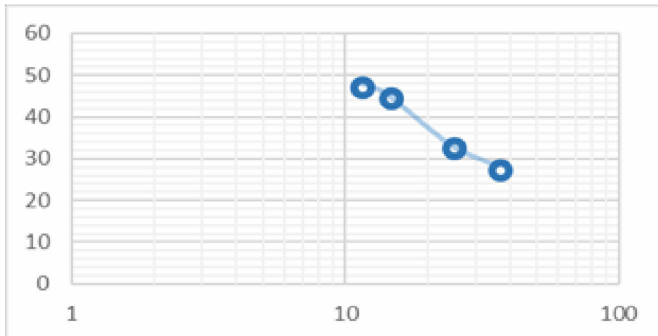

Fig-9: Liquid limit

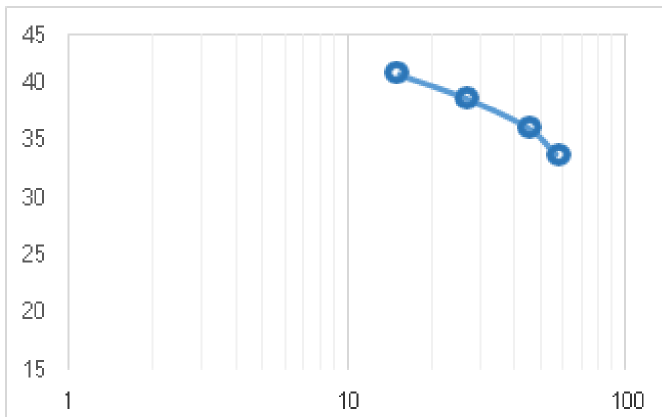

Fig- 10: Liquid limit

SAC 4

SL no	Trials	No of blows	Water Content (%)	LL(%)	PL(%)	PI(%)
1	1	40	35.16	38.4	17.22	21.18
2	2	25	38.67			
3	3	18	39.79			
4	4	10	41.27			

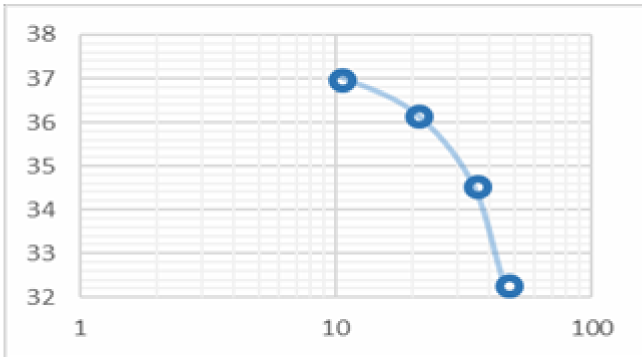

Fig- 11: Liquid limit

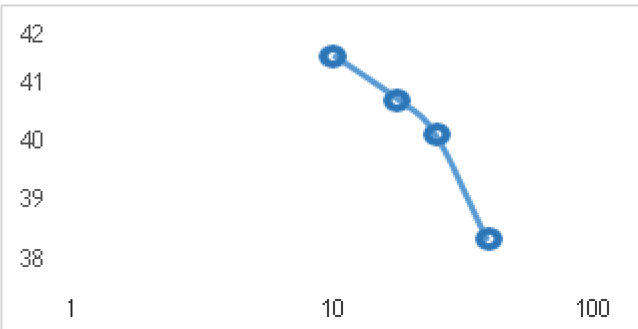

Fig- 12: Liquid limit

SAC 5

SL no	Trials	No of blows	Water Content (%)	LL(%)	PL(%)	PI(%)
1	1	33	28.91	29.8	12.23	17.57
2	2	19	31.44			
3	3	15	36.59			
4	4	13	41.65			

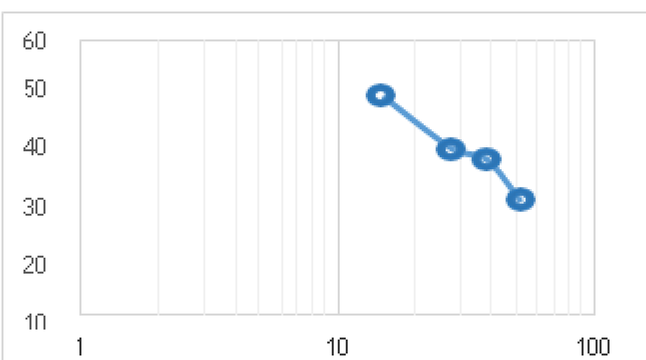

Fig- 13: Liquid limit

SAC 6

SL no	Trials	No of blows	Water Content (%)	LL(%)	PL(%)	PI(%)
1	1	52	24.91	37.2	14.95	22.25
2	2	38	34.2			
3	3	28	36.37			
4	4	15	47.85			

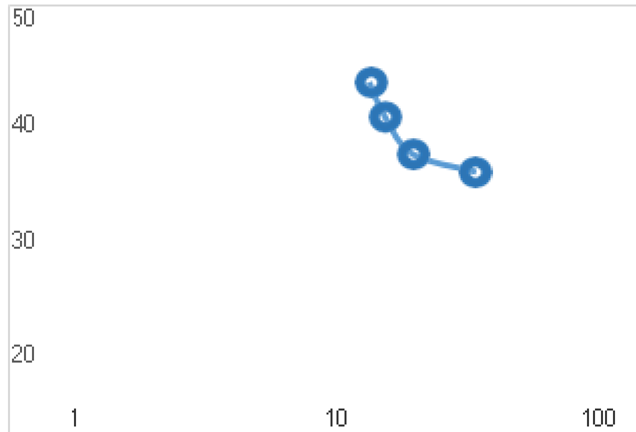

Fig- 14: Liquid limit

4.8 SPECIFIC GRAVITY TEST OF BLACK COTTON SOIL, FLY ASH AND GGBS

Table 11 : Specific gravity of BC , FA and GGBS

SPECIFIC GRAVITY TEST OF SOIL SAMPLE COMBINATION						
Sl no.	Combination	w1	w2	w3	w4	specific gravity
1	5	690	1061	1724	1498	2.568
2	SAC 1	690	1063	1727	1498	2.594
3	SAC 2	690	1054	1722	1498	2.599
4	SAC 3	690	1086	1742	1498	2.612
5	SAC 4	690	1037	1713	1498	2.623
6	SAC 5	690	1126	1769	1498	2.636
7	SAC 6	690	1094	1749	1498	2.651

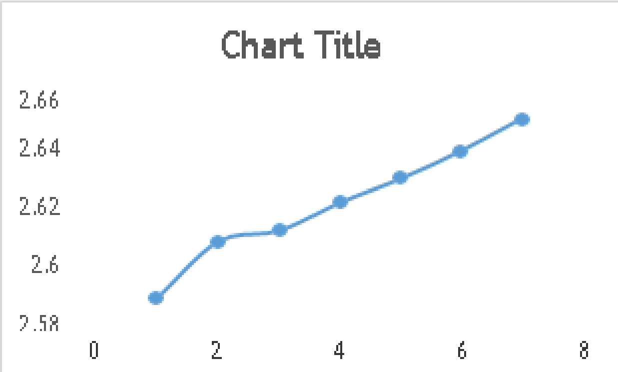

Fig- 15: Variation of Specific gravity values for different sample types

Table- 12 : Velocity for different curing period and admixtures(GGBS)

[illegible]	0DAY		1DAY		3DAY		7DAY		14DAY		21DAY		28DAY	
	Time [illegible]	[illegible]	Time [illegible]	[illegible] (m/s)	Time [illegible]	[illegible]	Time [illegible]	[illegible] (m/s)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8%	134.5	[illegible]	126	[illegible]	[illegible]	[illegible]	[illegible]	700.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10%	123.4	[illegible]	116.3	[illegible]	[illegible]	[illegible]	[illegible]	773.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12%	112.3	[illegible]	110.2	[illegible]	[illegible]	[illegible]	[illegible]	805.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14%	102.8	[illegible]	102.3	[illegible]	[illegible]	[illegible]	[illegible]	852.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16%	98.6	[illegible]	95.7	[illegible]	[illegible]	[illegible]	[illegible]	901.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18%	108.9	[illegible]	105.4	[illegible]	[illegible]	[illegible]	[illegible]	819.8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20%	116.5	[illegible]	108.6	[illegible]	[illegible]	[illegible]	[illegible]	754.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

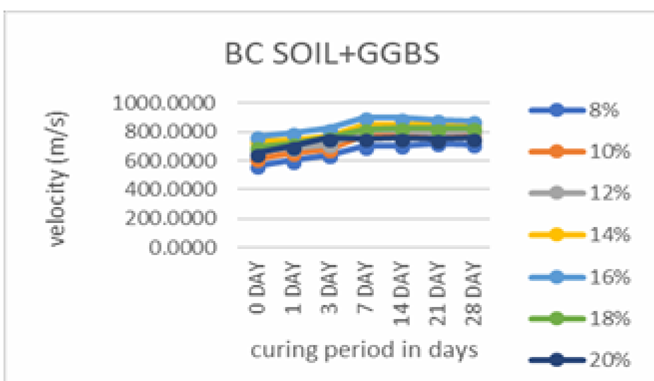

Fig- 16: Velocity vs Curing Period graph (GGBS)

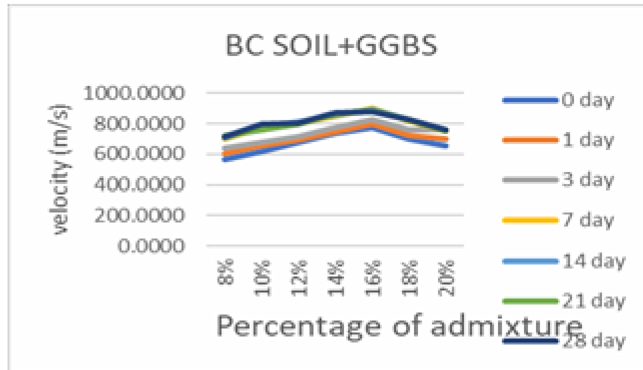

Fig- 17: Velocity vs Percentage of Admixture(GGBS + Fly Ash)

Table -13 : Velocity for different curing period and admixtures (GGBS + Fly ash)

[illegible]	0DAY		1DAY		3DAY		7DAY		14DAY		21DAY		28DAY	
	Time [illegible]	[illegible] (m/s)	[illegible]	[illegible] (m/s)	[illegible]	[illegible]	[illegible]	[illegible] (m/s)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] (m/s)
8%	138.6	[illegible]	128.6	[illegible]	[illegible]	[illegible]	88.6	857.8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10%	125.3	[illegible]	115.6	[illegible]	[illegible]	[illegible]	82.7	919.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12%	118.6	[illegible]	108.8	[illegible]	[illegible]	[illegible]	77.4	981.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14%	110.3	[illegible]	99.3	[illegible]	[illegible]	[illegible]	70.2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16%	105.8	[illegible]	95.6	[illegible]	[illegible]	[illegible]	68.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18%	115.6	[illegible]	100.2	[illegible]	[illegible]	[illegible]	75.8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20%	121.2	[illegible]	109.5	[illegible]	[illegible]	[illegible]	89.6	848.2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

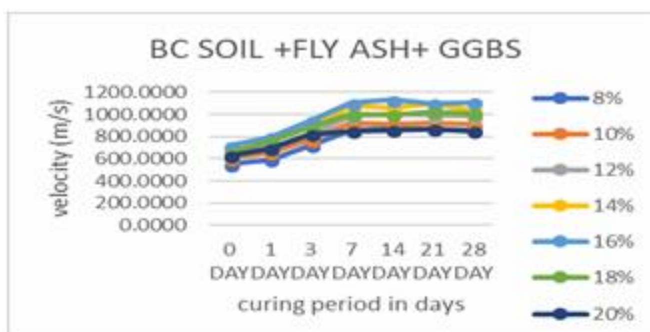

Fig- 18: Velocity vs Curing Period graph (GGBS)

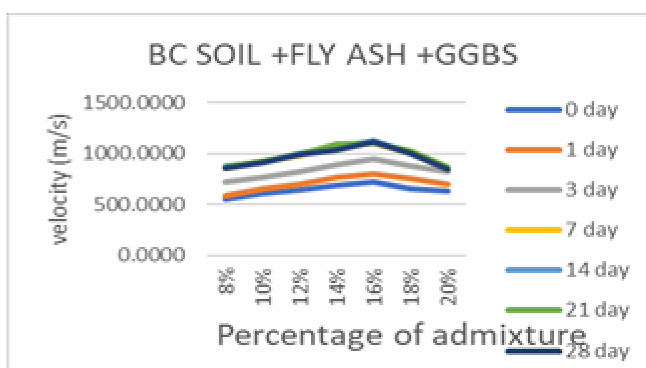

Fig-19 : Velocity vs Curing period graph (GGBS + Fly ash)

V. CONCLUSION

1. The various admixtures such as GGBS and FLY ASH could be used for B C Soil significantly increases the Geotechnical Properties of the Soil
2. It has been observed that increase in High Solid Content increases the velocity and hence the strength and upto optimum value.
3. Strength and velocity increases with increase in percentage of admixture , reaches maximum at the optimum and then starts decreasing
4. At the initial curing periods, the rate of increase in velocity is rapid and thereafter rate decreases
5. The Strength of the soil is increased when the admixture is added when compared with soil without Admixture.
6. Increase in the percentage of GGBS added to the BC soil liquid limit, plastic limit and plasticity index decreases.
7. The method can be used as an alternative to existing field methods., field verification is required to complete the development of the met

VI. ACKNOWLEDGEMENT

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