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An Experimental Study on Physical Properties of Clayey Soil by Using Destructive and Non Destructive Tests

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Abstract: - **Infrastructure projects such as highways, railways, water reservoirs, reclamation etc. requires earth material in very large quantity. In urban areas, borrow earth is not easily available which has to be hauled from a long distance Extensive laboratory field trials have been carried out by various researchers and have shown promising results for application of such expansive soil after stabilization with additives such as, lime, fly ash, GGBS etc. As fly ash is freely available, for projects in the vicinity of a Thermal Power Plants, it can be used for stabilization of expansive soils for various uses .Clayey soil is known for its high swell potential and low shear strength. In this paper, experimental investigations are done to know the effect of Fly Ash and Fly Ash and Lime in combination on clayey soil. The soil sample was collected from Holalkere taluk from Davangere District and additiondifferent percentages of FlyAsh (8%,10%,12%,14%,16%,18%,20%) was added and Fly Ash +Lime is added to find the variation in its Strength and the corresponding velocity of the soil specimens.Velocity of specimens is found by PUNDIT instrument. 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, Lime, Soil Stabilization, Ucc, PUNDIT, Velocity, Strength, California Bearing Ratio.

1. INTRODUCTION:

Aim of this research is to stabilize the locally available Black Cotton soil in Holalkere Taluk of Davangere district. The stabilization is done for the following reasons.

Soil stabilisation is widely used in connection with road, pavement and foundation construction. It improves the engineering properties of the soil, e.g:

- Strength - to increase the strength and bearing capacity,
- Volume stability - to control the swell-shrink characteristics caused by moisture changes,
- Durability - to increase the resistance to erosion, weathering or traffic loading.
- To reduce the pavement thickness as well as cost.

One method of improving the engineering properties of soil is by adding chemicals or other materials to improve the existing soil. This technique is generally cost effective: for example, the cost, transportation, and processing of a stabilizing agent or additive such as soil cement or lime to treat an in-place soil material will probably be more economical than importing aggregate for the same thickness of base course.

Additives can be mechanical, meaning that upon addition to the parent soil their own load-bearing properties and the engineering characteristics of the parent soil. Additives can also be chemical, meaning that the additive reacts with or changes the chemical properties of the soil, thereby upgrading its engineering properties. Placing the wrong kind or wrong amount of additive – or, improperly incorporating the additive into the soil – can have devastating results on the success of the project.In this Project we have made use of Fly Ash obtained from Raichur Thermal Power Station from Shaktinagar,Raichur .

Clayey soils are important area of concern in case of soil subgrade of Highways and backfills of bridges , as there occurs a significant amount of swelling and shrinkage in the soil. Soil stabilization by mixing it with fly ash and lime in various composition and different combinations. The destructive and non destructive tests are conducted ,impact of compaction and variation of constituent components of the mix on velocity and strength is assessed and the following relations are obtained.

The main Objectives of the Study are :

1. To find the optimum dosage of admixtures such as Fly Ash and Fly Ash and lime by means of strength assessement of test specimen.
2. To find the variation of velocities of soil mixed with different admixture and its combination for a particular water content
3. To find the strength of the optimum dosage of specimen using CBR.
4. To find the relationship between Stess vs Strain
5. To find the relationship between Velocity of wave and Curing period of the specimen.
6. To find the relationship between Velocity of wave and replaced percentage of admixture.

2.MATERIALS:

2.1 Clayey (Black Cotton) Soil:

In this experimental study Black Cotton soil is used which is obtained from Holalkere taluk ,near Davangere

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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
5	Compaction Characteristics	
	Max. dry density(kN/m^3)	1.77
	Optimum Moisture content (OMC)%	14

2.2 *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 (SiO_2) aluminium oxide (Al_2O_3) and calcium oxide (CaO), the main mineral compounds in coal-bearing rock strata.Class F fly ash is used in this study.

Figure 1: Fly Ash used as stabilizing Agent :

2.3 LIME :

Hydrated lime is an inorganic compound with the chemical formula $Ca(OH)_2$. It is a colorless crystal or white powder and is obtained when calcium oxide (called *lime* or *hydrated*) It has many names including hydrated lime, caustic lime, builders lime, slack lime or pickling lime.Here it is used in combination with the Fly ash to compare with the increase in strength between the admixtures.

Figure 2 : Lime used in the experiment along with fly ash as a stabilizing Agent .

3. .PREPARATION OF SAMPLES :

The samples meant for Unconfined Compression Test are prepared by addition of admixture such as only Fly Ash and combination of Fly Ash +Lime (70:30) ratio .Percentage of admixture is varied for every two percentage from 8% to 20%.The samples are tested on respective curing periods.

Table 2 : Number of ucs samples to be mould for different specified percentages of admixtures and curing periods.

Samples Plan for Each Admixture							
Percentage of admixture	0 DAY	1 DAY	3 DAY	7 DAY	14 DAY	21 DAY	28 DAY
8%	3	3	3	3	3	3	3
10%	3	3	3	3	3	3	3
12%	3	3	3	3	3	3	3
14%	3	3	3	3	3	3	3
16%	3	3	3	3	3	3	3
18%	3	3	3	3	3	3	3
20%	3	3	3	3	3	3	3

3.1 METHODS USED :

3.1.1 UNCONFINED COMPRESSION TEST : The test was conducted as per IS2720 (Part 10)-1991 to find the Shear Strength of the Clayey Soil. Various percentage of Clay constituent components like Clay , fly ash and lime are calculated in terms of weight are calculated. A dry homogenous mix is prepared by mixing clay and respective admixture for particular combination of water is added for consistency.

Mould meant for Unconfined Compression test is filled in three layers by using soil, and compacted by using compaction instrument .The Mould is placed in the dissicator for the specified number of days according to the decided age of testing such that its moisture content is retained.The specimen are tested .

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Table 3: Weights of Components of specimen for Fly Ash as admixture

Percentage of Admixture	Clay (g)	Fly Ash(g)	Lime(g)
8%	552	33.6	14.4
10%	540	42	18
12%	528	50.4	21.6
14%	516	58.8	25.2
16%	504	67.2	28.8
18%	492	75.6	32.4
20%	480	84	36

Table 4: Weights of Components of specimen for Fly Ash +Lime as admixture

Weights of the Constituent Components		
Percentage of Admixture	Clay(g)	Fly Ash(g)
8%	552	48
10%	540	60
12%	528	72
14%	516	84
16%	504	96
18%	492	108
20%	480	120

3 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.

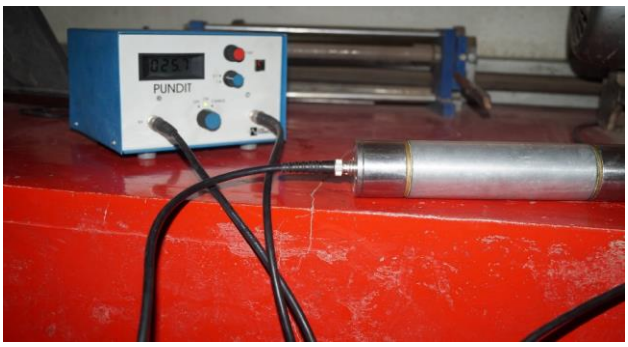

Figure 3:Ultrasound Non Destructive Testing Machine

3.1.3 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.

Figure 5: California Bearing Ratio Testing Machine

4. RESULTS AND DISCUSSION *:*

4.1 SEIVE ANALYSIS OF SOIL SAMPLE

Table 5:Dry sieve 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

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

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- Coefficient of uniformity = D60/ D10 = 7.550
- Coefficient of curvature= D30^2/(D10 * D60) = 0.9738

K= C * D10^2

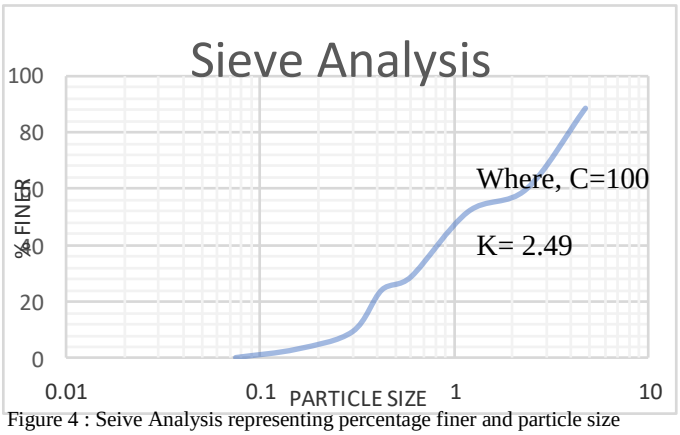

Figure 4 : Seive Analysis representing percentage finer and particle size

4.2 California Bearing Test :

It is the ratio of force per unit area required to penetrate a soil mass with standard circular piston at the rate of 1.25 mm/min. to that required for the corresponding penetration of a standard material.

In this test it is observed that the after addition of admixture the Strength of the Black Cotton Soil is improved by significant amount.The Load (KN) vs Penetration (mm) graph is plotted which shows as the load increased deformation also increases.Load at 2.5 mm and 5 mm penetration are significantly used.

Table 6 :Load and deformation values for plain soil sample

DEFORMATION (mm)	LOAD (kN)	
0	0	
0.5	19.024	
1	23.78	
1.5	28.563	
2	30.941	
2.5	35.67	X1/1370 * 100 = 2.60
3	40.426	
3.5	42.804	
4	48.371	
4.5	49.938	
5	54.694	X2/2055 * 100 = 2.66
7.5	70.151	
10	83.23	
12.5	84.12	

Table 7: Load and Deformation values for Plain with admixture

DEFORMATION	LOAD
0	0
0.5	15.67
1	23.398
1.5	28.749
2	29.938
2.5	33.505
3	34.099
3.5	34.694
4	35.883
4.5	39.45
5	40.044
7.5	45.395
10	47.178
12.5	51.934

k=21.19 Mpa/m

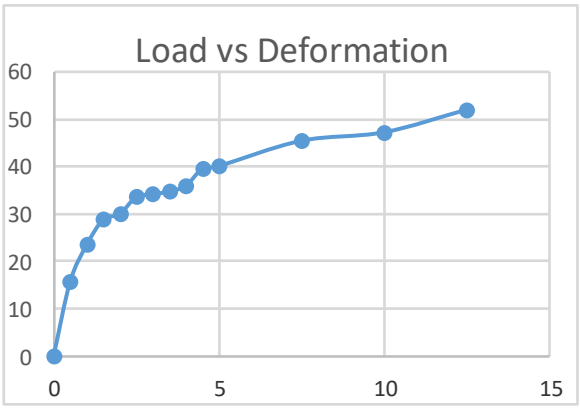

Figure 6: Load vs Deformation graph for Plain Soil Soil + Admixture

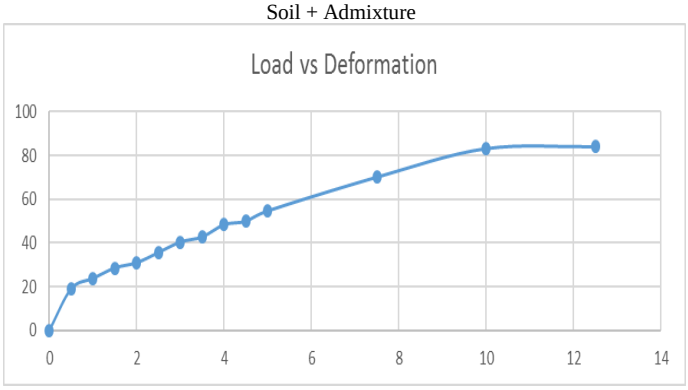

Figure 7: Load vs Deformation curve for Black Cotton Soil+Admixture

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k= 38.816 Mpa/m

4.3 PUNDIT

4.3.1 VELOCITY VS CURING PERIOD AND

4.3.2 VELOCITY VS PERCENTAGE OF ADMIXTURE

As the curing period of the specimen increases the velocity is observed to be increased.But the rate of increase in the velocity is more pronounced in the initial curng periods later the rate of increase in velocity with curing period decreses.More the velocity and more the strength .Untill optimum dosage of the admixture the velocity increases and later it decreases.

Table 8:Variation of velocity with curing period

	0 DAY		1 DAY		3 DAY		7 DAY		14 DAY		21 DAY		28 DAY	
Percentage Replacement of FLY ASH(%age))	Time (micro secods)	Velocity (m/s)	Time (micro secods)2	Velocity (m/s)3	Time (micro secods)4	Velocity (m/s)5	Time (micro secods)6	Velocity (m/s)7	Time (micro secods)8	Velocity (m/s)9	Time (micro secods)10	Velocity (m/s)11	Time (micro secods)12	Velocity (m/s)13
8%	165.5	459.2145	155	490.3226	141.2	538.2436	125	608.0000	125.6	605.0955	126.4	601.2658	127.4	596.5463
10%	157.8	481.6223	146.8	517.7112	132.8	572.2892	115	660.8696	116.7	651.2425	115.8	656.3040	115.6	657.4394
12%	148.6	511.4401	135.6	560.4720	116.8	650.6849	106.8	711.6105	105.8	718.3365	106.2	715.6309	104.9	724.4995
14%	142.3	534.0829	128.6	590.9798	113.6	668.0141	**96.8**	785.1240	95.4	796.6457	95.2	798.3193	102.3	742.9130
16%	**138.6**	548.3405	**120**	633.3333	**105.6**	719.6970	97.6	778.6885	**98.2**	773.9308	**97.2**	781.8930	**98.4**	772.3577
18%	142.6	532.9393	128.4	591.9003	110.3	689.0299	102.3	742.9130	103.5	734.2995	102.8	739.2996	103.2	736.4341
20%	148.9	510.4987	133.9	567.3878	118.6	640.8094	105.3	721.7474	105.8	718.3365	105.2	722.4335	106.1	716.3054

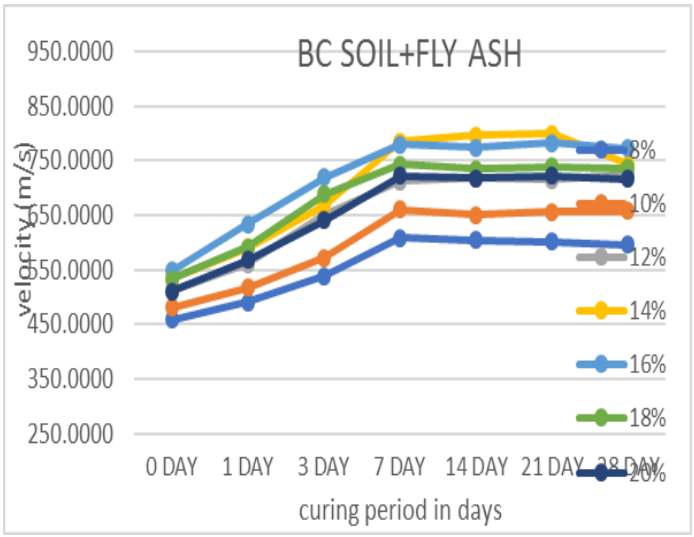

Figure 8: Velocity vs Curing Period graph (Fly Ash)

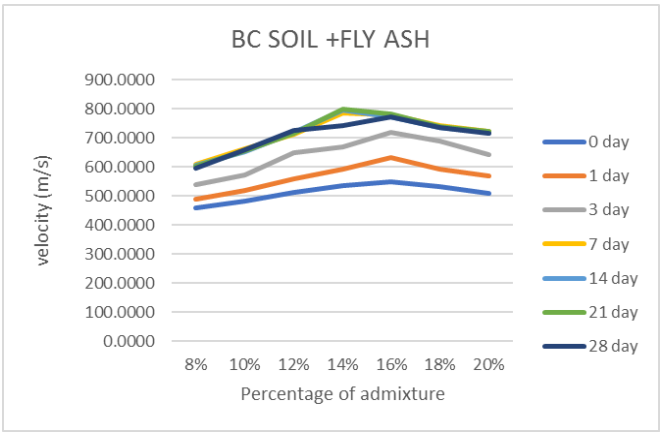

Figure 9 : Velocity vs Percentage of Admixture(Fly Ash)

FLY ASH +LIME :

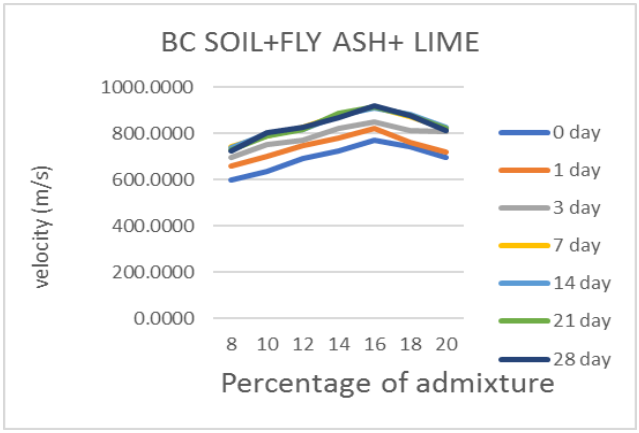

Figure10: Velocity vs Percentage of Admixture(Fly Ash+Lime)

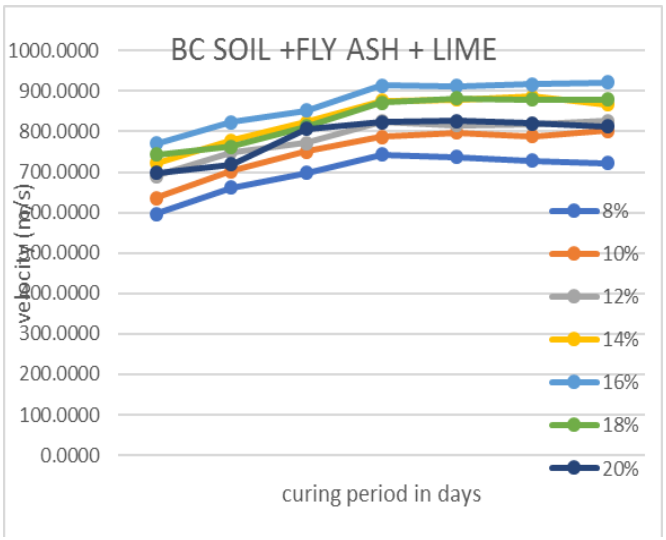

Figure11: Velocity vs curing period(Fly Ash + Lime)

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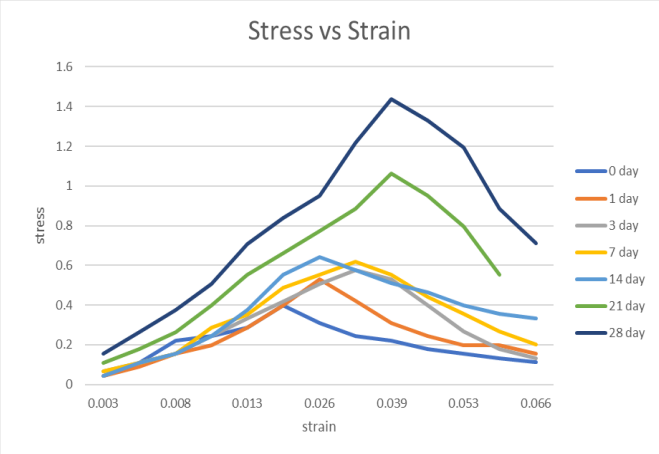

Figure 12: Stress vs Strain graph for 14% optimum dosage is shown above for BC Soil +Fly Ash

Table 8 : Velocity for different curing period (Fly Ash + Lime)

	0 DAY		1 DAY		3 DAY		7 DAY		14 DAY		21 DAY		28 DAY	
Percentage Replacement of FLY ASH +LIME (%age))	Time (micro seconds)	Velocity (m/s)	Time (micro seconds)2	Velocity (m/s)3	Time (micro seconds)4	Velocity (m/s)5	Time (micro seconds)6	Velocity (m/s)7	Time (micro seconds)8	Velocity (m/s)9	Time (micro seconds)10	Velocity (m/s)11	Time (micro seconds)12	Velocity (m/s)13
8	127.4	596.5463	115	660.8696	108.9	697.8880	102.3	742.9	103.2	736.4341	104.3	728.6673	105.2	722.4335
10	119.6	635.4515	108.3	701.7544	101.3	750.2468	96.5	787.6	95.3	797.4816	96.4	788.3817	94.8	801.6878
12	110.1	690.2816	101.4	749.5069	98.4	772.3577	92.1	825.2	93.1	816.3265	92.8	818.9655	91.9	826.9859
14	105.2	722.4335	97.6	778.6885	92.3	823.4020	86.7	876.6	**86.5**	878.6127	85.7	886.8145	87.6	867.5799
16	**98.7**	770.0101	**92.3**	823.4020	**89.2**	852.0179	**83.1**	914.6	83.3	912.3649	**82.9**	916.7672	**82.5**	921.2121
18	102.3	742.9130	99.7	762.2869	93.5	812.8342	87.2	871.6	86.2	881.6705	86.4	879.6296	86.4	879.6296
20	108.9	697.8880	105.6	719.6970	94.2	806.7941	92.3	823.4	91.9	826.9859	92.6	820.7343	93.5	812.8342

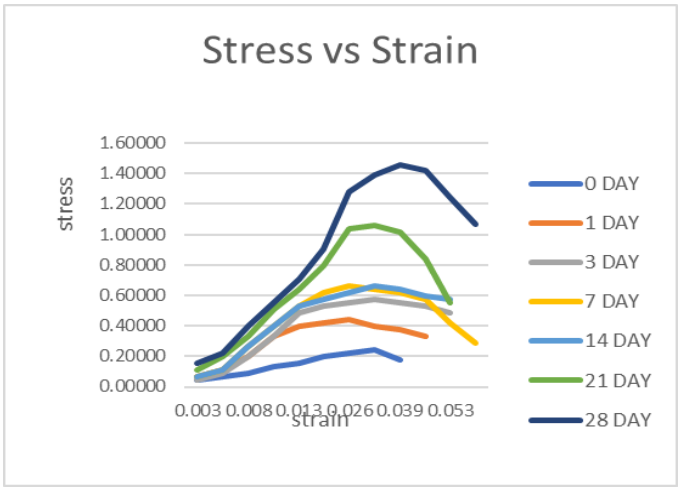

Figure 13 ; Stress vs Strain graph for BC Soil+Fly Ash+Lime for its optimum dosage of 16% of admixture replaced.

5. CONCLUSIONS:

The Main Objective of the study is to increase the stability of the Clayey Soil and establish relationship between descructive and Non Destrucitve Test .

Based on the experiments conducted , the following observationis are made :

1. The various admixtures such as Fly Ash and lime 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 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.

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