Relative Performance of Different Discrete Reinforcing Inclusions in Improving the Fly Ash (FA) Stabilized Expansive Soils

L N V N Varaprasad[1], B.Ganesh[2]
Department of Civil Engineering
[1]PG Student, Lenora College of Engineering, Rampachodavaram
[2]Associate Professor, Lenora College of Engineering, Rampachodavaram

Abstract- *The widespread increase of single-use plastics in day to day consumer applications continues to contribute to an ever growing volume of plastic material in municipal solid waste generated across the world. These plastics are used for disposable applications and therefore reach the waste stream more quickly as their usage life is shorter than that of the plastics used in the construction or automotive industry. Landfills are thus continually being filled up by plastic material that has been used for only a short time and has resulted in the generation of millions of tonnes of waste leading to environmental challenges such as diminishing landfill space for disposal. Reinforcement of problematic soil to improve its strength properties for civil engineering construction is a possible means to put to use the abundant waste plastics, which might become vital in contributing to sustainable development. This project presents the experimental programme undertaken to investigate the relative performance of different randomly distributed discrete waste inclusions on the behavior of an problematic expansive soil partially replaced with optimum percentage of Fly Ash (FA).*

Keywords- waste plastics, discrete waste inclusions, expansive soil Fly Ash (FA).

I. INTRODUCTION

For centuries mankind was wondering at the instability of earth materials, especially expansive soil. One day they are dry and hard, and the next day wet and soft. Swelling soil always create problem for lightly loaded structure, by consolidating under load and by changing volumetrically along with seasonal moisture variation. As a result the superstructures usually counter excessive settlement and differential movements, resulting in damage to foundation systems, structural elements and architectural features.Even when efforts are made to improve swelling soil, the lack of appropriate technology sometimes results volumetric change that are responsible for billion dollars damage each year. Expansive soil deposits occur in the arid and semi arid regions of the world and are problematic to engineering structures because of their tendency to heave during wet season and shrink during dry season (Mishra et al. 2008).

The objective of the present work is to study the experimental programme undertaken to investigate the relative performance of an industrial waste (partial replacement of expansive soil with optimum percentage of Fly ash (FA)) and different randomly distributed discrete waste inclusions in combination, on the behavior of a problematic expansive soil.

II. REVIEW OF LITERATURE

Expansive soils are composed primarily of hydrophilic clay minerals, such as Montmorillonite, and with significant swelling and shrinking characteristics. Compared with the common clay, expansive soil has three characteristics, expansive, crack and over-consolidation. Crack is concentrated expression of expansion and over consolidation. With the decline of water content expansive soil will shrink and result in crack the changing of environment leads to drying and wetting effect and the crack will further develop.

CH.MAHESH and Dr A.S.RAO Effect of Nylon Fibers & Rice Husk on Engineering Properties of Soils .Optimum moisture content and maximum dry density decreases with increase in the lime content.CBR value decreases with increase in the quantity of rice husk. CBR value is high at 5% rice husk. CBR value is high at 20% lime when compared to 5%, 10%, 40% of lime mixed with soil. CBR value is high at 10% lime + 1.5% fiber when compared to the remaining proportions. CBR value for (soil +10% lime) and (soil + 40% lime) is same. CBR gradually increases with increase in fibers up to 2% (soil + 5% lime). CBR value increases up to 1.5% addition of fibers in and decreases at 2% fiber in (soil + 10% lime). CBR value gradually decreases with increase of fiber content in (soil+ 20%lime). CBR value gradually increases with increase of fibers in 40% lime with soil. From the observations, the strength at 20% lime is more. Hence 20% of lime may be used for strength purpose and for low traffic the rice husk may be used for economical purpose

Dr.K.V KRISHNA REDDY made an attempt to determine the utility of industrial wastes in Stabilization of medium plastic clays (CI). Fly ash (FA) and waste tire rubber (WTR) have been considered to investigate their potential in stabilizing the CI soils. Laboratory Experimentation is done to evaluate the optimum contents of fly ash and waste tire rubber Content to check the California Bearing Ratio strength (CBR), Differential Free Swell % and Unconfined Compressive Strength (UCC) strength. The results indicated that the 25% addition of fly ash to the medium plastic clay soils (CI) resulted in a CBR value of 10% and a 7 Days UCC strength of 330 kN/Sq.m. 6% addition of waste tire rubber content to CI soil resulted in a CBR value of 4.36% and a 7 day UCC value of 80kN/Sqm. The differential free swell % evaluated for the optimal mixes indicated that the stabilized mixes exhibited low expansiveness. Industrial wastes namely fly ash and waste tire rubber can be effectively used to stabilize clay subgrades to achieve high strength values thus resulting in decreased pavement thickness and low maintenance.

III. METHODOLOGY

MECHANICS OF SOIL STABILIZATION

Stabilization is the process of blending and mixing materials with a soil to improve the soil's strength and durability. Soil Stabilization is the alteration of soils to enhance their physical properties. Stabilization can increase the shear strength of a soil and/or control the shrink-swell properties of a soil, thus improving the load bearing capacity of a sub-grade to support pavements and foundations. Soils stabilized by additives often provide an all-weather working platform for construction operations

Properties of soil sample

The soil sample collected from ODDALAREVU' near Amalapuram, in East Godavari District, Andhra Pradesh State, India.' has been selected for the present study after having a visual inspection of it. When a lump of sample was cut with a knife it gave a shining surface hence, it was concluded that the sample is of clayey nature. Laboratory tests were carried out as per the IS Codal Provisions by pulverizing the lumps into individual particles to determine the properties of the selected soil sample as mentioned here under.

Table 1: Properties of Expansive Soil

Natural Water Content	66.6%
% Fines	99.63%
% Sands	0.37%
Liquid limit	78.4%

.

Table 2: Properties of Expansive Soil

S.No	**PROPERTIES**	**VALUE**
1	Specific gravity	2.72
2	Differential free swell (%)	105
3	Atterberg limits Liquid limit (%) Plastic limit (%) Plasticity index (%)	 66.4 23.5 42.9
4	IS soil classification	CH
5	O.M.C. (%) M.D.D. (g/cc)	28.8 1.52
6	Un soaked C.B.R(%)	3.4
7	Soaked C.B.R (%)	1.6
8	Cohesion (C_u), (kpa) Angle of internal friction ($Ø_u$).(degrees)	42 0

Waste Tyre Rubber

Solid waste management is one of the major environmental concerns worldwide. For the last 30 years many studies have been conducted in order to assess the feasibility of using industrial by-products and waste materials in civil engineering applications.

Table 3: Physical properties of waste tyre rubber

Properties	**Measured value**

Specific gravity	0.94
Unit weight g/cm^3	0.69
Absorption %	1.8
Fineness modulus	3.78

Fly Ash

Fly ash is the finely divided residue that results from the combustion of pulverized coal and is transported from the combustion chamber by exhaust gases. It is produced by coal-fired electric and steam generating plants.

Table 4: Composition of fly ash

CONSTITUENTS	%
SiO_2	55.0
Al_2O_3	20.3
Fe_2O_3	6.3
CaO	12.0
MgO	3.5
Alkali	1.0
SO3	1.5
HeavyMetals	Trace

Pet Bottle Flakes

PET (also abbreviated PETE) is short for polyethylene terephthalate, the chemical name for polyester. PET is a clear, strong, and lightweight plastic that is widely used for packaging foods and beverages, especially convenience-sized soft drinks, juices and water. Virtually all single-serving and 2-liter bottles of carbonated soft drinks and water are made from PET.

Nylon Fibers

Nylon was the first truly synthetic fiber to be commercialized. It is a polyamide fiber, derived from a diamine and a dicarboxylic acid, because a variety of diamines and dicarboxylic acids can be produced, there are a very large number of polyamide materials available to produce nylon fibers.

IV. RESULTS AND DISCUSSIONS

In the laboratory, various experiments were conducted by adding different percentages of Waste Fiber materials in the 80%Expansive Soil (ES) + 20%Fly Ash (FA).

Table 5: Variation of Compaction Parameters

% of Fiber	WTR		WP		PBF		NF	
	MDD	OMC	MDD	OMC	MDD	OMC	MDD	OMC
0%	1.50	28.20	1.5	28.20	1.50	28.20	1.50	28.20
0.5%	1.51	28.10	1.5	28.10	1.51	28.00	1.51	28.00
1%	1.52	28.00	1.51	28.00	1.53	27.60	1.53	27.70
1.5%	1.53	27.80	1.5	28.00	1.52	27.90	1.51	27.90

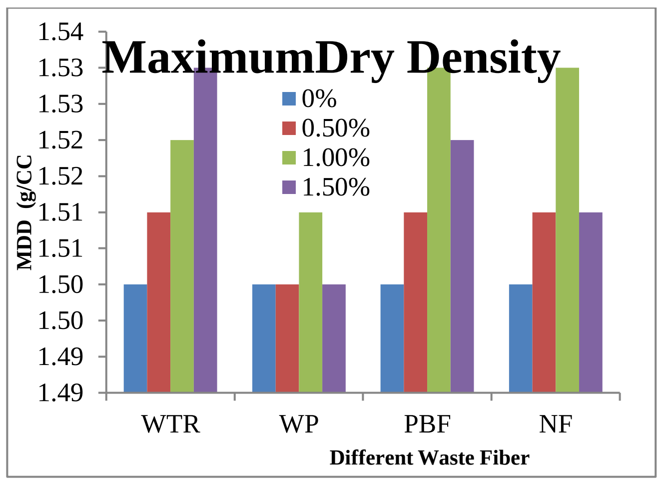

Fig 1 Variation of MDD with % Addition of Different Fiber

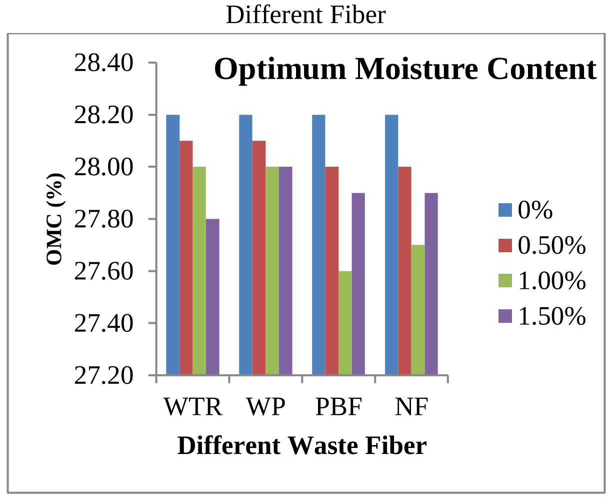

Fig 2 Variation of OMC with % Addition of Different Fibers

Figures 1, 2 shows summarized results for Compaction Properties. These all waste fibers are used as reinforcement for ES and FA Optimum mix from 0% to 1.5% with an increment of 0.5%. From above figures we can conclude that the OMC get reduced for WTR and WP with increase in Fiber content, where for PBF and NF up to 1.0% OMC get reduced, for 1.5% it's again raised. Coming to about MDD optimum MDD value is 1.53 g/cc for 1.0% as reinforcement for PBF and NF where at 1.5% for WTR. There is an improvement of in MDD about 2% compared to ES+FA optimum mix and 2.68% compared to virgin expansive soil.

Table 6: Variation of Shear Parameters

% of Fiber	WTR		WP		PBF		NF	
	C(kPa)	Φ 0	C(kPa)	Φ 0	C(kPa)	Φ 0	C(kPa)	Φ 0
0%	66	1	66	1	66	1	66	1
0.5 %	69	2	68	1	70	2	71	2
1.0 %	72	4	70	3	74	4	76	5
1.5 %	70	2	68	1	71	3	73	3

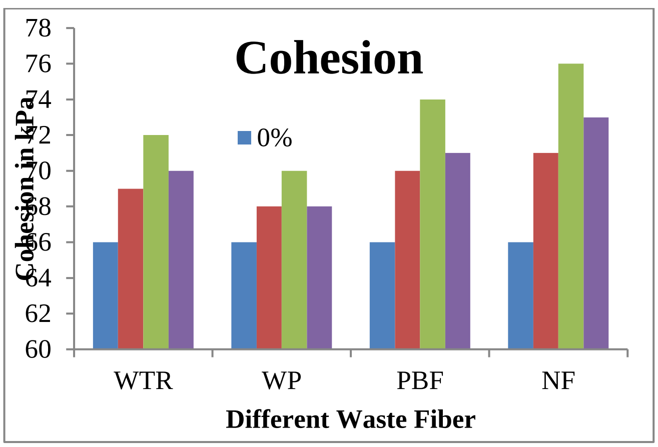

Fig 3 Variation of Cohesion with % Addition of Different Fibers

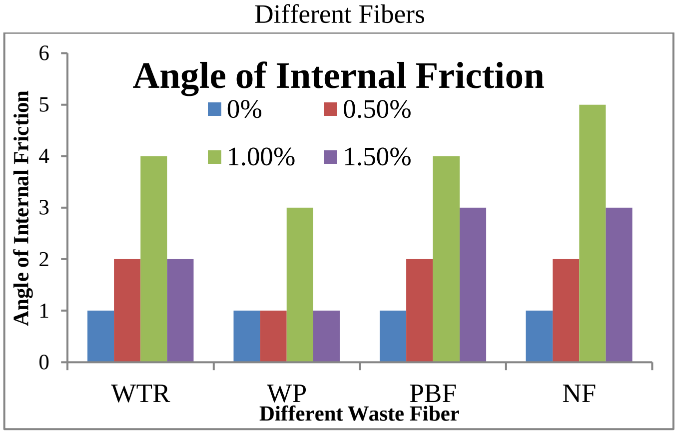

Fig 4 Variation of Angle of Internal Friction with % Addition of Different Fibers

Figures 3, 4 shows summarized results of shear parameters. These all waste fibers are used as reinforcement for ES and FA Optimum mix from 0% to 1.5% with an increment of 0.5%. From above figures we can conclude that the both properties get increased for all type of fibers up to 1.0% as reinforcement. For Nylon fiber we obtain best value in cohesion of 76kPa and is about 15.15% compared to ES+FA optimum mix and 31.03% compared to virgin expansive soil. Angle of internal friction also increased about 400% compared to ES+FA optimum mix and 500% compared to virgin expansive soil for Nylon Fiber.

Table 7: Variation of CBR Values

% of Fiber	WTR		WP		PBF		NF	
	US	*S*	*US*	*S*	*US*	*S*	*US*	*S*
0%	2.92	2.35	2.92	2.35	2.92	2.35	2.92	2.35
0.50 %	3.14	2.41	3.04	2.39	3.2	2.47	3.25	2.52
1.00 %	3.30	2.50	3.16	2.43	3.41	2.62	3.60	2.69
1.50 %	3.18	2.40	3.08	2.39	3.23	2.51	3.34	2.54

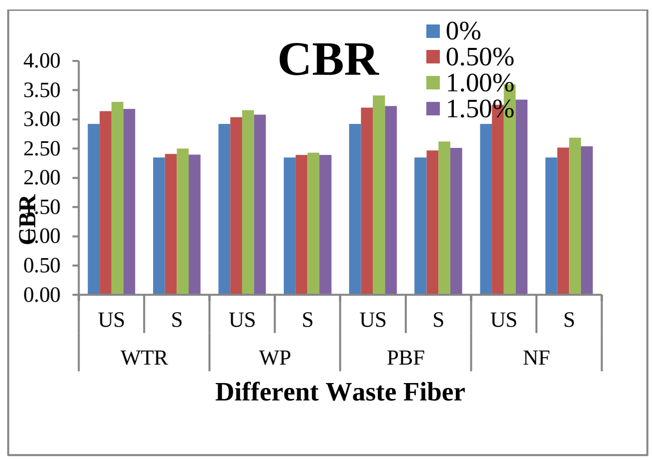

Fig 5 Variation of Unsoaked & Soaked with % Addition of Different Fibres.

Figure 5 shows the summarized results of CBR for all fibers. These all waste fibers are used as reinforcement for ES and FA Optimum mix from 0% to 1.5% with an increment of 0.5%. From above figures we can conclude that the both unsoaked and soaked values get increased for all type of fibers up to 1.0% as reinforcement. For Nylon fiber we obtain best value in unsoaked condition of 3.60 and is about 23.28% compared to ES+FA optimum mix and 33.33% compared to virgin expansive soil. CBR in soaked condition also increased about 14.46% compared to ES+FA optimum mix and 48.61% compared to virgin expansive soil for Nylon Fiber. From the above results the 1% addition of Fiber to 20 % replacement of Fly Ash (FA) in Expansive soil can be considered.

Table 8: Variation of shear and penetration parameters for different curing periods

Curing Period (Days)	Samples with optimum % of fibre dosage i.e. 1% NF and for 6% & 9% Lime Content							
	C (kPa)		ϕ' - (Degrees)		CBR -US (%)		CBR - S (%)	
	6% Lime	9% Lime	6% Lime	9% Lime	6% Lime	9% Lime	6% Lime	9% Lime
0	96	99	8	8	5.86	6.15	5.2	5.95
7	104	107	9	10	6.72	6.9	6.13	6.56
14	109	114	10	11	7.23	7.45	7.18	7.5
28	117	122	12	14	8.11	8.4	8.03	8.28

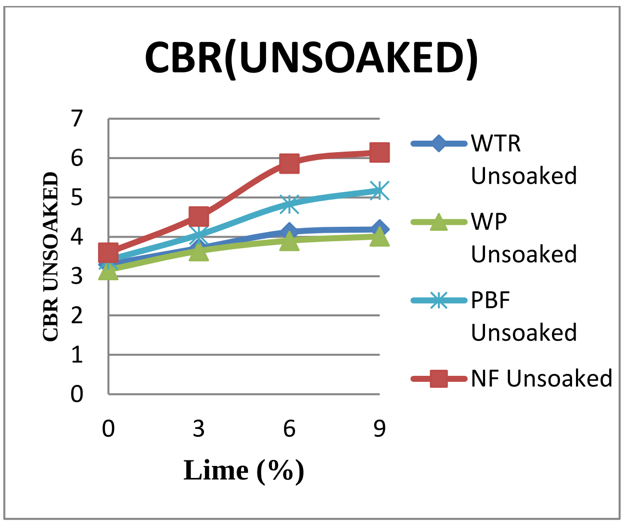

Fig 6 Variation of CBR with % Addition of LIME

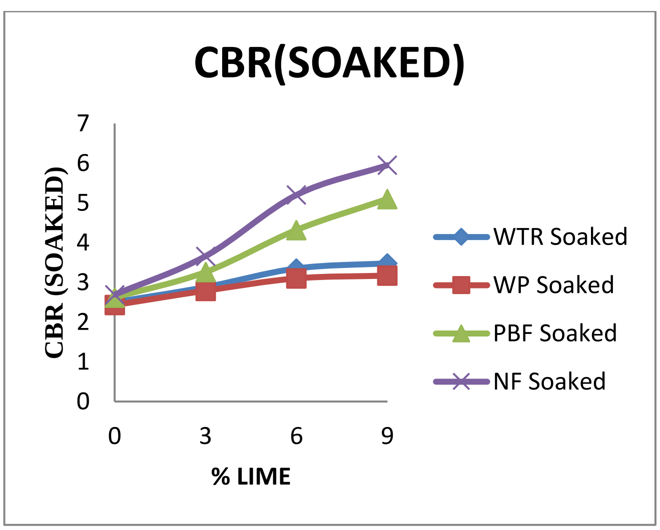

Fig 7 Variation of CBR with % Addition of LIME

6.9 Variation Of Cbr Values For Different Percentage Of Lime With 1% Addition Of Fiber To 20 % Replacement Of Fly Ash (Fa) In Expansive Soil

Table 8, Figures 6 to 7 shows the variation of CBR Values of Unsoaked and soaked conditions for Waste Tire Rubber (WTR), Waste Plastic (WP), Pet Bottle Fiber (PBF) and Nylon Fiber (NF) with Lime. Lime is used as binder for ES and FA Optimum mix from 0% to 9% with an increment of 3%. From above figures we can conclude that the both unsoaked and soaked values get increased for 6% to 9% Lime. For Nylon fiber we obtain best value in unsoaked condition of 6.15 for 9% lime and 5.85 for 6% lime.. CBR in soaked condition also increased and obtained a value of 5.95 for 9% lime and 5.2 for 6% lime.

DURABILITY STUDIES - (CURING)

Table 9: Variation of shear and penetration parameters for different curing periods

Curing period in days	C (kPa)		ϕ' - (Degrees)		CBR -US (%)		CBR - S (%)	
	6% Lime	9% Lime	6% Lime	9% Lime	6% Lime	9% Lime	6% Lime	9% Lime
0	96	99	8	8	5.86	6.15	5.2	5.95
7	104	107	9	10	6.72	6.9	6.13	6.56
14	109	114	10	11	7.23	7.45	7.18	7.5
28	117	122	12	14	8.11	8.4	8.03	8.28

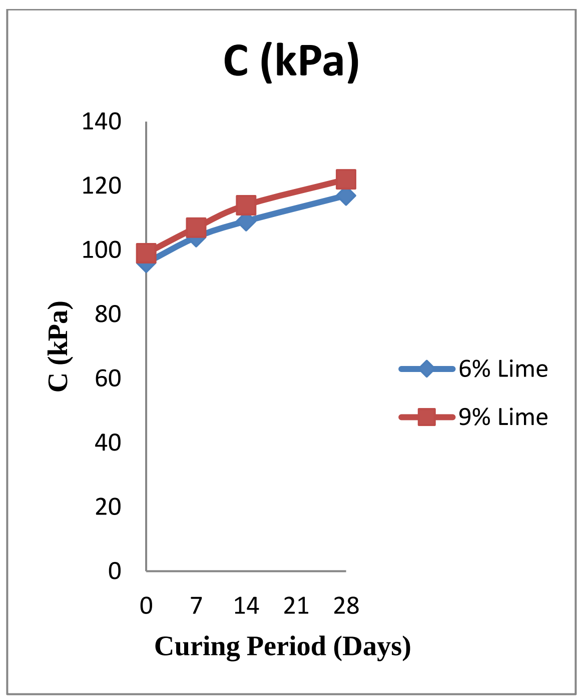

Fig 8 Variation of COHESION with Curing periods

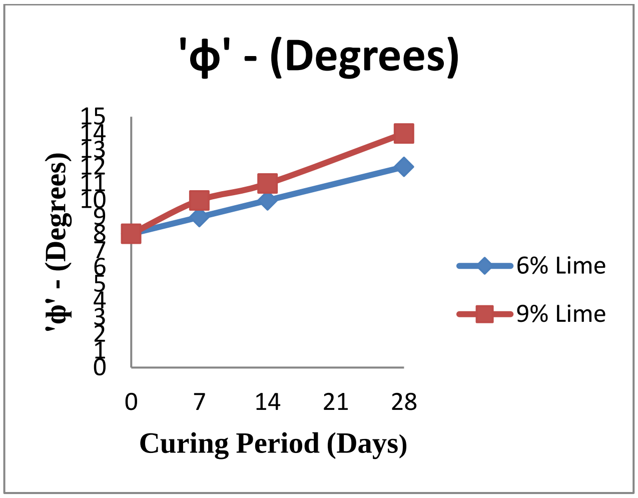

Fig 9 Variation of 'ϕ' - (Degrees) with Curing periods

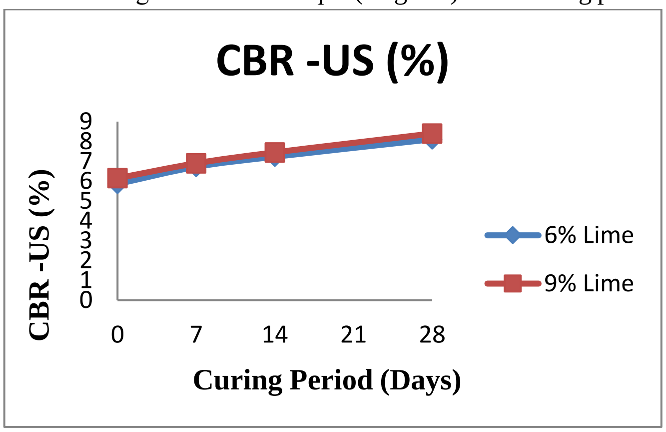

Fig 10 Variation of CBR with Curing periods

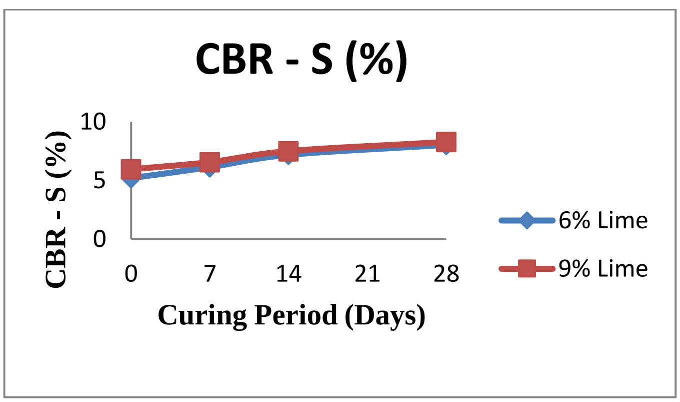

Fig 11 Variation of CBR with Curing periods

6.10 Variation Of Shear And Penetration Parameters For Different Curing Periods With Optimum % Of Fibre Dosage I.E. 1% Nf And For 6% & 9% Lime Content

Table 9, Figures 8, 9, 10, and 11 shows the variation of cohesion, angle of internal friction, CBR (US) and CBR(S) For Different Curing Periods With 6% and 9% Lime respectively. From above figures we can conclude that the cohesion, angle of internal friction and both unsoaked and soaked values get increased for increment of Curing periods

V. CONCLUSIONS

- There is a gradual increase in maximum dry density with an increment in the % of all type of fibres to the optimum mix of ES+FA an improvement of about 2%.
- There is an improvement in shear parameters about 15.15% for cohesion and 400% for angle of internal friction. This optimum increase of shear parameters are belongs to Nylon fibre.
- Among four waste fibres Nylon Fibre shows a good results in CBR for unsoaked and soaked conditions of about 23.28% and 14.46% respectively.
- Further lime is added to the optimum % of fibre dosage i.e. 1% NF to 20% fly ash stabilized expansive soil. Lime with 6%and 9% gives better results. In economical point of view 6% lime is taken in to consideration. And further durability studies are done for the Samples with optimum % of fibre dosage i.e. 1% NF and for 6% & 9% Lime Content and the graph shows increment of C & ϕ and CBR values with increment of curing periods.
- From above all discussions we can conclude that the all fibres show a prominent effect on properties of Expansive soil is replaced by 20% with Fly ash. Among them Nylon Fibre is best fibre to used as reinforcement for optimum mix of ES+FA and Lime.

Finally it can be summarized that the fibers WTR, WP, PBF and NF and Lime had shown promising influence on the properties of 80%Expansive soil + 20% Fly Ash, thereby giving a two-fold advantage in improving problematic expansive soil and also solving a problem of waste disposal.

REFERENCES

[1] Al-Rawas, A.A., Taha R., Nelson, J.D., Al-Shab, T.B. and Al-Siyabi, H.Geotechnical Testing Journal, Vol. 25, No. 2, pp. 199-209, 2002.

[2] Holtz, W.G. (1969): "Volume Change in Expansive Clay Soils and Control by lime Treatment". Proc. of 2nd Int. Research and Engg. Conf on expansive clayey soils, Texas A & M Press, Texas, pp. 157-174.

[3] Pramod K Stabilization of Black Cotton Soil Using Fly Ash And Geopolymer 2004.

[4] Vaibhav R. Dhawale black cotton soil stabilization by using fly ash, lime and nylon.

[5] Megnath Neopaney Stabilization of Soil by Using Plastic Wastes (March-2012)

[6] Dr. K.V Krishna Reddy stabilization of medium plastic clays using Industrial wastes M. NEERAJA.,, A Study on Black Cotton Soil-Shredded Rubber Tyre Chips.
[7] Lund, O.L and Ramsey, W.J.(1959): Experimental lime stabilization in Nebraska, bulletin 231, highway research board, Washington
[8] Lambe, T.W. and Whitman, R.V., Soil Mechanics, John Wiley and Sons Inc., New York, 1969