A Study on the Influence of Vitrified Polish Waste (VPW), Lime and Waste Plastic Inclusions (WPI) in Improving The Expansive Clays

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Abstract- *Soil is one of the most commonly encountered materials in civil engineering. All the structures except some, which are founded on solid rock, rest ultimately on soil. Geotechnical engineers all over the world face enormous problems, when the soils founding those structures are expansive in nature. This expansiveness is imparted to such soils when they contain clay minerals such as montmorillonite, Illite, Kaolinite etc. in appreciable quantity. It is due to them (clay minerals) that the expansive soils expand on wetting and are subjected to shrinkage on drying. Depending upon the use of expansive soils as foundation support or construction materials, their properties need careful studies to estimate their potential for damages based on volume change with reference to the imposed structural loads and the tolerance of structures for maximum settlement, differential settlement etc. Considering the requirement of the structural tolerance required, proper remedial measures are to be thought of for controlling the effect of expansive properties of the soil on the structure. Among several techniques adopted to overcome these problems posed by expansive soils, lime stabilization gained prominence during the past few decades due to its abundance and adaptability (Snethan et al, 1979). Various remedial measures had been practiced over years with varying degrees of success.*

The main objective of this experimental study is to improve the properties of the soil by adding a relatively new waste material vitrified Polish Material (VPW) which causes environmental pollution and also a binder, lime and different waste plastic inclusions. The soil properties with and without adding of these materials have been studied. An attempt has been made to use these waste materials for improving the strength and penetration values of soil which will also prove environment friendly. Thus, from this experimental study, a two-fold solution was evolved, i.e., improving a problematic soil and also solving a problem of waste disposal.

Keywords- expansive soil, vitrified polish waste, waste plastic, stabilization.

I. INTRODUCTION

Expansive soils are a worldwide problem that poses several challenges for civil engineers. They are considered a potential natural hazard, which can cause extensive damage to structures if not adequately treated. Such soils swell when given an access to water and shrink when they dry out (Al-Rawas et al. 2002). In general, expansive soils have high plasticity, and are relatively stiff or dense. The expansive nature of soil is most obvious near the ground surface where the profile is subjected to seasonal, environmental changes. The pore water pressure is initially negative and the deposit is generally unsaturated.

Transportation and Communication facilities are necessary f or any developing countries like India. The technology of road construction depends mainly upon the vehicular pattern, construction materials and sub grade condition. Sub grade is an integral part of the road pavement structure as it provides the support to the pavement from beneath. The main function of the sub grade is to provide adequate support to the pavement and for this the sub grade should possess sufficient stability under any adverse climate, loading and deformation loading conditions.

These soils often have some montmorillonite clay mineral present. The higher the amount of monovalent cations absorbed to the clay mineral (e.g. sodium), the more severe the expansive soil problem (Fredlund and Rahardjo, 1993). Expansive soils have been reported from many parts of the world, mainly in the arid or semi-arid regions of the tropical and temperate zones like Africa, Australia, India, South America, United States, and some regions in Canada. This never means that expansive soils do not exist elsewhere, because they can be found almost everywhere. However, in the humid regions water tables are generally at shallow depth and moisture changes, which are responsible for volume changes in soils, are minimal excepting under extended drought conditions (Arnold, 1984; Shuai and Fredlund, 1998;

Wayne et al. 1984). The problems with foundations on expansive soils have included heaving, cracking and break-up of pavements, roadways, building foundations, slab-on-grade members, channel and reservoir linings, irrigation systems, water lines, and sewer lines. In INDIA, these soils are generally called as black cotton soils and cover about 20% of the total land area. They are found in the states of Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra and Tamilnadu.

For a long time, we are facing problems like failures of small and big structures. The biggest problem behind this is swelling soil. This is very unstable soil. Its property varies from hard to soft and dry to wet. It exhibits swelling and shrinkage with different water content. As a result the many structures usually face excessive settlement and differential movements, which results in damage to foundation systems and structural elements. We are aware about this situation for a long time, but unable to make improvements due to absence of technologies till now. So now our main aim is to improve the properties of swelling soils.

PROBLEMS ASSOCIATED WITH EXPANSIVE SOILS

The swelling and shrinking properties of the soil depends on the water content of the soil. The water content of soil is considerably reduced during summer hence the soil becomes stiff and shrinkage cracks develop. During the rainy season the water content of the soil is increased resulting in swelling when a building is constructed on this type of soils, the soil below the building is protected from excess heat even during summer. This soil swells because its evaporation is obstructed. However the soil adjacent to the building which is open to atmosphere will experience normal swelling and shrinkage. Thus, the differential movements occur during the hot weather.

Because of this swelling and shrinking behaviour of soils,

- The floor slab of a building is pushed up, it takes a dome shape and cracks develop in the floor.
- The footing wall is pushed outward due to swelling.
- Cracks occur at the junction between the wall and the floor slab and also between the wall and roof slab because movements are restricted at these points.
- Cracking also occur at the corners of the window and door openings because of diagonal cracking of walls.
- Utilities buried in the soil like water pipes, sewage lines, gas lines, telephone lines… may be damaged.
- Pavements become uneven, rough and subject to cracks which affect the comfort of road users.

Construction of structures on this type of soil results in failure economically and structurally.

II. REVIEW OF LITERATURE

MANDEEP SINGH, ANUPAM MITTAL (29 MARCH 2014) observed that, solid waste materials such as rice husk ash and waste tyres are used for this intended purpose with or without lime or cement. Disposal of these waste materials is essential as these are causing hazardous effects on the environment. With the same intention literature review is undertaken on utilization of solid waste materials for the stabilization of soils and their performance is discussed. Soil stabilization means alteration of the soils properties to meet the specified engineering requirements. Methods for the stabilization are compaction and use of admixtures. Lime and Cement was commonly used as stabilizer for altering the properties of soils. Earth reinforcement techniques with commonly used with mild steel rods, geo synthetics etc.

TAPASH KUMAR ROY (APRIL 29-MAY 4TH 2013) investigated the benefits of using rice husk ash (RHA) with clayey soil as the subgrade material in flexible pavements with addition of small amount of lime. Four ratios of RHA of 5%, 10%, 15% and 20% mixed with the clayey soil by weight of soil sample. Further for getting the better performance, lime has been added in this study in the varying proportions from 1% to 3% by weight of soil. The compaction characteristics and unconfined compressive strength tests were conducted on these different mixed soils. The test results shows that the rice husk ash can be used advantageously with addition of clayey soil and lime as cost effective mix for construction of subgrade of the roadway pavement.

DR. D. KOTESWARA RAO , G.V.V. RAMESWARA RAO P.R.T. PRANAV (APRIL 29-MAY 4TH 2013) reported that The soil found in the ocean bed is classified as marine soil. It can even be located onshore as well. The properties of marine soil depend significantly on its initial conditions. The properties of saturated marine soil differ significantly from moist soil and dry soil. Marine clay is microcrystalline in nature and clay minerals like chlorite, kaolinite and illinite and non-clay minerals like quartz and feldspar are present in the soil. The soils have higher proportion of organic matters that acts as a cementing agent. Clay is an impermeable soil, meaning it holds water, as opposed to permeable soil that allows water to rapidly drain, like a gravel or sand. It is also an expansive soil, such as the marine clay which predominates in almost all countries of the world, which when shrinking or expanding, can damage foundations and structures. The shrink and swell movements are due to changes in soil moisture. Providing uniform soil moisture next to and under your foundation is the only best thing to reduce or minimize the damaging effects of expansive soil. Accumulation of various waste materials is now becoming a major concern to the environmentalists. Rice Husk ash is one such by-product from Timber industries and Wood cutting factories. Rice Husk ash by itself has little cementitious value but in the presence of moisture it reacts chemically and forms cementitious compounds and attributes to the improvement of strength and compressibility characteristics of soils. So in order to achieve both the need of improving the properties of marine clays and also to make use of the industrial wastes, the present experimental study has been taken up. In this paper the effect of Rice Husk ash and Lime on strength properties of marine clay has been studied.

LAXMIKANT YADU AND DR. R K TRIPATHY (2013) studied the effect of Granulated blast furnace slag and fly-ash stabilization on soft soil. The soil was classified as CI-MI as per Indian Standard Classification System. Different amount of GBS (3%, 6%, 9%, and 12%) and fly ash (3%, 6%, 9%, 12%) was mixed to the parent soil and both UCS and CBR are carried out. They found that there was an increase in maximum dry density but decrease in Optimum Moisture Content with increasing GBS content. Addition of GBS increased the UCS value and this increase was maximum up to 9% and then it started falling. In case of both soaked and unsoaked CBR samples, addition of GBS caused sharp increase in CBR value and it is maximum up to 6%. Hence they found out 3% fly ash + 6% GBS mix to be optimum.

AKINMUSURU (1991) put his effort in finding out the effect of mixing of GGBS on the consistency, compaction characteristics and strength of lateritic soil. GGBS content varied from 0% -15% by dry soil weight. He observed a decrease in both the liquid and plastic limits and an increase in plasticity index with increasing GGBS portion. Further, he observed that the compaction, cohesion and CBR increased with increasing the GGBS content up to 10% and then subsequently decreased. The angle of friction was to be decreased with increasing percentage of GGBS.

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

CHEMICAL STABILIZATION:-

Chemical stabilization includes the use of chemicals and emulsions as compaction aids to soils, as binders and water repellents, and as a means of modifying the behavior of clay. It also includes deep mixing and grouting. Chemical stabilization can aid in dust control on roads and highways, particularly unpaved roads, in water erosion control, and in fixation and leaching control of waste and recycled materials. Under this category, soil stabilization depends mainly on chemical reactions between stabilizer (cementitious material) and soil minerals (pozzolanic materials) to achieve the desired effect. A chemical stabilization method is the fundamental of this review and, therefore, throughout the rest of this report, the term soil stabilization will mean chemical stabilization.
The following chemicals have been successfully used:

- Calcium Chloride
- Sodium Chloride
- Sodium Silicate
- Polymers
- Chrome Lignin
- Other chemicals

MATERIALS USED

Properties of soil sample

The marine clay used in this study was obtained from Kakinada Seaports Limited, Kakinada, collected at a depth of 1.0m from ground level. The Index & Engineering properties of marine clay are determined as per IS code of practice and presented in table

Vitrified Polish Waste (VPW)

Vitrified tiles manufacturing units are the largest growing industry to meet the requirement of tiles across the globe. Vitrified tiles have far superior properties compared to natural stones and other man made tiles. Available Vitrified Polish Waste from the RAK Ceramics, Samarlakot, East Godavari Dist., A.P., India.

Waste plastic:-

From the date of birth, plastic waste plastic is concerned in society mainly because of the use of plastic in packaging; disposable packaging material produced large amounts of waste, especially plastic bags, bottles. But plastic is one of the major toxic pollutants today. Plastic is a non-biodegradable substance, composed of toxic chemicals, plastic pollutes earth, air and water. Plastic causes serious damage to environment both during its production and disposal.

Pieces of polythene bags which may be cut into standard dimensions of Waste Plastic Inclusions (WPI) (2 mm wide and 50 mm long) are cut into discrete fibres and used in the project.

IV. RESULTS AND DISCUSSIONS

Details of the laboratory experimentation carried-out with different combinations of materials have been discussed in the previous chapter. In this chapter a detailed discussion on the results obtained from various laboratory tests done on untreated and treated expansive soil are presented.

In the laboratory, various experiments were conducted by replacing different percentages of Vitrified Polish Waste (VPW) in the expansive soil and also further stabilizing it with lime as a binder and further reinforced with waste plastic inclusions. Compaction, Strength and CBR tests were conducted with a view to determine the optimum combination of Vitrified Polish Waste (VPW) as replacement in expansive soil and Lime as a binder and waste plastic as reinforcing inclusions.

The influence of the above said materials on the Compaction and Strength characteristics were discussed in following sections. In the laboratory, all the tests were conducted per IS codes of practice.

Table 4.1: Variation of properties of soil for the different percentages of VPW in the expansive soil

VPW (%)	DFSI (%)	LL (%)	PL (%)	PI (%)	MDD (g/cc)	OMC (%)	CBR (US) (%)	CBR (S) (%)	UCS (kPa)
0	101	68.6	25.2	43.4	1.45	27.9	3.3	1.5	82
10	95	64.4	26.1	38.3	1.47	27.4	3.7	1.8	87
20	88	62.1	26.9	35.2	1.49	27.1	4.1	2.3	99
30	80	61.8	27.2	34.6	1.48	27	4.1	2.2	96
40	76	61.5	27.7	33.8	1.46	26.8	4	2.2	95

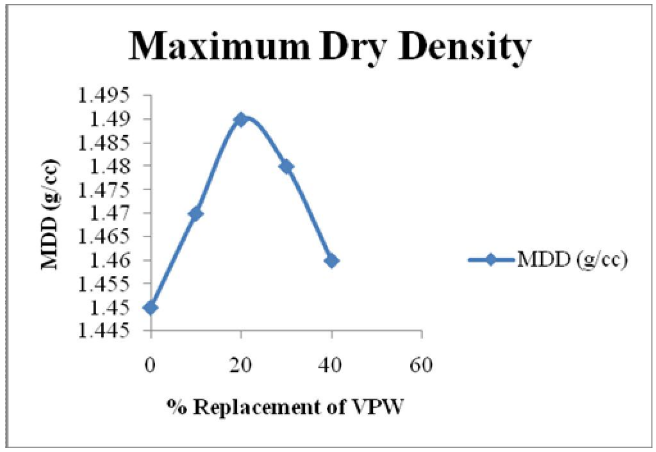

Fig 4.1 Variation of MDD with % Replacement of Vitrified Polish Waste (VPW)

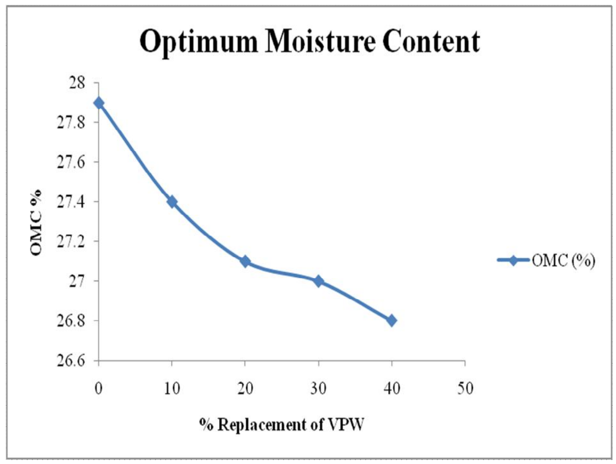

Fig 4.2 Variation of OMC with % Replacement of Vitrified Polish Waste (VPW)

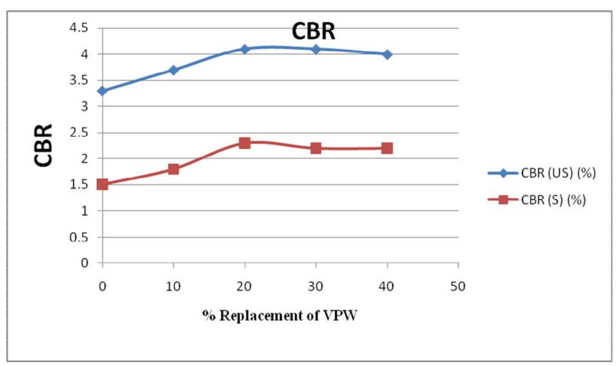

Fig 4.3 Variation of CBR with % Replacement of VPW

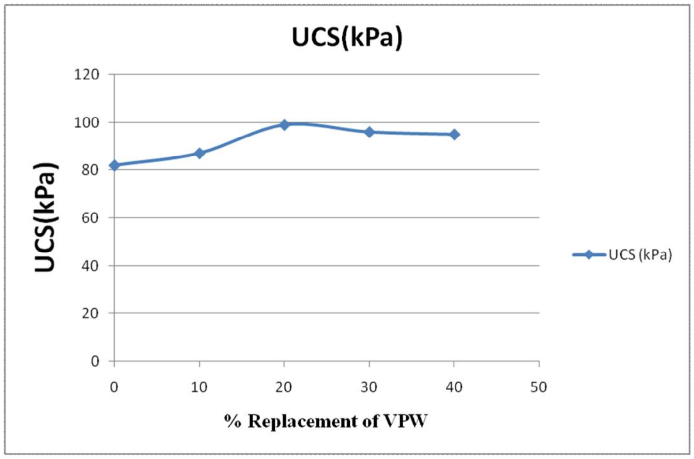

Fig 4.4 Variation of UCS with % Replacement of Vitrified Polish Waste (VPW)

It can be inferred from the graphs, that there is a gradual increase in SOIL PROPERTIES With percentage replacement of Vitrified Polish Waste (VPW). From the above results the 20% replacement of Expansive Soil with VPW can be considered as optimum.

Table 4.2: Evaluating the Optimum Content of Lime Content with 20% VPW as replacement

Lime (%)	DFSI (%)	LL (%)	PL (%)	PI (%)	MDD (g/cc)	OMC (%)	CBR (US) (%)	CBR (S) (%)	UCS (kPa)
0	88	62.1	26.9	35.2	1.49	27.1	4.1	2.3	99
2	67	55.8	29.1	26.7	1.51	27.5	5.5	4.6	124
4	55	47.4	31.1	16.3	1.54	27.7	7.2	5.4	148
6	42	43.1	33.6	9.5	1.59	27.9	8.6	6.7	172

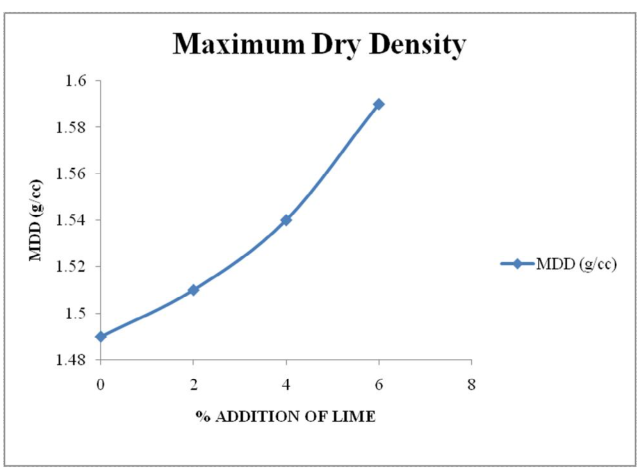

Fig 4.5 Variation of MDD with % Addition of LIME

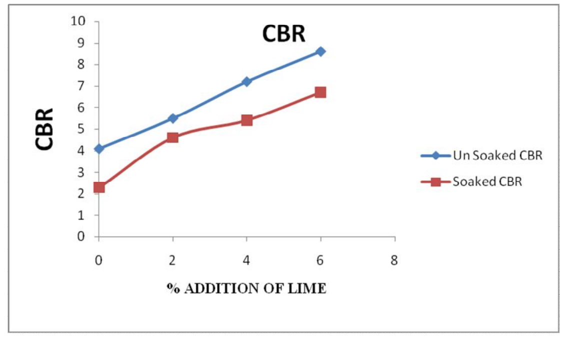

Fig 4.6 Variation of CBR VALUES with % Addition of LIME

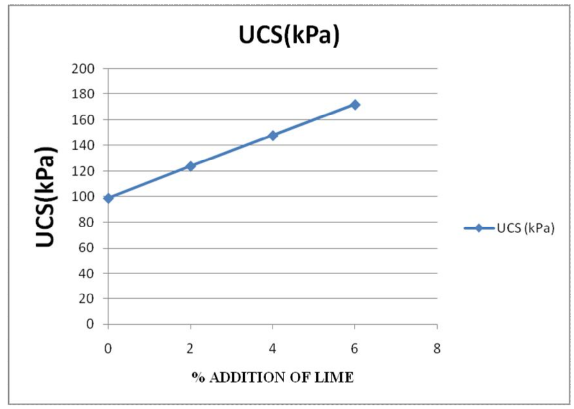

Fig 4.7 Variation of UCS with % Addition of LIME

It can be inferred from the graphs, that there is a gradual increase in SOIL PROPERTIES With percentage replacement of Vitrified Polish Waste (VPW) and percentage addition of lime. From the above results the Optimum Content of Lime with 20% VPW as replacement of Expansive Soil is 6%.

Further different waste plastic inclusions were added to the Vitrified Polish Waste (VPW) treated expansive soil with an optimum percentage of lime i.e. 6% and the studies was done**.**

Table: 4.3 Evaluating the Optimum Content of Waste Plastic Inclusions (WPI) with 20% VPW as replacement + 6% Lime Content

WPI (%)	MDD (g/cc)	OMC (%)	CBR (US) (%)	CBR (S) (%)	UCS (kPa)
0	1.59	27.9	8.6	6.7	172
0.5	1.58	27.8	9	7.1	194
1	1.59	27.7	9.6	8.3	218
1.5	1.57	27.8	9.3	7.9	206
2	1.56	27.8	8.9	7.7	197

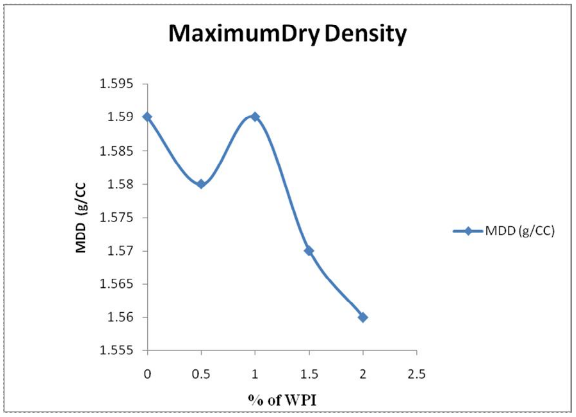

Fig 4.8 Variation of MDD with % of different waste plastic inclusions

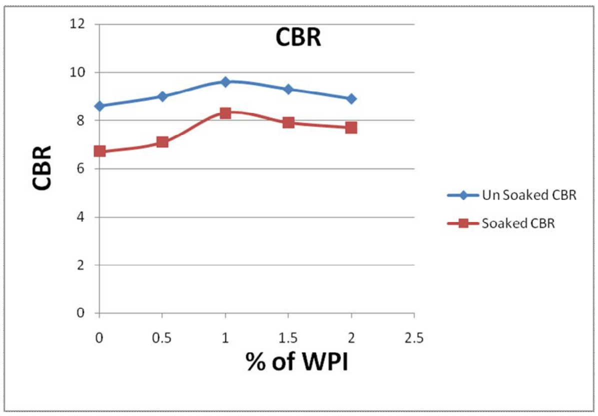

Fig 4.9 Variation of CBR with % of different waste plastic inclusions

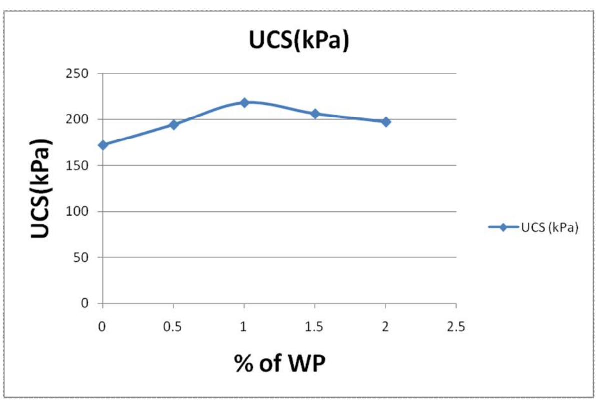

Fig 4.10 Variation of CBR with % of different waste plastic inclusions

Finally from the above discussions, From the above results the Optimum Content of WPI with 6% Lime + 20% VPW as replacement of Expansive Soil is 1.0%. it is clear that there is improvement in the behavior of Expansive soil stabilized with Vitrified Tile Sludge (VTS) + LIME +WPI. It is evident that the addition of Vitrified Tile sludge (VTS) to the virgin Expansive soil showed an improvement in Compaction and Strength characteristics to some extent and on further addition of lime shows a prominent results and further blending it with discrete waste plastic inclusions, the improvement was more pronounced. This made the problematic expansive soil which if not stabilized is a discarded material, a useful fill material with better properties. The Vitrified Tile Sludge (VTS) replacement in the expansive soil has improved its strength and upon further blending with WPI, the strength has further improved and also these materials has imparted friction to the clayey soil. It can be summarized that the materials Vitrified Tile Sludge (VTS), LIME and WPI had shown promising influence on the Strength and Penetration properties of expansive soil.

4. DURABILITY STUDIES - (CURING)

Durability Studies (Curing) on samples prepared with 1.0% WPI + 6% Lime + 20%VPW as replacement of Expansive Soil

Table 4.4: Variation of strength and penetration parameters for different curing periods

Curing Period (Days)	CBR (US) (%)	CBR (S) (%)	UCS (kPa)
0	9.6	8.3	218
7	10.4	9.2	235
14	11.7	10.1	263
28	12.2	10.5	276

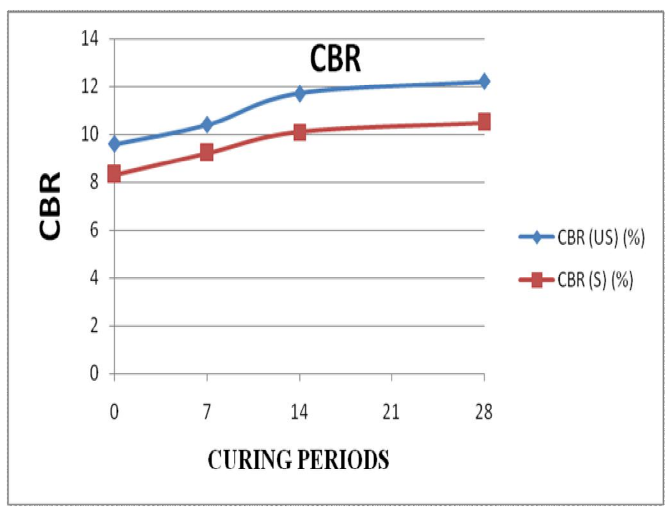

Fig 4.11 Variation of COHESION with different Curing period

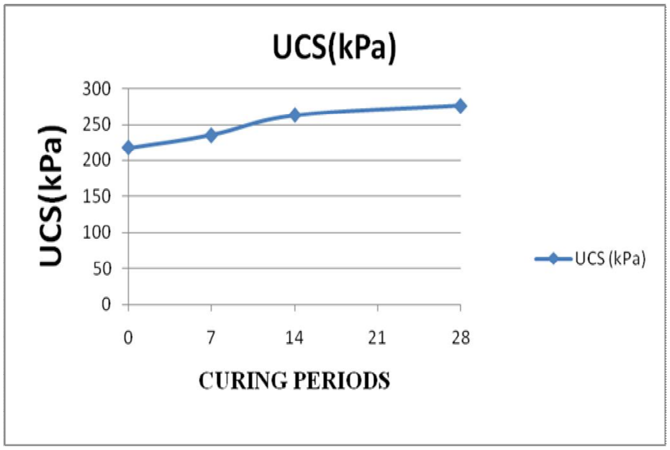

Fig 4.12 Variation of UCS VALUES with different Curing periods

4.9 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

Variation of UCS VALUES, CBR (US) and CBR(S) For Different Curing Periods With 6% 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

The following conclusions are made based on the laboratory experiments carried out in this investigation.

- From the laboratory studies, it is observed that the Expansive Soil chosen was a problematic soil having high swelling, and high plasticity characteristics.
- It was observed that the treatment as individually with 20% VPW has moderately improved the expansive soil.
- There is a gradual increase in maximum dry density with an increment in the % replacement of VPW up to 40% with an improvement of about 10% and it is observed that for the replacement of 20% there is gradual increase in Maximum dry density about 2.75%.
- There is an improvement in maximum dry density and also corresponding strength characteristics with an increase in the lime content from 0% to 6% with an increment of 2%.There is an improvement of 191.5% In CBR and 73.7% in UCS values.
- Further blending with different waste plastics with 0% to 2% with an increment of 0.5% there is increment of CBR and UCS values is about 23% and 26.7% respectively.
- Durability Studies (Curing) on samples prepared with 1.0% WPI + 6% Lime + 20%VPW as replacement of Expansive Soil graph shows increment of CBR and UCS values with increment of curing periods.
- It is evident that the addition of Vitrified Polish Waste (VPW) to the virgin Expansive soil showed an improvement in compaction, strength and penetration characteristics to some extent and on further blending it with lime and waste plastic inclusions the strength mobilization was more pronounced.
- Finally it can be summarized that the materials Vitrified Polish Waste (VPW) and lime and different waste plastic inclusions had shown promising influence on the strength characteristics of expansive soil, thereby giving a two-fold advantage in improving problematic expansive soil and also solving a problem of waste disposal.

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