Role of Waste Tyre Rubber Inclusion in Improving the Properties of Vitrified Tile Sludge Stabilized Expansive Soil

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Abstract- *Infrastructure projects such as highways, railways, water reservoirs, reclamation etc. requires earth material in very large quantity. For centuries mankind was wondering at the instability of earth materials, especially expansive soil. Quite often, large areas are covered with highly plastic and expansive soil, which is not suitable for such purpose. 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. Extensive laboratory / field trials have been carried out by various researchers and had shown promising results for application of such expansive soil after stabilization with additives such as sand, silt, lime, fly ash, etc. A relatively new solid waste, Vitrified Tile Sludge (VTS), a by-product from Vitrified Tile Industry, can be used for stabilization of expansive soils for various uses. In combination with waste tyre rubber. The present study was planned to access the role of waste tyre rubber inclusions in improving the weak expansive soil besides stabilizing it with Vitrified tile sludge in different proportions.*

Keywords- Engineering properties, Expansive soil, Stabilization, Vitrified Tile Sludge, Waste Tyre Rubber.

I. INTRODUCTION

In India, the area covered by expansive soils is nearly 35% of the total area. They normally spread over a depth of 2 to 20m. In Rainy season, structures on this soils experience large-scale damage due to heaving accompanied by long strength, where as in summer season, they shrink and gain density and become hard. Their alternative swelling & shrinkage damages structure severely. This is severe for lightly loaded structures.

The deformations produced as a result of swelling or shrinkage is significantly greater than elastic deformation and classical elastic or plastic theory cannot predict them. During summer, Polygonal Shrinkage Cracks appear at surface, which may extend to a depth of about 2m indicating the active zone in which volume change occurs. Because of the swelling of black cotton soils during rainy season & their shrinkage during summer, extensive damages have been carved such as “Building Cracks”, canal Landslides, healing & rutting of pavements, damage to conduits etc. Soil is a natural body consisting of layers that are primarily composed of minerals which differ from their parent materials in their texture, structure, consistency, colour, chemical, biological and other characteristics. It is the unconsolidated or loose covering of fine rock particles that covers the surface of the earth. Soil is the end product of the influence of the climate (temperature, precipitation), relief (slope), organisms (flora and fauna), parent materials (original minerals), and time. In engineering terms, soil is referred to as regolith, or loose rock material that lies above the 'solid geology'. In horticulture, the terms 'soil' is defined as the layer that contains organic material that influences and has been influenced by plant roots and may range in depth from centimetres to many metres. Soil is composed of particles of broken rock which have been altered by physical, chemical and biological processes that include weathering with associated erosion.

The experimental study is concerned with the selection of approximate type of soils to achieve a very high degree of compaction and to expose the compaction properties of clay. The clayey soils are difficult to compact in the initial stages of compaction, but as the moisture content increases the compaction becomes quite easy. The results of the study can provide thoughts for applying clay soil in various applications of soil stabilization process.

II. LITERATURE RIEVIEW

The history of the study of soil is intimately tied to our urgent need to provide food for ourselves and forage for our animals. Throughout history, civilizations have prospered or declined as a function of the availability and productivity of their soils. The scientists who studied the soil in connection with agricultural practices had considered it mainly as a static substrate. However, soil is the result of evolution from more ancient geological materials. Other scientists later began to study soil genesis and as a result also soil types and classifications.

Extensive studies have been carried out on the stabilization of problematic soil (such as marine clay and swelling soil, etc.) using various additives such as lime, fly ash, and Fiber P. R. Modak et al. [1] studied stabilization of black cotton soil by using lime and Fly ash. BC soils are highly clayey soils. Seda et al. [2] had found that Sp and Ps reduced significantly by addition of small particles of waste tire rubber to expansive soil. Patil et al. [3] had studied the swell behavior of expansive soil by adding independently with stiff (silica sand) and flexible (granular tire rubber) granular material and found that with increase in additive materials and increase in surcharge stress the swell reduction increases. It was found, better swell reduction in stiff sand grains than flexible granulated tire rubber. Palaniappan and Stalin [4] had stabilized expansive soil using marble dust and were successful in improving different properties of expansive soil. Sabat and Nanda [5] had studied the effects of marble dust on strength and durability of rice husk ash stabilized expansive soil and found that addition of marble dust increased the strength, decreased the swelling pressure and made the soil-rice husk ash mixes durable. Koyuncu et al. [6] had stabilized Na –bentonite using ceramic tile dust and found that at 40% addition of ceramic tile dust waste, the PS and Sp were reduced by 86% and 57% respectively. Sabat [7] had stabilized expansive soil using waste ceramic dust. Ceramic dusts were added up to 30% and had found positive effects on index, strength and swelling properties. From the economic analysis it was found that ceramic dust up to 30% can be utilized for strengthening the subgrade of flexible pavement with a substantial save in cost of construction. Sabat and Bose [8] had studied the effects of ceramic dust on compaction properties, UCS, CBR, Ps and durability of fly ash-lime stabilized expansive soil. The optimum percentages of fly ash, lime and ceramic dust were found to be 10%, 5% and 35% respectively with improvement in strength, swelling and durability characteristics.

III. METHODOLOGY

Expansive Soil

The Clay that has been used in this study was a typical BC soil collected from Odalarevu near Amalapuram, East Godavari District. The soil used for the investigation was dried, pulverized and then sieved through 4.75mm size sieve. The properties of black cotton soil experimented, based on relevant I.S. code provisions are given in the Table 1 below.

Table 1 Physical properties of Black Cotton Soil

Laboratory Experimentation	Value
Specific gravity	2.72
Grain size distribution	
Sand(%)	03
Silt (%)	35
Clay(%)	62
Compaction Parameters	
Maximum Dry Density(g/cc)	1.52
O.M.C. (%)	28.8
Atterberg's limits	
Liquid limit (%)	66.4
Plastic limit (%)	23.5
Plasticity index(%)	42.9
IS classification	CH
Differential Free Swell (%)	105
CBR- Unsoaked	3.4
Soaked	1.6

Vitrified Tile Sludge –VTS

Vitrified Tiles are the latest and largest growing industry alternate for many tiling requirements across the globe with far superior properties compared to natural stones and other manmade tiles. India and China are the largest regions to contribute to the 6900 million square meters of production every year. With an annual growth rate of 20% worldwide and 25% in India, Vitrified tile is the fastest growing segment in the tile industry. Vitrified tiles own 12% share of the overall tile production across the world. With the increase in production of vitrified tiles in India, there is growing concern about the huge generation of tile polishing dust.. The raw material composition of Vitrified tiles is

- Quartz of 99% Silica,
- Potash Feldspar of 12% to 14% Alkalis,
- Soda Feldspar of 12% to 14% Alkalis,
- Strengthening agent, China clay, body stains for producing in various colors.

VTS is used as a stabilizing material which was collected from the RAK Ceramics, Samalkota. The physical properties of Vitrified Tile Sludge (VTS) are given in the Table 2 below.

Table 2 Physical properties of Vitrified Tile Sludge (VTS)

Laboratory Experimentation	Value
Specific gravity	2.46
Grain size distribution	
Medium sand (%)	1.43
Fine sand (%)	97.5
Silt &clay(%)	1.07
Compaction properties	
MDD (g/cc)	1.58
OMC (%)	19.4

Waste Tyre Rubber – WTR

Scrap vehicle tyres make a significant contribution to the generation of waste. For instance, the rate of scrap tyre generation in industrialized countries is approximately one passenger car tyre equivalent (PTE, or 9 kg) per capita per year. Furthermore, it is estimated that an additional 2-3 billion scrap tyres are stockpiled on unregulated or abandoned piles throughout the US. For EU Member States, it is reasonable to assume illegal or semi-legal scrap tyre accumulation in the same order of magnitude.

Table 3 Physical properties of Waste Tyre Rubber

Properties	Measured value
Specific gravity	0.94
Unit weight g/cm3	0.69
Absorption %	1.8
Fineness modulus	3.78

IV. RESULTS AND DISCUSSION

In the laboratory, various experiments were conducted by replacing different percentages of Vitrified Tile sludge (VTS) in the expansive soil and also further stabilizing it with Waste tyre rubber as a binder. Compaction, Strength and CBR tests were conducted with a view to determine the optimum combination of Vitrified Tile Rubber (VTS) as replacement in expansive soil and waste tyre rubber as a binder.

Effect of % Vitrified Tile Sludge (VTS) as Replacement on the Strength Characteristics of Expansive Soil The individual influence of Vitrified Tile Sludge (VTS) on the Compaction and Strength characteristics of expansive soil are clearly presented in Chart.1. The percentage of Vitrified Tyre sludge (VTS) was varied from 0% to 25% with an increment of 5%. From the above graphs, it was observed that the treatment as individually with 25% VTS has moderately improved the expansive soil. It can be inferred that there is a gradual increase in maximum dry density with an increment in the % replacement of VTS up to 25% with an improvement of about 2% and it was about 25% for strength characteristics. The addition of VTS had mobilized little amount of friction to the pure Clayey soil without friction.

Table 4 Showing the test results conducted on expansive soil replaced with different % of vitrified tile sludge

ES+VTS	MDD	OMC	DFS	C	Ø
100+0	1.50	30.4	160	52	0^0
95+5	1.51	30.6	136	58	0^0
90+10	1.53	30.3	115	67	1^0
85+15	1.56	29.8	101	81	3^0
80+20	1.55	29.6	84	80	3^0
75+25	1.54	29.4	59	77	2^0

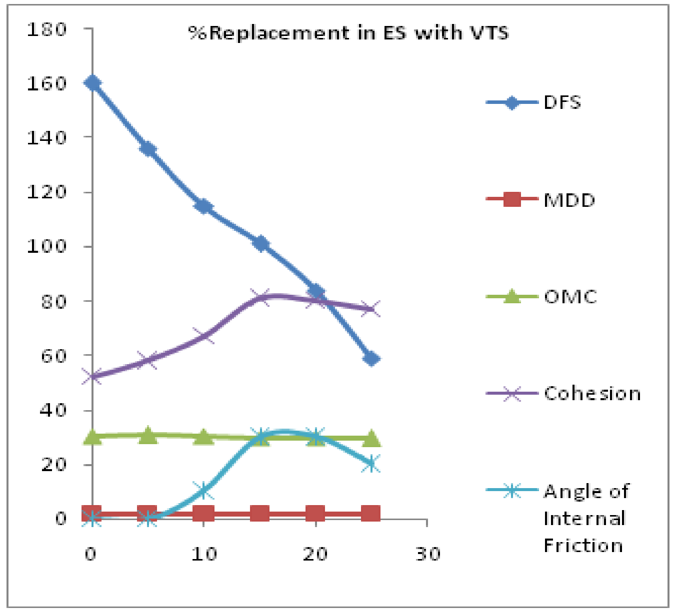

Chart 1 Plot showing the variation of Various Properties with % of Vitrified Tile Sludge as replacement in Expansive soil.

Effect of Waste Tyre Rubber Content on the Strength Characteristics of Expansive Soil + Vitrified Tile Sludge (VTS) Mixes

The influence of Waste tyre rubber as binder on the Compaction and Strength characteristics of expansive soil + Vitrified Tile Sludge (VTS) mixes are clearly presented in Chart.2 for different percentages of Waste tyre rubber respectively. The percentage of WTR was varied from 0% to 1.5% with an increment of 0.5%.In the laboratory, tests were conducted by blending different percentages of WTR to expansive soil + Vitrified Tile sludge (VTS) mixes with a view to determine its optimum blend. It is observed from the graphs, that there is an improvement in maximum dry density and also corresponding strength characteristics with an increase in the waste tyre rubber content from 0% to 1.5% with an improvement of 126% for cohesion, 8 times for friction angle and about 3 times for soaked CBR respectively. From the above results it is evident that the addition of waste tyre rubber to the VTS–Expansive soil mix had improved its Compaction and Strength characteristics.

Finally from the above discussions, it is clear that there is improvement in the behavior of Expansive soil stabilized with Vitrified Tile Sludge (VTS) + Waste tyre rubber. 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 blending it with WTR, 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 WTR, 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) and Waste tyre rubber had shown promising influence on the Strength and Penetration properties of expansive soil.

Table 5 Showing the results of the tests conducted on Waste Tyre Rubber inclusions in optimum mix of expansive soil & vitrified tile sludge.

ES + VTS+ WTR	MDD	OMC	C	Ø	Un Soaked	Soaked
0	1.56	29.8	81	3^0	3.61	2.75
0.5	1.56	29.5	84	4^0	3.63	2.77
1.0	1.57	29.1	92	6^0	4.88	3.12
1.5	1.55	29.0	90	5^0	4.81	3.09

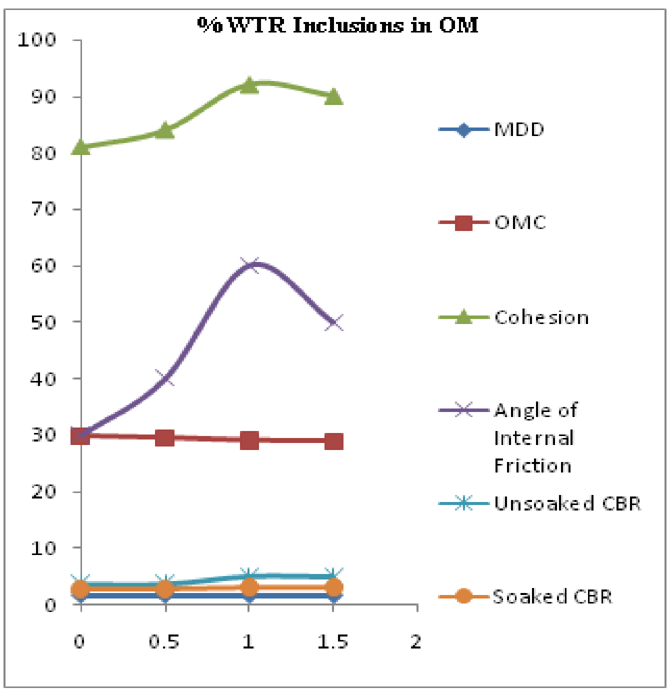

Chart 2 Plot showing the variation of Various Properties with % of waste tyre rubber in optimum mix of expansive soil & vitrified tile sludge.

V. CONCLUSION

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 25% VTS has moderately improved the expansive soil.
- There is a gradual increase in maximum dry density with an increment in the % replacement of VTS up to 25% with an improvement of about 2% and it was about 25% for strength characteristics.
- There is an improvement in maximum dry density and also corresponding strength characteristics with an increase in the WTR content from 0% to 1.5% with an improvement of 126% for cohesion, 8 times for friction angle and about 3 times for soaked CBR respectively.
- It is evident that the addition of Vitrified Tile sludge (VTS) to the virgin Expansive soil showed an improvement in compaction, strength and penetration characteristics to some extent and on further blending it with WTR, the strength mobilization was more pronounced.

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