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Strength Behaviour of Expansive Soil Treated with Tile Waste

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Abstract:- The amount of wastes has increased year by year and the disposal becomes a serious problem. This paper presents the effects of tile waste on, liquid limit, plastic limit, compaction characteristics, California Bearing Ratio and swelling pressure of an expansive soil. The expansive soil collected locally was mixed with tile waste from 0 to 30% at an increment of 10%. From the analysis of test results it was found that, liquid limit, plastic limit, optimum moisture content, and swelling pressure are decreased, maximum dry density and California bearing ratio are increased with an increase in tile waste.

Keywords:- Expansive soil, Tile waste, California bearing ratio, swelling pressure

I. INTRODUCTION

Expansive soils are so widespread that it becomes impossible to avoid them for highway construction. Many highway agencies, private organizations and researches are doing extensive studies on waste materials and research projects concerning their feasibility and environmental suitability. Swelling of expansive soils causes serious problems and produces harm to many structures. Many research organizations are doing extensive work on waste materials concerning the viability and environmental suitability. Expansive clays are the most problematic soils due to their unique alternate swell-shrink behavior with fluctuations in moisture content. World over, many case studies [1-2] of failed structures built on expansive soils have been reported. The situation in India is also no different with extensive coverage of expansive soils that occupy almost one-fifth of the geographical land area [3]. It is an established fact that suitable site conditions are not available everywhere due to wide variations in the subsoil specially the presence of treacherous soils pose a challenge to the civil engineers. To put the infrastructure in position, there is no other-go but to improve the sub soil for expected loads and make them suitable for the type of construction planned. Further, it is to be stated that the road alignment is constrained due to accessibility and connectivity criteria, which invariably may encounter expansive soils enroute and hence it becomes imminent to improve their load carrying capacities due to traffic operations with suitable treatment to the in-situ soil in general and expansive soils in particular.

The earlier ceramics were pottery objects made from clay, either by itself or mixed with other materials, hardened in fire. Later ceramics were glazed and fired to create a colored, smooth surface. The potters used to make glazed tiles with clay; hence the tiles are called as “ceramic tiles”. The raw materials to form tile consist of clay minerals mined from the earth’s crust, natural minerals such as feldspar that are used to lower the firing temperature, and chemical additives for the shaping process. A lot of ceramic tiles wastage is produced during formation, transportation and placing of ceramic tiles. This wastage or scrap material is inorganic material and hazardous. 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 man made tiles. Hence its disposal is a problem which can be removed with the idea of utilizing it as an admixture to stabilization

From the results of [4]**,** addition of marble dust in expansive soil vary from 10% to 40% of dry weight of clay showed a increase in maximum dry density (MDD) from 1.72 g/cc to 1.86 g/cc and decrease in optimum moisture content (OMC) from 20.5% to 14.2%, differential free swell (DFS) of black-cotton soil is reduced from 66.6% to 20% and significant increase in soaked California Bearing Ratio (CBR) and Unconfined compressive Strength (UCS) values. Experimental program carried out by [5] in the laboratory to evaluate the effectiveness of using foundry sand and flyash with tile waste for soil stabilization by studying the compaction and strength characteristics for use as a subgrade material. The highest value of maximum dry density is achieved for clay-foundry sand-fly ash-tile waste mix of 54:36:10:2.25 followed by other proportions. The California bearing ratio value of clayey soil improved significantly i.e. from 2.43% to 7.35% with addition of foundry sand, flyash and tile waste in appropriate proportion. Thus, clayey soil stabilized with foundry sand, fly ash and tile waste can be used as a sub-grade material for construction of flexible pavements in rural roads with low traffic volume. [6], studied the effect of granite dust on the index properties of Black Cotton Soil stabilized with 5% lime and the test results showed liquid limit and plasticity index decreases from 37% to 28% and 17.45% to 4.80%, respectively if Black Cotton Soil is blended with 5% lime and granite dust from 0% to 30% by weight of Black Cotton Soil. With the increase in the granite dust percentage the liquid limit values decrease from 57% to 28%, plasticity index values decrease from 37.2% to 3.7%, differential free swell decreased drastically from 56.6% to 4.1%, shrinkage limit values increases from 8.15% to 18% with the increase in granite dust. [7], study the strengthening of marine clay used for foundation-beds by the influence of vitrified polish waste as an admixture. From the test results that the plasticity index improved by 38.65, liquid limit improved by 35.66%, Shrinkage Limit increased 65.80%, Maximum Dry Density improved by 16.99%, CBR. Increased by 187.3%, Cohesion improved by 27.34%, Angle of Internal Friction increased 50.68 and DFS value reduced by 66.66% on addition of 15% Vitrified Polish waste as an optimum when compared with the untreated marine clay. So finally it is concluded from the above results that the CBR value of VPW treated marine clay may be improved by using chemicals or reinforcement techniques to use as sub grade material for the pavement construction. [8] study of stabilization of Dune- Sand with Ceramic Tiles Wastage as admixture by conducting California Bearing Ratio, Standard Proctor Tests and Direct shear tests. From the test results M.D.D.increases on increasing the quantity of admixture (increment from 10% to 30%), increase in CBR values in both unsoaked and soaked conditions. Direct Shear Test, angle of internal friction increases with increase in size of ceramic tiles wastage and also increases with the quantity of the ceramic tiles wastage. [9] made an attempt for the performance assessment of vitrified Polish waste and granulated blast furnace slag in mitigating the problems of expansive soils by conducting index properties, compaction, CBR of expansive soil. When blended with the GGBS, there is a marginal improvement in the compaction parameters, while a considerable improvement was seen in the case of CBR value. Finally it can be concluded that the performance of the Vitrified Polish Waste (VPW) was more effective than Ground Granulated Blast Furnace Slag (GGBS) in improving the characteristics of problematic expansive soils. Addition of 0 to 30% ceramic dust in expansive soil results of [10], liquid limit, plastic limit and plasticity index, OMC goes on decreasing MDD, UCS and soaked CBR increasing with increase in percentage, , the swelling pressure decreasing with increase in percentage.

An ideal solution lies for reducing project cost, increasing longevity and reduce accumulation of waste shall be through utilization of industrial waste combined with weak soil for pavement construction. Few types of waste materials namely crusher dust, fly ash and tile waste are popular as admixtures in improving weak soils. From the available literature it is found that limited research has been done to study the effects of tile waste on different geotechnical properties of expansive soil. In the present study has been undertaken to investigate the effects of tile waste on index properties, compaction properties, soaked California Bearing Ratio (CBR) and swelling pressure of an expansive soil .The economy of stabilization has also been studied by strengthening the expansive soil subgrade of a flexible pavement.

II. MATERIALS AND THEIR PROPERTIES

Materials used in the experiments are Expansive soil and tile waste for this study.

Expansive Soil: The subgrade soil used in this study was a typical expansive block cotton soil collected from 'Tanuku, West Godavari District of Andhra Pradesh State, India. The properties of the expansive type of subgrade soil are given in Table1.

TABLE: 1 PHYSICAL AND ENGINEERING PROPERTIES OF BC SOIL

Properties of Expansive Soil	Value
Grain Size Distribution	
Gravel (> 4.75mm) (%)	10
Sand (4.75-0.0 75mm) (%)	85
Fines (<0.075mm) (%)	5
Coefficient of Uniformity (Cu)	13.33
Coefficient of Curvature (Cc)	5.2
Atterberg's Limits	
Liquid Limit (%)	68
Plastic Limit (%)	31.02
Plasticity Index (%)	36.98
Specific gravity	2.65
Compaction Properties	
Optimum Moisture Content (%)	23.95
Maximum Dry Density (kN/m^3)	15.5

Free swell index (%)	53
Soaked CBR (%)	2

Tile Waste: A ceramic tile is an inorganic, nonmetallic solid prepared by the action of heat and subsequent cooling. Ceramic materials may have crystalline or partly crystalline structure, or may be amorphous. The tile waste mainly consisting of 1.60% of Cao and 59.12% Silica. The physical properties are OMC-16.1%,MDD-21.34kN/m^3.

III. LABORATORY EXPERIMENTATION

Tiles waste was collected from a local industry Narayanapuram near Tanuku, Andhra Pradesh. These tiles were broken into small pieces by using a hammer. The smaller pieces were fed into a Los Angeles abrasion testing machines to make it further smaller. For conducting different tests, the expansive soil was mixed with the ceramic dust from 0 to 30% at an increment of 10%. In total 4 mixes were prepared. Liquid Limit tests, plastic limit tests, standard Proctor compaction tests, soaked CBR tests and swelling pressure tests were conducted on these mixes as per Indian Standard Codes for finding optimum percentage of tile waste material. The details of these tests are given in the following sections.

Index Properties

Standard procedures recommended in the respective I.S. Codes of practice [IS:2720 (Part-5)-1985; IS:2720 (Part-6)-1972],were followed while finding the Index properties viz. Liquid Limit and Plastic Limit of the samples tried in this investigation.

Compaction Properties

Optimum moisture content and maximum dry density of expansive soil with various percentages of tile waste were determined according to I.S heavy compaction test (IS: 2720 (Part VIII).

California Bearing Ratio (CBR) tests

Different samples were prepared in the similar lines for CBR test using treated and untreated expansive soil with tile waste. The CBR tests were conducted in the laboratory for all the samples as per I.S.Code (IS: 2720 (Part-16)-1979) as shown in the Fig.1.

Fig: 1 California Bearing Ratio Test Apparatus

Swell Pressure Tests

Different samples were prepared in the similar lines for swell pressure test using treated and untreated expansive soil with tile waste. The swell pressure tests were conducted in the laboratory for all the samples as per IS: 2720 (Part XL1) - 1977 as shown in the Fig.2.

Fig: 2 Swell Pressure Test Apparatus

IV. TEST RESULTS

Index Properties

The results of liquid limit tests on expansive soil treated with different percentage of tile waste can be seen that with increase in percentage of tile waste the liquid limit of soil goes on decreasing from 68% to 47%, when tile waste is increased from 0 to 20% is effective beyond also there is a reduction in liquid limit as shown in the fig.3.The results of plastic limit tests on expansive soil treated with different percentage of tile waste , it can be seen that with increase in percentage of tile waste, the plastic limit of soil goes on decreases from 31.02 % to 24.94 % when tile waste is increased from 0 to 20% as shown in fig.4.

Compaction: All the expansive soil samples were mixed with varying percentages of tile waste material by weight. From the test results maximum dry density increases from 15.5 kN/m^3 to 16.11 kN/m^3 at 20% of tile waste, beyond which it decreases as shown in fig.5. However water content continuously decreases as shown in the fig. 6.

California Bearing Ratio (CBR): The results of soaked CBR tests on expansive soil treated with different percentage of tile waste are shown in Fig. 7. From the results it can be seen that with increase in percentage of tile waste, the soaked CBR of soil goes on increasing from 2 to 4.1 when tile waste is increased from 0 to 20%. There is 105% increase in soaked CBR of soil at this percentage of tile waste as compared to untreated soil.

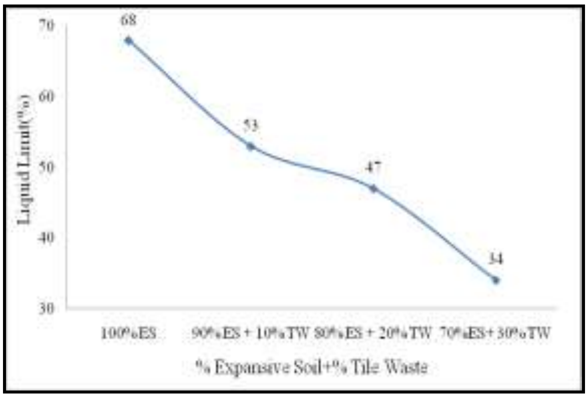

Fig 3: Variation of Liquid limit with percentage of Tile Waste

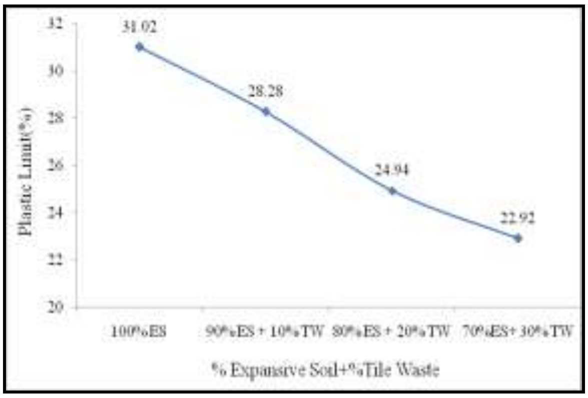

Fig 4: Variation of Plastic Limit with Percentage of Tile Waste

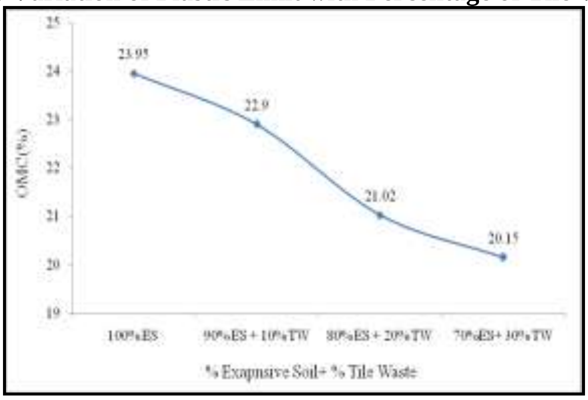

Fig 5: Variation of OMC with Percentage of Tile Waste

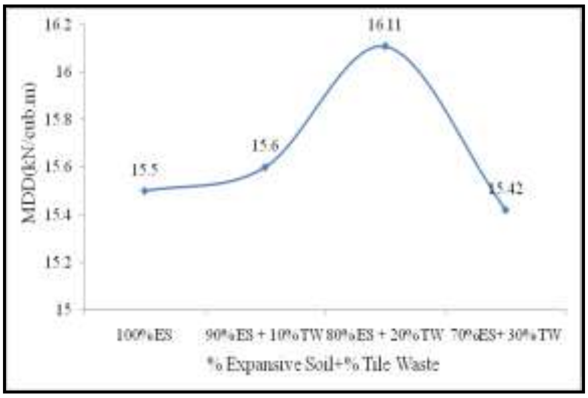

Fig 6: Variation of MDD with Percentage of Tile Waste

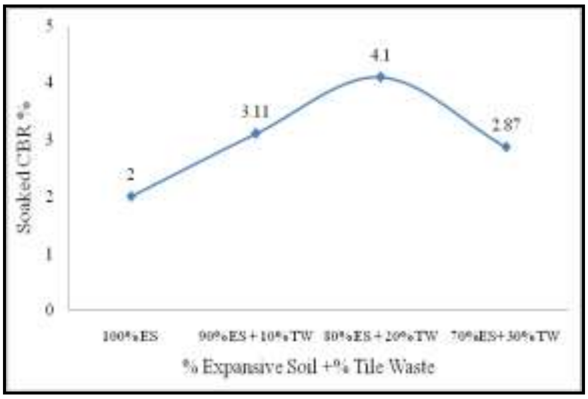

Fig 7: Variation of Soaked CBR with Percentage of Tile Waste

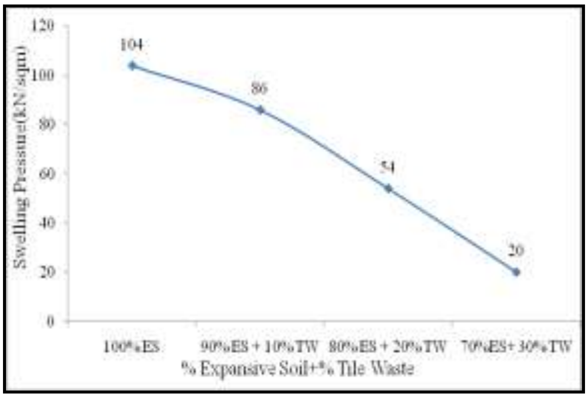

Fig 8: Variation of Swelling Pressure with Percentage of Tile Waste

Swell Pressure

The results of swell pressure tests on expansive soil treated with different percentage of tile waste are shown in Fig. 8. From the results it is observed that with increase in percentage of tile waste, the swelling pressure of soil goes on decreasing from 104 kN/m^2 to 54 kN/m^2 when tile waste is increased from 0 to 20% and nearly 48% reduction in swell pressure. This happens due to decrease in clay content of the expansive soil by replacement of tile waste, which is non-expansive in nature and that result in decrease in the swelling pressure.

It is observed from the test results that the expansive soil with tile waste has shown better performance when compared to expansive soil without tile waste. It is also observed that from CBR and swell pressure tests the stabilized expansive soil has shown maximum improvement compared to untreated expansive soil. From the results of compaction, CBR, Swell Pressure Tests, the optimum percentages of tile waste is 20%.

V. CONCLUSIONS

A series of laboratory tests were conducted to study the effects of tile waste on the, liquid limit, plastic limit, MDD, OMC, soaked CBR and swelling pressure of an expansive soil .Based on the observations, following conclusions are drawn from this study.

• The liquid limit and plastic limit decreasing irrespective of the percentage of addition of tile waste.
• The Maximum Dry Density attained at 20% tile waste and OMC goes on decreasing with increase in percentage of tile waste.
• The soaked CBR goes on increasing with increase in percentage of addition of tile waste. There is 105% increase in soaked CBR value as compared to untreated soil, when 20% tile waste was added.
• The swelling pressure goes on decreasing with addition of tile waste. There is 48 % decrease in swelling pressure of soil as compared to untreated soil, when 20% tile waste was added.

From the above analysis it is found that tile waste up to 20% can be utilized for strengthening the expansive soil subgrade of flexible pavement with a substantial save in cost of construction.

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