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STABILIZATION OF EXPANSIVE SOIL WITH EGG SHELL POWDER AND QUARRY DUST

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ABSTRACT

Soil plays an important role for many construction works especially for dams, bridges and canals. The presence of clay minerals exhibit alternate swelling & shrinkage depends upon the seasonal variations. Large numbers of researches are being carried out throughout the world to improve the soil quality. Various laboratory investigations were carried out for utilizing Egg Shell Powder (ESP) and Quarry Dust (QD) as a stabilizing agent to improve physical and mechanical properties of soil. To utilize the waste product to the corrected material for construction works and doesn't affect the environmental aspect also. Stabilization of soil with lime, cement, bitumen are expensive and therefore in need of an economic replacement. Soil taken with various ratios by addition of which 4% of ESP and without ESP followed by the increment of 5% of QD through moisture-density relationship at Standard Proctor Compaction test, California Bearing Ratio (CBR) at soaked condition, Consistency limits, Unified Compressive strength (UCS) test and Swell Pressure Test were carried out . The purpose of the study is to use of QD and ESP and evaluate the optimum combination to increase soil stabilization, geotechnical properties, reduce plasticity index and provide a solution for land filling, pavement structure and also for environmental problem.

Keywords

Soil stabilization, Egg Shell Powder, Quarry Dust, Geotechnical properties, , , Pavement structure

1. INTRODUCTION

In Expansive soil, settlement occurs easily depends upon weathering condition. Clay soil exhibit plastic and compressible and they expand when moisturized and shrink when dries; so they shrink during summer and swell during rainy seasons. This type of soil mostly consists of many states including Tamilnadu in India. Expansive soil mostly suitable for the growth of Paddy and Cotton also. Soil stabilization involves the utilization of stabilizing agents in weak soils (expansive soil) to improve its geotechnical properties. Stabilization of the clayey soils can be accomplished either by mechanical or chemical or combination of both methods to improve the civil engineering requirements.

Many researchers studied, at the initial stage of moisture content soil gets heave and allowed to full shrink (Chen et al (1985), Chen and Ma (1987), Akshayakumar Sabat & Bidula Bose (2013) and Dif & Bluemel (1991). Enormous quantities of quarry dust, a waste product, during crushing of rubble are produced across the country but it could be utilized rarely for some places for some materials. In order to overcome those problems stabilize the soil with admixtures namely Egg Shell Powder (ESP) and Quarry Dust (QD). ESP is the main ingredient in many food industries since it consists of inorganic and organic compounds contains large amount of calcium carbonate and small amount of magnesium carbonate also it behaves better stabilizing agent for controlling swell-shrink. In organism, calcium carbonate is most common materials especially for building protective mineral structure (Addadi and Weiner 1992). ESP is the beginning stage material for synthesis of hydroxy apatite and used for various medical applications especially to control the healing damaged bones and teeth due to its bioactivity and prevent from natural tissues and bones (B.Viswanath and N.Ravishankar 2008, L.Xu and K.A.Khor et al 2009). Many literature showed that the addition of ESP improve the texture of grain size in the extrusion industries (Kurogawa 1988). Egg Shells are immediately available and they produce some environmental pollution while milling because it can be used as precursor material for the synthesis of hydroxy apatite. (G.Goller F.N Oktar S et al). Few studies are available in literatures Quarry Dust is the better stabilizing agent to improve the geotechnical properties of the soil. It improves the shear strength as well as the CBR value of the soil by adding 30% of QD with 4% of ESP fulfills the requirement as per Indian Road Congress (IRC) code.

2. MATERIALS AND METHODS

The soil sample collected from Reddiyarpatti, Tirunelveli, thoroughly dried at normal room temperature. This type of expansive soil predominantly contains Montmorolinite clay minerals exhibit swelling and shrinkage when they are subjected to moisture. Specific gravity of the soil is 2.38. The geotechnical properties of expansive soils are presented in table 1.

2.1 Egg shell Powder (ESP)

Egg shell powder (ESP) is a waste material obtained from hotels and restaurants. ESP was received after that outer cover has been cleaned by mechanically. They kept in hot air oven for drying at 900˚C for 3 hours of heating. The dried egg shell powder was powered and sieved to 425µ. Specific gravity of egg Shell Powder is 2.09.

2.2 Quarry Dust (QD)

Quarry dust used for the study was received from Aruppukkottai. It was sieved through BIS sieve number 4.75μ and then stored for further investigations. Quarry dust exhibits high shear strength which is richly increased for engineering properties of the soil. The soil was tested for liquid limit, plastic limit, optimum moisture content, maximum dry density, unified compressive strength, CBR value, swell pressure and free swell index. Its specific gravity is 2.65.

Table 1. General properties of soil

Types of tests	% of values
Liquid limit	60
Plastic limit	31.2
Shrinkage limit	13.88
Specific gravity	2.38
Gravel	0.8
Coarse sand	1.3
Medium sand	8.68
Fine sand	10.9
Clay & Silt	78.32
Optimum Moisture Content	24
Maximum Dry Density (MDD)	1.77g/cc
Unconfined Comp. Strength (UCS)	7.16x10-3 N/mm^2
CBR value	1.12
Expansion Ratio	8.1
Free Swell Index	40
Swell Pressure	128KN/m2
Soil Classification	CH (High Compressibility)
Uniformity coefficient (Cu)	12.33
Coefficient of curvature (Cc)	2.62

Fig 1 shows the liquid limit value was decreased gradually when the egg shell powder was added from 0.5% to 5.5% at an interval of 0.5% to the blended soil. The gradual decrease in the value of liquid limit was due to the porous property of egg shell powder. Gradual increase of the plastic limit value was be observed with the increasing the % of egg shell powder and this is due to the change in the liquid limits and plastic limits, which consequently affects the plasticity index of the soil. The plasticity index of the soil got reduced from 27.5% to 11.3% during the experiment. The reduction of plasticity index, indicates the improvement of soil property.

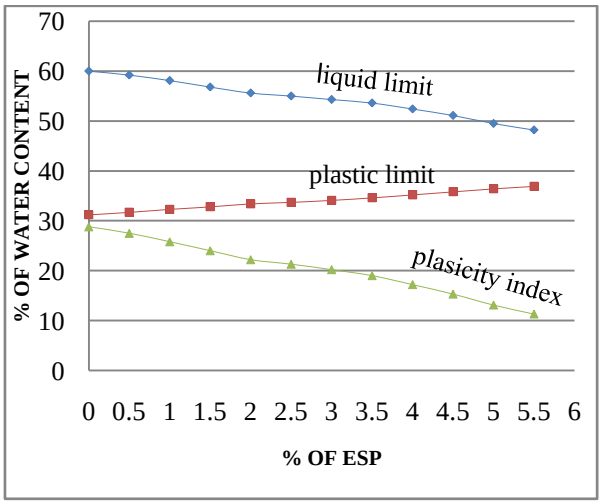


Fig 1: Influence of Egg Shell Powder on Consistency Limits

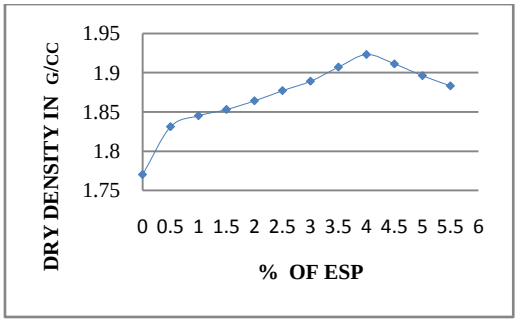


Fig 2: Influence of Egg Shell Powder on DD

The dry density of the soil mixture and the egg shell between 0% and 5.5% of egg shell were derived and plotted in Fig 2 The curve is more like bell shaped. The highest dry density is seen at 4% ESP.

Due to the porous property of the ESP, it absorbs moisture content. The initial decrease in OMC was attributable to this property and the subsequent increase of OMC was the result of binding action of egg shell powder and soil, which needs more water (Fig 3).

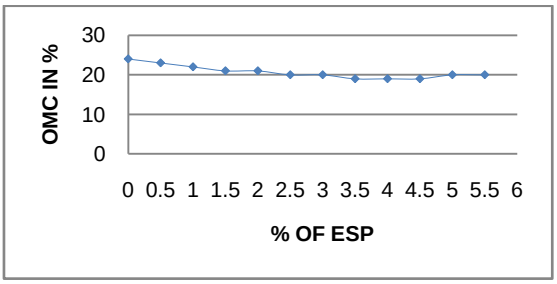


Fig 3: Influence of Egg Shell Powder on OMC

From the Fig 4, value of unconfined compressive strength test result, addition of 4% egg shell powder to the soil, the UCS value increased and a sudden decrease was observed at 4.5% addition of egg shell powder to the soil. The initial increase in the UCS value was reached because of the gradual formation of calcium carbonate present in the egg shell powder, soil and water. The decrease in the UCS values after the addition of 4% egg shell powder was due to the cohesive nature of the soil.

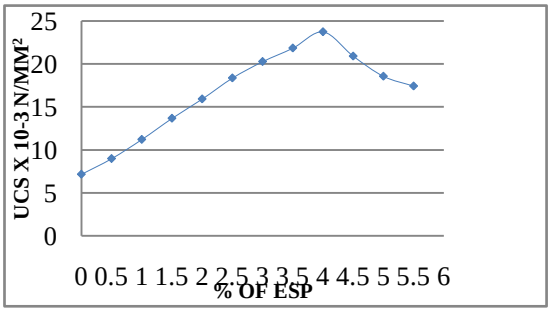


Fig 4: Influence of ESP on UCS

From the above test results, it is concluded that 4% addition of egg shell powder to that of the soil mixture showed best results with the increased OMC, dry density and unconfined compressive strength. Additions of egg shell powder alone with expansive soil increase the strength considerably but when quarry dust is used, the geotechnical properties of the soil increase to a larger extent. Egg shell powder – Quarry dust stabilization is cheapest method with considerable scope for construction where quarry dust and egg shells are available as waste products.

It is clearly seen from the fig 5, the percentage of quarry dust in the soil increases, the liquid limit of the soil gradually decreases. The further decrease in the value of liquid limit when egg shell powder is added to the soil – quarry dust mixes was due to the decrease in clay content with the addition of quarry dust and the porous property of egg shell powder. It can be observed that with the addition of 4% of egg shell powder, the liquid limit decreases by approximately 7% when compared with the soil mixes without ESP.

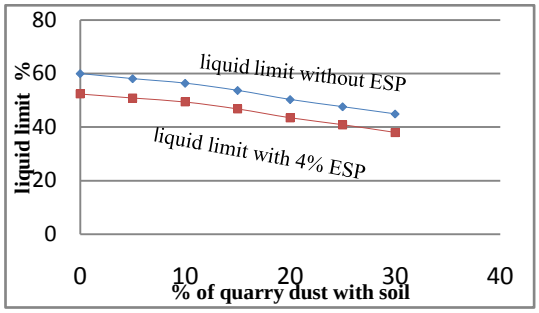


Fig 5: Soil behavior of Liquid Limit for varying % of QD with and without optimum % of ESP

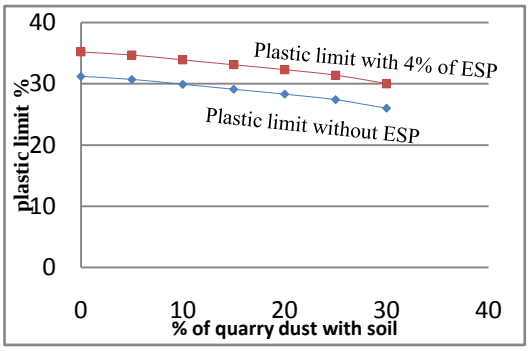


Fig 6: Soil behavior of Plastic Limit for varying % of QD with and without optimum % of ESP

The quarry dust helps in decreasing the plastic limit of the expansive soil sample. The experimental values of the plastic limit of the soil with & without ESP are plotted in Fig 6. The addition of 4% of egg shell powder increases the plastic limit of the soil – quarry dust mixes by as the addition of egg shell powder to the soil – quarry dust mixes decreases the liquid limit but increases the plastic limit, the plasticity index of the soil – quarry dust mixes is decreased further with the addition of egg shell powder. From Fig 7, almost 11% decrease can be observed in the soil mixes when 4% egg shell powder is added. This reduced plasticity of clay is very much required to avoid the failure of expansive soil over pavement of the structures.

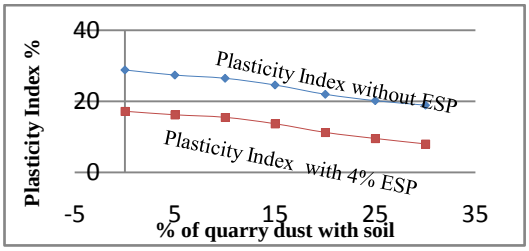


Fig 7: Soil behavior of PI for varying % of QD with and without optimum % of ESP

The variation in the DD of the admixture with and without the addition of ESP were determined and plotted (Fig 8 & 9) As percentage of quarry dust increases, the OMC of soil goes on decreasing at all percentages from 5 to 30 (Fig 8) . MDD increases by increasing the content of QD as shown in Fig 9. As the % of the QD increases, the DD of the mixture started to increase sharply from 2 to 2.5 when the QD % started to increase from 20 to 30 %. The addition of egg shell powder decreases the optimum moisture content of soil – quarry dust mixes further which can be attributed to the porous nature of egg shell powder. It can be noticed that for 30% replacement of soil with quarry dust, the optimum moisture content is reduced by 2% by mass when egg shell is added as compared to the same without the addition of egg shell powder.

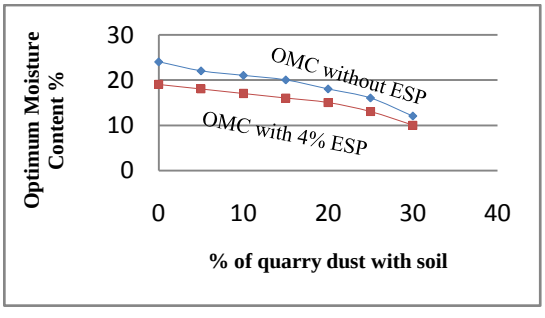


Fig 8: Soil behavior of OMC for varying % of QD with and without optimum % of ESP

Fig 9 shows the egg shell powder further increases the MDD of the soil – quarry dust mixes. The higher density helps to increase the strength of the soil. The MDD is increased by 13% for the mixture of 70% soil and 30% quarry dust with the addition of 4% egg shell powder.

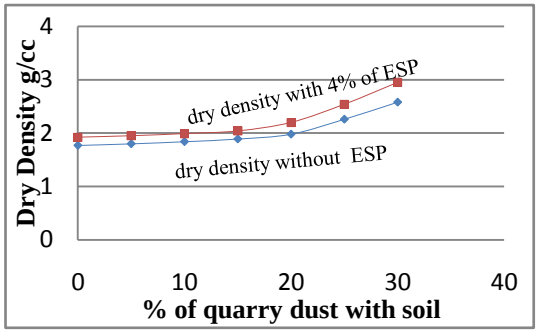


Fig 9: Soil behavior of Dry Density for varying % of QD with and without optimum % of ESP

Quarry dust helps in improving the strength of the soil, addition of egg shell powder to the soil – quarry dust mixes further leads to improve geotechnical properties of the expansive soil. So much of interest should be taken to add only the optimum amount of egg shell powder. Further addition of egg shell powder to the soil – quarry dust mixes make it very stiff which can decrease the strength of the soil. The UCS is increased by 23% with the addition of egg shell powder to the soil sample having 30% quarry dust. It can be noted that the increment in the UCS value decreases when the amount of quarry dust in the soil is increased.

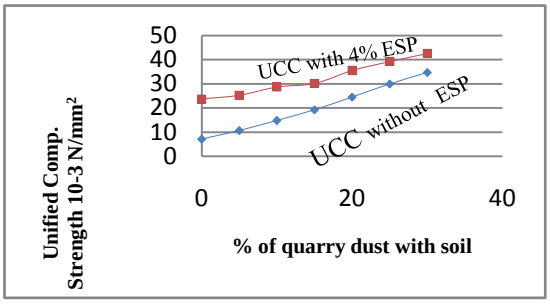


Fig 10: Soil behavior of UCS for varying % of QD with and without optimum % of ESP

2.3 Soaked California Bearing Ratio Test

To design a pavement, soaked CBR value of the soil subgrade is suitable. From that, the total thickness of the flexible pavement needed to cover the sub-grade is obtained. The expansion ratio is used to correctly identify the potential expansiveness of the soil. As per IRC: 37 – 2001, the CBR value required for a minimum pavement thickness for flexible pavement is 10%. As the CBR value of soil specimen having 30% quarry dust added with 4% egg shell powder satisfies the requirement, it is taken as the optimum proportion.

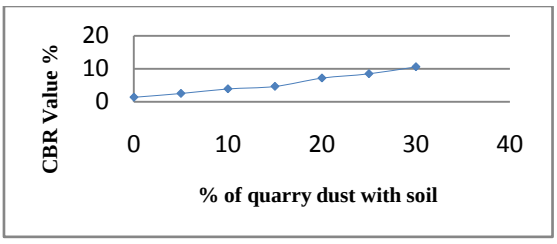
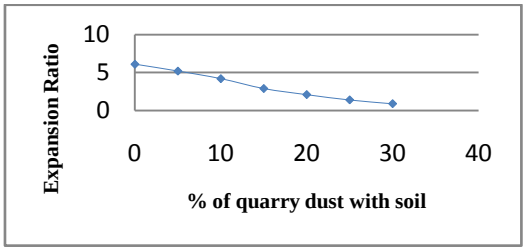


Fig 11: Soil behavior of CBR with varying % of QD with optimum % of ESP



2.4 Fig 12: Soil behavior of Expansion Ratio with varying % of QD with optimum % of ESP Swell Pressure

Swelling pressure test is used to determine the moisture load of the expansive soil. Lightly loaded structures founded on these type of clays causes structural damage to the buildings due to the swelling of the subsoil. Swelling pressure must be taken for consideration when designing the structure to avoid structural damage. Swell pressure of soil sample without any additives are 128kN/m^2 and Swell pressure of the optimum proportion of sample is 18.88 kN/m^2

The free swell test is one of the most commonly used simple tests in the field of geotechnical engineering for getting an estimate of soil swelling potential. It can be seen clearly that the swell pressure is decreased drastically by the addition of 4% egg shell powder to the soil-quarry dust mixture. Free swell index of the soil sample without any additives are 40% and free swell index of the optimum proportion of sample is 3.7%.

3 RESULT & DISCUSSION

The gradual decrease in the value of liquid limit was due to the porous property of egg shell powder. Gradual increase of the plastic limit value was due to the increasing the % of egg shell powder and also the changes in the liquid limits which consequently affects the plasticity index of the soil. The reduction of plasticity index, 27.5% to 11.3% indicates the improvement of soil property. The initial decrease in OMC was attributable to the porous property of the ESP and the subsequent increase of OMC was the result of binding action of egg shell powder and soil, which needs more water.

The initial increase in the UCS value was due to the gradual formation of calcium carbonate present in the egg shell powder, soil and water. The decrease in the UCS values were due to cohesive nature of the soil. From the experimental study, with the addition of 4% of egg shell powder, the liquid limit decreases by approximately 7% when compared with the soil mixes without ESP. For 30% replacement of soil with quarry dust, the optimum moisture content is reduced by 2% by mass which further increases MDD by 13%.

4 CONCLUSION

Proper combination of soil and admixture will improve the stability of the soil. The combination of quarry dust and egg shell powder is more effective than the addition of quarry dust or egg shell powder alone for the improvement of properties of clay. From the observed results , we can conclude that egg shell powder along with quarry dust used in combination with clay possessed certain properties which enables it to be used effectively for the improvement of expansive soil. Various tests were conducted in the laboratory with combination of soil QD and ESP. From the analysis, 70% soil + 30% Quarry dust added with 4% Egg Shell Powder gave the maximum in UCS of clay soil. At this optimum mix proportion the swell pressure reduces by almost 85% for the optimum mix proportion. By using the egg shell powder and quarry dust as soil stabilizers with the above said combination, we can minimize the waste disposal problem and also provide an economic means for the stabilization of expansive soils. It has highly recommended for the sampled region to use the above said combination of soil, quarry dust with ESP to provide economical completion of the civil engineering projects.

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