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PERFORMANCE OF SEASHELL POWDER ON SOIL STABILIZATION

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ABSTRACT

Usage of sea shells like clamps, mussels, oysters are wasted every day. It further raises the quantity of sea shell material waste. This contributes to numerous issues with the environment and climate. Million tons of sea shells are produced as the waste generated today create odours and promote microbial growth and emit co2 in lesser extent as they biodegrade and lead to environmental pollution will linger in the atmosphere, posing a number of environmental problems. therefore, excess will be utilized successfully in any sector of technological advancement. They have been made into necklace, buttons, belt buckles, earrings by adding sea shell powder wastes to the clay soil, we have to know about the changes in the strengths like, Atterbergs limits and Unconfined Compression test. The soil collected for the investigation is from the southern district of Tamil nadu, India. The different percentage of plastic powder was replaced to improve the soil property. In India, increase in population coupled with heavy laden loads of vehicles conveying heavier stresses concentrates especially on roads running in clayey soil zones which create significant problems for pavement and hence need to be stabilized. And by coordinating on the sea shell powder as part of the dose of 2.5%, 5%, 7.5%, 10%, are used as stabilizers.

Keywords : Stabilization; Soil; Characters; Properties; Sea shell

1 INTRODUCTION

1.1General

Clay soils have wide development in Bombay, western part of Madhya Pradesh, part of Gujarat, and in some parts of Tamil Nadu. Here, large area is occupied by soils derived from the Deccan trap. Clay soil absorb water heavily, swell, become soft and lose strength. These soils are easily compressible when wet and possesses a tendency to heave during wet condition [1,2].

Clay soil shrink in volume and develop cracks during summer. They are characterized by extreme hardness and cracks when dry. These properties make them poor foundation soils and earth construction material. The stability and performance of the pavements are greatly influenced by the sub grade and embankment as they serve as foundations for pavements. For developing a good and durable road network in clay soil areas, the nature of soils shall be properly understood. On such soils suitable construction practices and sophisticated methods of design need to be adopted [3,4].

1.2 Characteristics of Clay Soil

Clay soils are inorganic clays of medium to high compressibility and form a major soil group in India. Clay soil has a high percentage of clay which is predominantly montmorillonite in structure and black or blackish grey in colour. Because of its high swelling and shrinkage characteristics, the Clay soil has been a challenge to geotechnical and highway engineers. The soil is very hard when dry, but loses its strength completely when in wet condition (Balasubramaniam, et. al, 1989). The wetting and drying process causes vertical movement in the soil mass which leads to failure of a pavement, in the form of settlement, heavy depression, cracking and unevenness [5,6].

It also forms clods which cannot be easily pulverized as treatment for its use in road construction (Holtz& Gibbs, 1956). This poses serious problems as regards to subsequent performance of the road. Moreover, the softened sub grade has a tendency to heave into the upper layers of the pavement, especially when the sub-base consists of stone soling with lot of voids. Gradual intrusion of wet Clay soil invariably leads to failure of the road. However, since this soil is available easily at low cost, it is frequently used for construction purposes (Bell, 1988).Some of the factors which influence the behaviour of these expansive soils are initial moisture content, initial dry density, amount and type of clay, Atterberg limits of the soil, California bearing ratio and swell potential [7,8].

Fig.1 shrinkage in summer and swelling in rainy

1.3 Soil Stabilization

For any land-based structure, the foundation is very important and has to be strong to support the entire structure. In order for the foundation to be strong, the soil around it plays a very critical role. So, to work with soils, we need to have proper knowledge about their properties and factors which affect their behaviour. The process of soil stabilization helps to achieve the required properties in a soil needed for the construction work [9,10].

From the beginning of construction work, the necessity of enhancing soil properties has come to the light. Ancient civilizations of the Chinese, Romans and Incas utilized various methods to improve soil strength etc., some of these methods were so effective that their buildings and roads still exist [11].

In India, the modern era of soil stabilization began in early 1970's, with a general shortage of petroleum and aggregates, it became necessary for the engineers to look at means to improve soil other than replacing the poor soil at the building site. Soil stabilization was used but due to the use of obsolete methods and also due to the absence of proper technique, soil stabilization lost favour. In recent times, with the increase in the demand for infrastructure, raw materials and fuel, soil stabilization has started to take a new shape. With the availability of better research, materials and equipment, it is emerging as a popular and cost-effective method for soil improvement [12,13].

Here, in this project, soil stabilization has been done with the help of cement kiln dust and plastic powder obtained from cement industry. The improvement in the shear strength parameters and California bearing ratio which plays vital role in pavement construction has been stressed upon and comparative studies have been compute [14].

2 LITERATURE REVIEW

2.1 G Venkatappa Raoin 1998.

Many investigators have conducted the studies on fibre-reinforced materials. The results of direct shear tests performed on sand specimens indicated increased shear strength, increased ductility, and reduced post peak strength loss due to the inclusion of discrete fibres. These results were supported by a number of researchers. Investigations were also conducted to determine the behaviour of material properties of fibre-reinforced sands. The failure envelopes for fibre-sand composites were bilinear. The critical confining stress was a function of surface friction properties of the fibres and soil. The inclusion of discrete fibres increased both the cohesion and angle of internal friction of the specimens [15].

2.2 Akshaya Kumar Sabat in 2002.

This paper presents the effects of waste ceramic dust on, liquid limit, plastic limit, plasticity index, compaction characteristics, unconfined compressive strength, California bearing ratio, shear strength parameters and swelling pressure of an expansive soil. The expansive soil collected locally was mixed with ceramic dust from 0 to 30% at an increment of 5%. From the analysis of test results it was found that, liquid limit, plastic limit, plasticity index, optimum moisture content, cohesion and swelling pressure decreased, maximum dry density, unconfined compressive strength, California bearing ratio and angle of internal friction increased with an increase in ceramic dust content [16].

2.3 Mandeep Singh, Anupam Mittal in 2003.

This paper presents the effects of waste ceramic dust on, liquid limit, plastic limit, plasticity index, compaction characteristics, unconfined compressive strength, California bearing ratio, shear strength parameters and swelling pressure of an expansive soil. The expansive soil collected locally was mixed with ceramic dust from 0 to 30% at an increment of 5%. From the analysis of test results it was found that, liquid limit, plastic limit, plasticity index, optimum moisture content, cohesion and swelling pressure decreased, maximum dry density, unconfined compressive strength, California bearing ratio and angle of internal friction increased with an increase in ceramic dust content [17].

2.4 Subasis Patiin2001.

Preliminary tests were performed on three samples, A, B and C for identification and classification purposes followed by the consistency limit tests. Geotechnical strength tests (compaction, California bearing ratio (CBR), unconfined compression test and triaxial) were also performed on the samples, both at the stabilized and unsterilized states (adding 2, 4, 6, and 8% sugarcane straw ash). The results showed that sugarcane straw ash improved the geotechnical properties of the soil samples. Optimum moisture content increased from 19.0 to 20.5%, 13.3 to 15.7% and 11.7 to 17.0%, CBR increased from 6.31 to 23.3%, 6.24 to 14.88% and 6.24 to 24.88% and unconfined compression strength increased from 79.64 to 284.66kN/m2, 204.86 to 350.10kN/m2 and 240.4 to 564.6kN/m2 in samples A, B and C respectively [18].

3 MATERIALS AND METHODS

3.1Soil Stabilization

Soil stabilization is the process of altering some soil properties by different methods, mechanical or chemical in order to produce an improved soil material which has all the desired engineering properties. Soils are generally stabilized to increase their strength and durability or to prevent erosion and dust formation in soils. The main aim is the creation of a soil material or system that will hold under the design use conditions and for the designed life of the engineering project. The properties of soil vary a great deal at different places or in certain cases even at one place; the success of soil stabilization depends on soil testing. Various methods are employed to stabilize soil and the method should be verified in the lab with the soil material before applying it on the field [19,20].

3.1.1 Principles of Stabilization

- Evaluating the soil properties of the area under consideration.
- Deciding the property of soil which needs to be altered to get the design value and choose the effective and economical method for stabilization.
- Designing the Stabilized soil mix sample and testing it in the lab for intended stability and durability values.

3.1.2 Needs and Advantages

Soil properties vary a great deal and construction of structures depends a lot on the bearing capacity of the soil, hence, we need to stabilize the soil which makes it easier to predict the load bearing capacity of the soil and even improve the load bearing capacity. The gradation of the soil is also a very important property to keep in mind while working with soils. The soils may be well-graded which is desirable as it has less number of voids or uniformly graded which though sounds stable but has more voids. Thus, it is better to mix different types of soils together to improve the soil strength properties. It is very expensive to replace the inferior soil entirely soil and hence, soil stabilization is the thing to look for in these cases [21,22].

The various soil properties such as bearing capacity, shear strength, drainage etc. can be improved by reinforcing with plastic wastes.

- For developing a good and durable road network in clay soil area.
- Plastic bags are difficult and costly to recycle and most end up on landfill

- sites where they take around 300 years to photo degrade.
- All these instances, instigated the research to conduct this study to assess the knowledge and attitude of adolescents regarding the environment hazards due to mismanagement of plastic wastes.

3.1.3 Methods of Stabilization

Mechanical Method

In this procedure, soils of different gradations are mixed together to obtain the desired property in the soil. This may be done at the site or at some other place from where it can be transported easily. The final mixture is then compacted by the usual methods to get the required density [23].

Additive Method

It refers to the addition of manufactured products into the soil, which in proper quantities enhances the quality of the soil. Materials such as cement, lime, bitumen, fly ash etc. are used as chemical additives [24].

3.2 Soil Properties

3.2.1 Atterberg Limits

1) Shrinkage Limit:

2) Plastic Limit:

This limit lies between the plastic and semi-solid state of the soil. It is determined by rolling out a thread of the soil on a flat surface which is non-porous. It is the minimum water content at which the soil just begins to crumble while rolling into a thread of approximately 3mm diameter. Plastic limit is denoted by W_P.

3) Liquid Limit:

It is the water content of the soil between the liquid state and plastic state of the soil. It can be defined as the minimum water content at which the soil, though in liquid state, shows small shearing strength against flowing. It is measured by the Casagrand's apparatus and is denoted by W_L.

3.2.2 Particle Size Distribution

Soil at any place is composed of particles of a variety of sizes and shapes, sizes ranging from a few microns to a few centimetres are present sometimes in the same soil sample. The distribution of particles of different sizes determines many physical properties of the soil such as its strength, permeability, density etc [26].

Particle size distribution is found out by two methods, first is sieve analysis which is done for coarse grained soils only and the other method is sedimentation analysis used for fine grained soil sample. Both are followed by plotting the results on a semi-log graph. The percentage finer as the ordinate and the particle diameter i.e., sieve size as the abscissa on a logarithmic scale. The curve generated from the result gives us an idea of the type and gradation of the soil. If the curve is higher up or is more towards the left, it means that the soil has more representation from the finer particles; if it is towards the right, we can deduce that the soil has more of the coarse-grained particles [27].

The soil may be of two types- well graded or poorly graded (uniformly graded). Well graded soils have particles from all the size ranges in a good amount. On the other hand, it is said to be poorly or uniformly graded if it has particles of some sizes in excess and deficiency of particles of other sizes. Sometimes the curve has a flat portion also which means there is an absence of particles of intermediate size, these soils are also known as gap graded or skip graded [28].

3.2.3 Specific Gravity.

Specific gravity of a substance denotes the number of times that substance is heavier than water. In simpler words we can define it as the ratio between the mass of any substance of a definite volume divided by mass of equal volume of water. In case of soils, specific gravity is the number of times the soil solids are heavier than equal volume of water.

3.2.4 Shear Strength

Shearing stresses are induced in a loaded soil and when these stresses reach their limiting value, deformation starts in the soil which leads to failure of the soil mass. The shear strength of a soil is its resistance to the deformation caused by the shear stresses acting on the loaded soil. The shear strength of a soil is one of the most important characteristics. There are several experiments which are used to determine shear strength such as DST or UCS etc [29,30]. The shear resistance offered is made up of three parts:

- The structural resistance to the soil displacement caused due to the soil particles getting interlocked,
- The frictional resistance at the contact point of various particles, and
- Cohesion or adhesion between the surface of the particles.

In case of cohesion less soils, the shear strength is entirely dependent upon the frictional resistance, while in others it comes from the internal friction as well as the cohesion.

3.2.5 Unconfined Compression Test (UCS test)

This test is a specific case of triaxial test where the horizontal forces acting are zero. There is no confining pressure in this test and the soil sample tested is subjected to vertical loading only. The specimen used is cylindrical and is loaded till it fails due to shear.

4 EXPERIMENTAL INVESTIGATION

4.1 Scope of work

The experimental work consists of the following steps:

1. Specific gravity of soil
2. Determination of soil index properties (Atterberg Limits)
   i) Liquid limit by Casagrande's apparatus
   ii) Plastic limit
3. Particle size distribution by sieve analysis
4. Determination of the shear strength by:
   i) Unconfined compression test (UCS)

4.2 Materials

4.2.1. **Clay soil**

Clay soil is collected from avadi road which is used for our experimental study.

4.2.2.**Sea shells waste powder**

Sea shells waste like clamps have been collected from the marina beach and besant nagar beach. And they are washed and cleaned with water and dried completely in sunlight and then crushed by grinding stone to get the powdered sea shell.

The Sea shell powder produced after burning the shells at high temperatures, is rich in calcium oxide (caO-52 to 57%) depending on the type and the composition of cacO3.

content of the raw shells. But shells are strong and resistant to fracturing, and this is because the calcium carbonate is combined with proteins which bind the crystals together, and make them stronger and sometimes tougher.

Fig 1. clay soil and sea shell powder

4.3 Steps Involved In Experiments

4.3.1 Specific Gravity of The Soil

The specific gravity of soil is the ratio between the weight of the soil solids and weight of equal volume of water. It is measured by the help of a volumetric flask in a very simple experimental setup where the volume of the soil is found out and its weight is divided by the weight of equal volume of water.

Specific Gravity $G = (W2-W1)/ (W4-W1) - (W3-W2)$

W1- Weight of bottle in gms

W2- Weight of bottle + Dry soil in gms

W3- Weight of bottle + Soil + Water

W4- Weight of bottle + Water

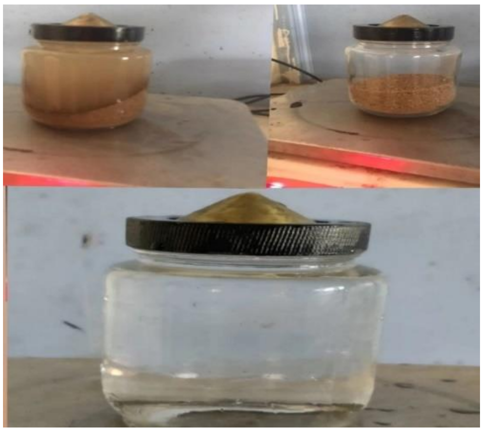

Fig.2 Pycnometer

4.3.2 Liquid limit

The Casagrande tool cuts a groove of size 2mm wide at the bottom and 11 mm wide at the top and 8 mm high. The number of blows used for the two soil samples to come in contact is noted down. Graph is plotted taking number of blows on a logarithmic scale on the abscissa and water content on the ordinate. Liquid limit corresponds to 25 blows from the graph.

Fig. 3 Casagrande Apparatus

4.3.3 Plastic Limit

This is determined by rolling out soil till its diameter reaches approximately 3 mm and measuring water content for the soil which crumbles on reaching this diameter. Plasticity index (Ip) was also calculated with the help of liquid limit and plastic limit;

$$I_p = W_L - W_P \; (W_L\text{-Liquid limit, } W_P\text{- Plastic limit})$$

4.3.4 Particle Size Distribution

The results from sieve analysis of the soil when plotted on a semi-log graph with particle diameter or the sieve size as the abscissa with logarithmic axis and the percentage passing as the ordinate gives a clear idea about the particle size distribution. From the help of this curve, D10 and D60 are determined. This D10 is the diameter of the soil below which 10% of the soil particles lie. The ratio of, D10 and D60 gives the uniformity coefficient (Cu) which in turn is a measure of the particle size range.

Fig 4. Sieve Shaker

4.3.6 Unconfined Compression Test

This experiment is used to determine the unconfined compressive strength of the soil sample which in turn is used to calculate the unconsolidated, undrained shear strength of unconfined soil. The unconfined compressive strength (qu) is the compressive stress at which the unconfined cylindrical soil sample fails under simple compressive test. The experimental setup constitutes of the compression device and dial gauges for load and deformation. The load was taken for different readings of strain dial gauge starting from ε = 0.005 and increasing by 0.005 at each step. The corrected cross-sectional area was calculated by dividing the area by (1 - ε) and then the compressive stress for each step was calculated by dividing the load with the corrected area.

Fig 7. Ucc Apparatus

5 RESULT AND DISCUSSION

5.1 Specific Gravity

Table :1

Specific Gravity	Normal Clay	2% of Sea Shell Powder	6% of Sea Shell Powder	8% of Sea Shell Powder	10% of Sea Shell Powder
G	2.55	2.63	2.71	2.87	2.72

Average specific gravity G=2.77

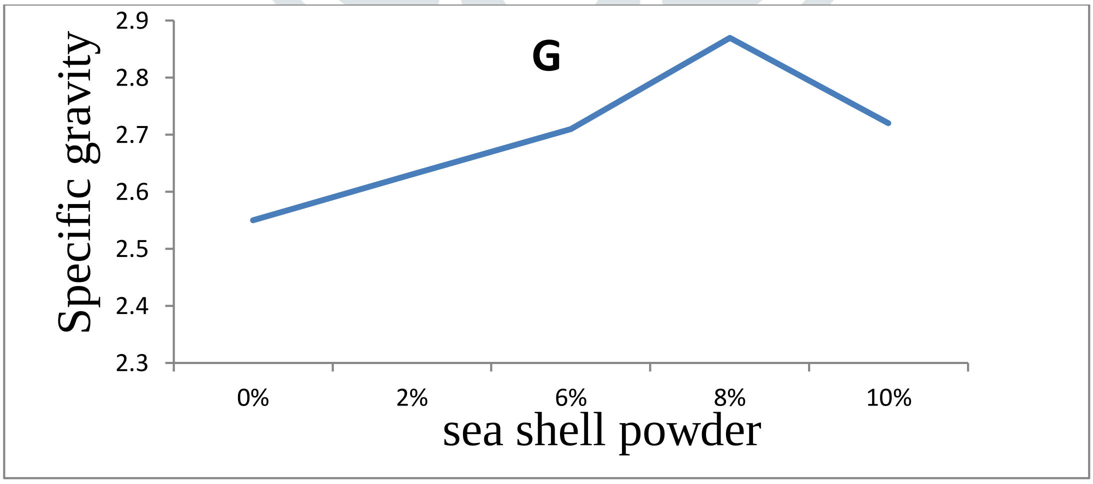

Fig 8. Specific Gravity

5.2 Particle Size Distribution (sieve analysis)

Table 2: Particle Size Distribution:

Is Sieve	Wt Of Soil	Cumul Wt.	Soil Retained %	% of Finer Soil
4.75 mm	0.007	0.007	0.7	99.3
2.36 mm	0.053	0.060	6.0	94
1.18 mm	0.190	0.250	25	75
600 µ	0.309	0.559	55.9	44.1
425 µ	0.213	0.772	77.2	22.8
300 µ	0.078	0.850	85	15
150 µ	0.136	0.986	98.6	1.4
75 µ	0.007	0.993	99.3	0.7
Pan	0.007	1.000	100	0

i. Uniformity co.eff. (C_u) = 2.36

ii. Co.eff of curvature (C_c) = 0.816

C_c = 1-3 for well graded soil

C_u must be greater than 4 for gravel and 6 for sand **so, it is poorly graded clay soil.**

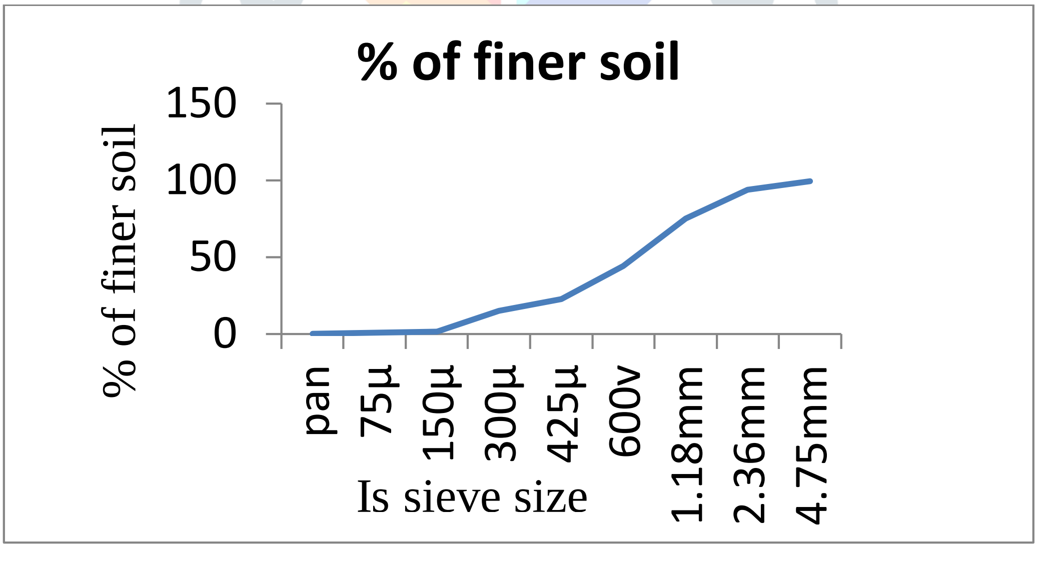

Fig 9. Sieve Analysis

5.3 Index Properties

5.3.1. Liquid Limit

Table: 3: Liquid limit with percentage of sea shell powder

Liquid Limit	Normal Clay	2.5% Of Sea Shell Powder	5% Of Sea Shell Powder	7.5% Of Sea Shell Powder	10% Of Sea Shell Powder
W_L	64%	60%	52%	**45%**	51%

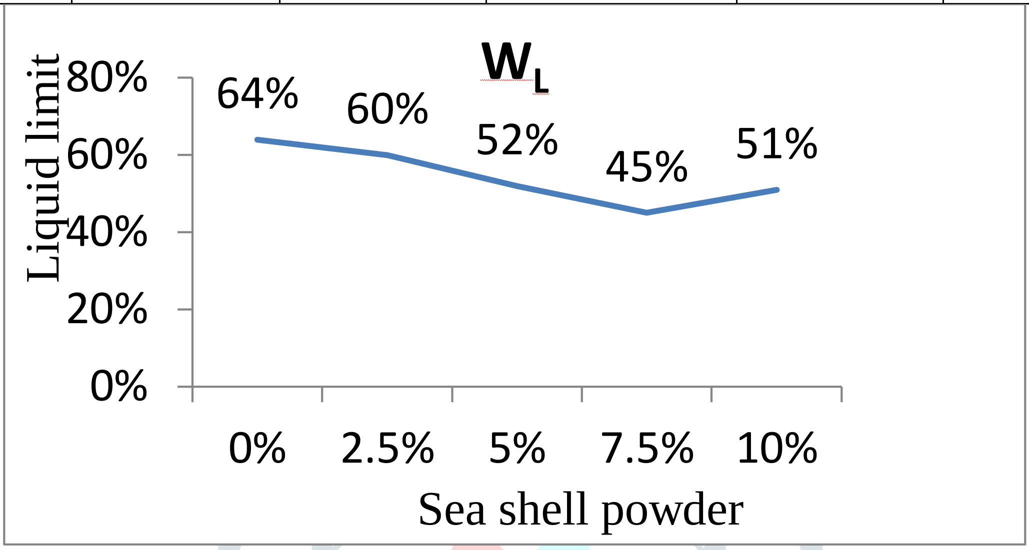

Fig 10 Liquid Limit

- The results of liquid limit tests on clay soil treated with different percentage of sea shell powder waste shown in graph.
- From the graph it can be seen that with increase in percentage of sea shell powder the liquid limit of soil goes on increasing.

5.3.2 Plastic Limit

Table 4: Comparison of Plastic limit with percentage of sea shell powder

Plastic Limit	Normal Clay	2.5% Of Sea Shell Powder	5% Of Sea Shell Powder	7.5% Of Sea Shell Powder	10% Of Sea Shell Powder
W_P	30%	27%	25%	**24%**	25%

- The results of plastic limit tests on clay soil treated with different percentage of sea shell powder are shown in graph.
- From the graph it can be seen that with increase in percentage of sea shell powder the plastic limit of soil goes on decreasing.
- The plastic limit of the soil increases from 30% to 24% with increase in sea shell powder up to 8%.
- Further we combine the liquid limit of the soil decreases from30% to 24% with increase in sea shell powder waste.

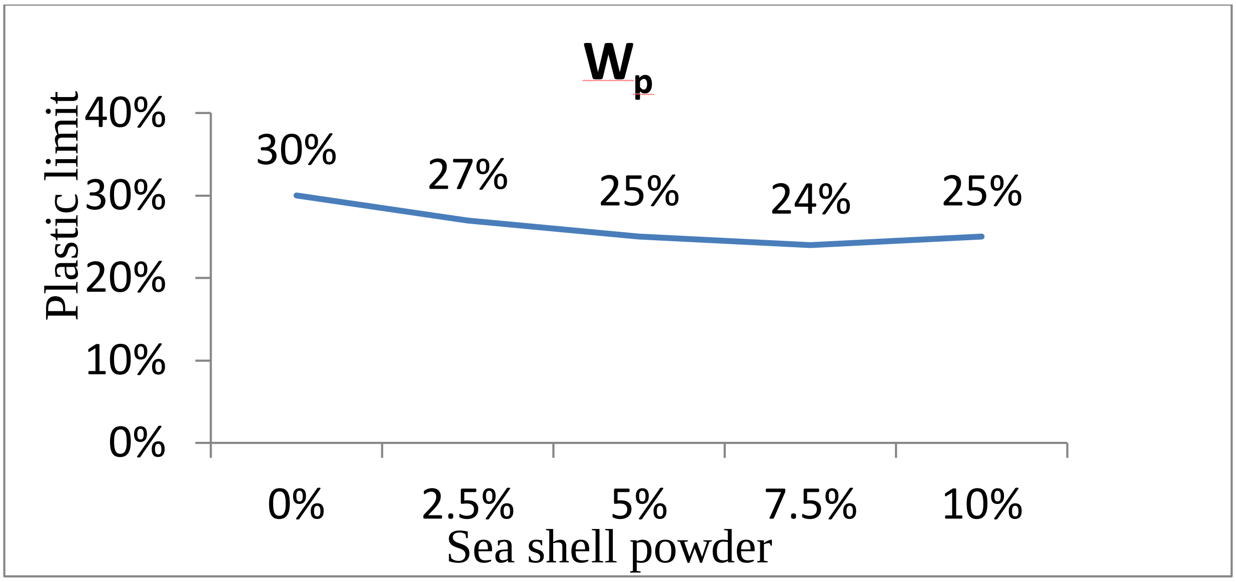

Fig 11 Plastic Limit

5.3.3 Plasticity Index

Table 5: Plastic Index

I_P	**SOIL PLASTICITY**
0-3	NON-PLASTIC
3-15	SLIGHTLY PLASTIC
15-30	MEDIUM PLASTIC
30 ABOVE	HIGH PLASTIC

Table 6: Plastic Index decrease with increase in sea shell powder

Plasticity Index	Normal Clay	2.5% Of Sea Shell Powder	5% Of Sea Shell Powder	7.5% Of Sea Shell Powder	10% Of Sea Shell Powder
I_p	34%	33%	27%	**21%**	25%
Soil Plasticity	High Plastic	High Plastic	Medium Plastic	**Medium Plastic**	Medium Plastic

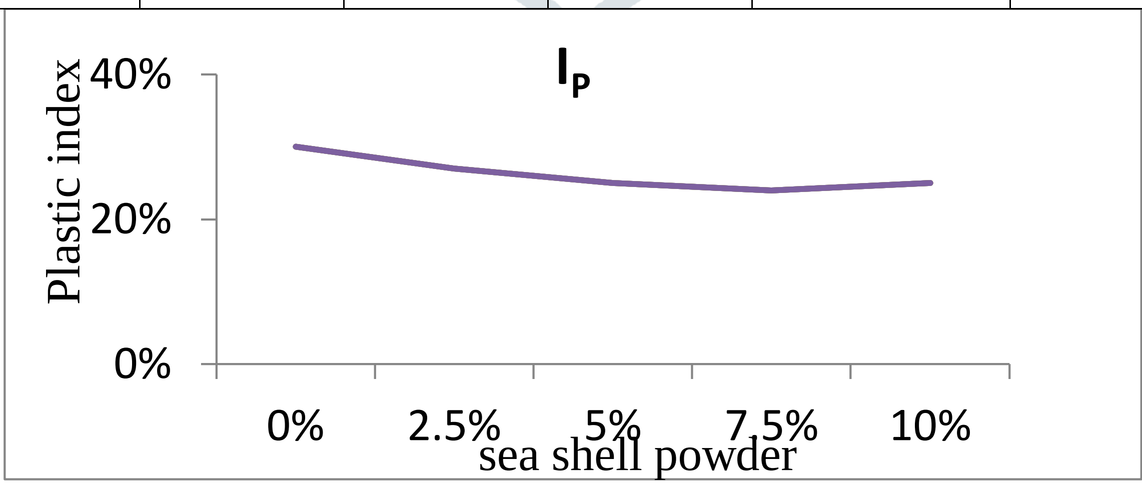

Fig 12 Plastic Index

- The results of plasticity index tests on clay soil treated with different percentage of sea shell powder are shown in graph.

- From the graph it can be seen that with increase in percentage of sea shell powder the plasticity index of soil goes on decreasing. It decreases from 34% to 21 %.
- The plasticity index of the soil decreases from 34% to 21 %with increase in sea shell powder up to 8%.

5.4 Unconfined Compression Strength

Table7: comparison of UCC with percentage of sea shell powder.

Unconfined Compression Strength	Normal Clay	2.5% Of Sea Shell Powder	5% Of Sea Shellpowder	7.5% Of Sea Shell Powder	10% Of Sea Shell Powder
UCS (KN/m^2)	74	78	86	**92**	88

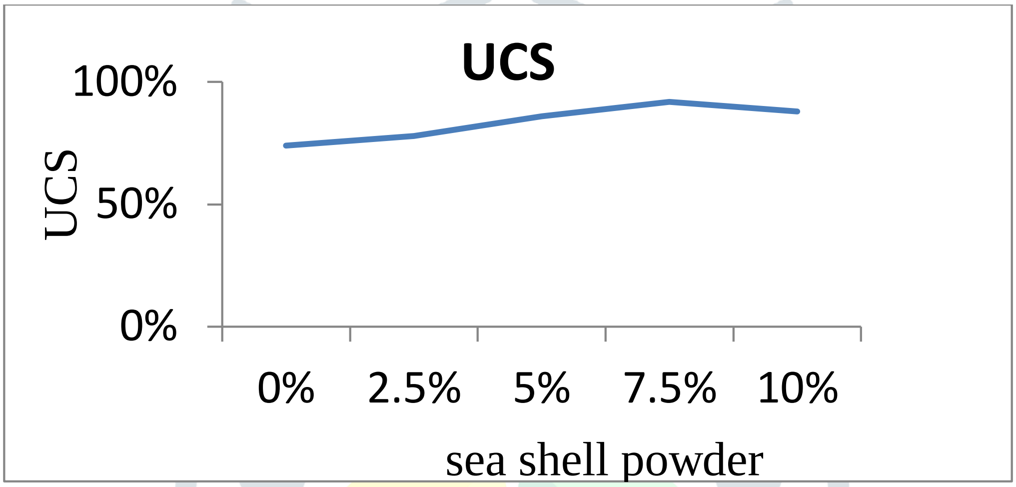

Fig .13 Unconfined Compression Strength

- From the graph it can be seen that with increase in percentage of plastic powder, the UCS of soil goes on increasing.
- The UCS of soil goes on increasing. The UCS increases from $74kN/m^2$ to $92kN/m^2$ when sea shell is increased from 0 to 8%.

ECONOMY OF STABILIZATION

To study the economy of stabilization, a flexible pavement has been designed for cumulative traffic of 1,5 and 10 msa (million standard axles), based on the guide lines provided by IRC: 37-2001(Guidelines for the design of Flexible Pavements) for CBR values of both unstabilized and stabilized soil. According to IRC:37-2001, if the soaked CBR value of a subgrade is less than 2%,then the design of the pavement should be done by taking the soaked CBR value as 2% and a capping layer of 150 mm thickness with materials having minimum CBR value of 10% should be provided in addition to sub base. Hence the soaked CBR of unstabilized soil subgrade has been taken as 2% instead of 1.6% for design purpose. The soaked CBR value is 4% for the mix having proportion of soil 70% and plastic powder 30%. Hence the soaked CBR of stabilized soil subgrade has been taken as 4% for the design purpose. The variation of pavement thickness for both the unstabilized and stabilized subgrade, with cumulative traffic (1, 5 and 10 msa) has been shown in Figure . It can be seen from this figure that the pavement thickness varies from 660 mm to 850mm for unstabilized soil and from 480 mm to 700 mm for stabilized soil for cumulative traffic 1 -10 msa.

As per the schedule of rates - 2012, Government of Tamilnadu, India, the cost of stabilized and unstabilized pavement per m2 of pavement for cumulative traffic 1-10 msa in Indian Rupees has been shown in Figure 13. It includes the cost of transportation of plastic powders from a distance of 20 km, grinding of plastic powders and mixing of plastic powder with soil. It can be seen from this figure, that the cost of pavement per m2 varies from `914.5/- to `1931/- Rupees for unstabilized subgrade (which includes the cost of capping layer of 150mm thickness) and from`687.4/- to `1635.4/- Rupees for stabilized sub grade for cumulative traffic of 1 -10 msa.

CONCLUSION

A series of laboratory tests were conducted to study the effects of waste sea shell powder on the, liquid limit, plastic limit, plasticity index, UCS, soaked CBR, shear strength parameters of an clay soil. Based on the observations and discussions, following conclusions are drawn from this study.

- The liquid limit gradually increases with increasing %of sea shell powder.
- Plastic limit and plasticity index go on decreasing of the percentage of addition of Sea shell powder.
- The UCS goes on increasing with increase in percentage of addition of sea shell powder.
- Further we add sea shell powder by 2%,6%,10% respectively. The liquid limit of the soil decreases from 64% to 45% with increase in sea shell powder.
- The plasticity index of the soil decreases from 34% to 21% with increase in sea shell powder.
- The UCC of the soil increases from 74% to 92% with increase in sea shell powder.
- From the economic analysis it is found that sea shell powder up to 8% can be utilized for strengthening the sub grade of flexible pavement with a substantial save in cost of construction.

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