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Stabilization of Subgrade Soil Using Chicken Feather Fiber under Flooding Condition

Akshaya T P

Jyothi Engineering College Cheruthuruthy,
Thrissur

ABSTRACT

Soil stabilization is the process which involves enhancing the physical properties of the soil in order to improve its strength, durability etc. by blending or mixing with additives. The strength of subgrade soil or road foundation could influence the design of road pavement structures. Flood can be one of the causes of weakened subgrade and consequently road damages. Since the condition of subgrade layer is critical in the road pavement stability, a preliminary study was carried out to ascertain the use of CFF In stabilization mechanism in road subgrade. This study was conducted based on expansive soil ie,clay. California Bearing Ratio (CBR) test was conducted on the various categories of soaked conditions to determine the strength of subgrade soil with and without mixing of CFF fibers. It can be concluded that CFF can be used to increase or maintain the strength of subgrade soil from the inundation effect.

CHAPTER 1
INTRODUCTION

➢ *GENERAL*

Soil stabilization refers to the procedure in which a special soil, a cementing material, other chemical or non chemical materials are added to a natural soil or a technique use on a natural soil to improve one or more of its properties. One may achieve stabilization by physically mixing the natural soil and stabilizing materials together so as to achieve a homogeneous mixture or by adding stabilizing material to an undisturbed soil deposits and obtaining interaction by letting it permeate through soil voids, Abood et.al. (2007).Soil stabilizing additives are used to improve the properties of less desirable road soils. When used these stabilizing agents can improve and maintain soil moisture content, increase soil particle cohesion and serve as cementing and water proofing agents, Janathan (2004).In the United States, engineers are often faced with the problem of constructing road beds on or with soils, which do not possess sufficient strength to support wheel loads imposed up on them either in construction or during the service life of the pavements, OGE (2008). It is, at times, necessary to treat or modify these soils to provide a stable sub grade or a working platform for the construction of the pavement. The result of these treatments are that less time and energy is required in the production, handling and placement of road and bridge fills and sub grades and therefore, less time to complete the construction process thus reducing the disruption and delays to traffic.

Infrastructure networks are often considered to be the backbone of cities. Ensuring their resilience, has become a vital aspect of governing and managing an economically-viable and liveable city. In particular, transport networks support the safety and wealth of communities, especially in the context of a global economy increasingly reliant on the mobility of goods, information and people Changes in the climate, rapid urbanisation, and increased infrastructure interdependence are putting societies, assets, and the built environment under increasing pressure. This is particularly evident in urban areas when transport systems are affected by weather-related hazards.

Flooding, especially flash flood events that start rapidly as a result of intense precipitation, is the predominant cause of weather-related disruption to the transport sector and this is expected to continue into the future . As a type of special soil, the expansive soil possesses three features, swelling and shrinkage, over-consolidation and multiple fissures. The fundamental behavior for expansive soil is not well understood, particularly, the effect of loading mode and flooding condition on the in-situ shear strength parameters of expansive soils should be paid further attention in engineering design.

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For instance ,Petric-Gray et.al. applied wool to stabilize soils used in the building industry. They used two different percentages, 0.25 and 0.5, in order to modify soil properties. From their results it was observed that wool stabilized soil increases the compressive strength considerably compared within stabilized soils. Similarly, Galan Marin et.al. studied the stabilization of soils with natural polymers(alginate)and fibers from sheep's wool (0.25 and 0.5%) to produce a composite; their results show that the addition of alginate separately increases compression strength from 2.23 to 3.77MPa and the addition of wool fiber increases compression strength until 37%.

Generally these chicken feathers are the dumped wastes of poultry farms. Chicken feathers are used as an animal feeder, melted and made into plastic. The usage of chicken feathers in any field is very less and they become debris to over this problem, they are for stabilization of soft soils which are very weak in nature and contain many voids. Chicken feathers has three parts barbs, quills and rachis. These are cut into small pieces of 6cm and mixed with the soft soils for stabilization.

1.1 OBJECTIVES

The basic objective of the project are:

– Study of using chicken feather fibre which is a locally available waste material for improving subgrade strength under flooding conditions.
– Utilisation of sustainable materials like chicken feather fiber for soil stabilization

1.2 NEED AND SCOPE

This study is performed to obtain the properties of CFF for its application in the stabilization of soft soil. The properties of CFF will be evaluated with various laboratory tests to investigate the feasibility of using CFF in soil stabilization under flooding conditions.

- These findings are useful for road design and maintenance strategies of flood affected road links.To improve the subgrade soil characteristics against the flooding condition.
- Expansive soil have more chances of getting deteriorated under flooding conditions.
- To study the feasibility of a waste material in subgrade soil stabilization
- To prevent deterioration of subgrade soil characteristics using waste materials namely chicken feather fibre.
- 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.
- Soil Stabilization can be utilized on roadways, parking areas, site development projects, airports and many other situations where sub-soils are not suitable for construction.

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- Stabilization can be used to treat a wide range of sub-grade materials, varying from expansive clays to granular materials.
- It is also used to provide more stability to the soil in slopes or other such places. Soil stabilization is also used to prevent soil erosion or formation of dust, which is very useful especially in dry and arid weather.
- Stabilization is also done for soil water-proofing; this prevents water from entering into the soil and hence helps the soil from losing its strength.
- Stabilization improves the workability and the durability of the soil. Increase the service life of the structure.

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CHAPTER 2

METHODOLOGY

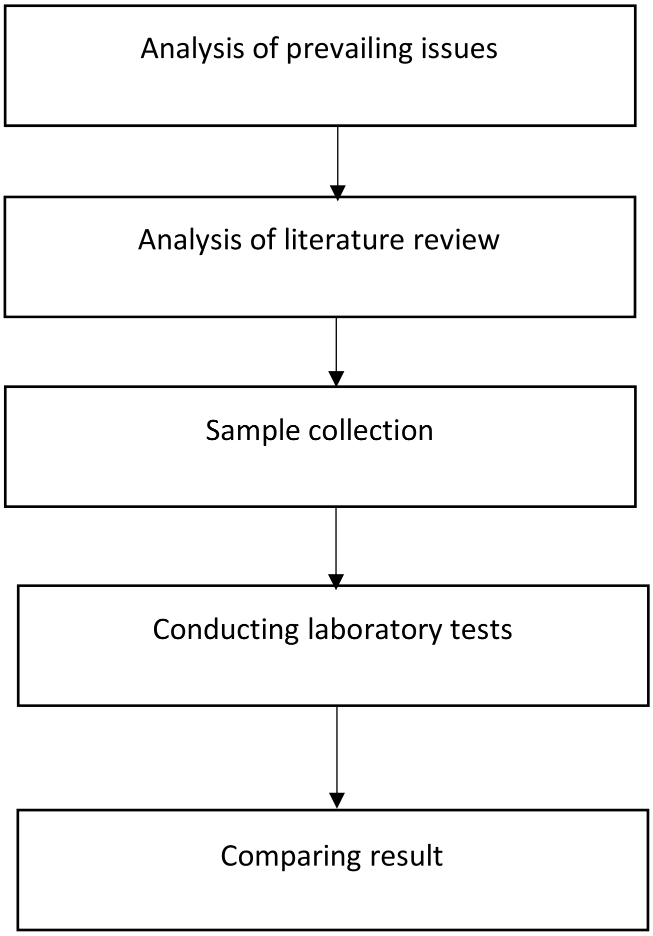

Fig 1

2.1 ANALYSIS OF PREVAILING ISSUES

First of all, problems and challenges and the prevailing issues of the subsurface soil is analyzed.

2.2 ANALYSIS OF LITERATURE REVIEW

The literature review which are sufficient for the progression of the project were collected and analyzed. The details about the materials and experiments are analyzed and discussed.

2.3 SAMPLE COLLECTION

Soil sample from Jyothi Engineering College was collected at required quantity. Chicken feather was also collected for conducting various soil tests to improve strength to the soil.

2.5 CONDUCTING LABORATORY TESTS

Conducting various laboratory soil tests like Specific gravity, Atterberg limits (Liquid limit by Casagrande apparatus, Plastic limit), Particle size distribution by sieve analysis, Direct shear test, California bearing ratio test, Unconfined compression strength, Determination of maximum dry density (MDD), and the corresponding optimum moisture content (OMC) of the soil sample.

2.6 COMPARING THE RESULTS

The results of various tests from soil tests for raw soil and polypropylene added soils with various percentages are compared.

2.7 ARRIVAL AT CONCLUSION

After the collection of various data and soil tests we arrived a conclusion by comparing the properties of fiber with soil properties and found out the effectiveness of fibre reinforcement.

CHAPTER 3
LITERATURE REVIEW

3.1 GENERAL

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. 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. The impact of flooding can be disastrous to the infrastructure and then environment. On top of that there will be huge expenditure for the rehabilitation process and it may take some time to make things back to normal. Soil stabilization is one method for soil improvement which help to improve the subgrade soil strength hence reducing the impact of flooding on road infrastructures.

3.2 WHAT IS SOIL STABILIZATION?

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.

Soil Stabilization can be utilized on roadways, parking areas, site development projects, airports and many other situations where sub-soils are not suitable for construction. Stabilization can be used to treat a wide range of sub-grade materials, varying from expansive clays to granular materials. This process is accomplished using a wide variety of additives, including lime, fly-ash, and Portland cement. Other material byproducts used in Stabilization include lime-kiln dust (LKD) and cement-kiln dust (CKD).

3.3 BENEFITS OF SOIL STABILIZATION

Benefits of Soil Stabilization process can include:

- Higher resistance (R) values
- Reduction in plasticity
- Lower permeability
- Reduction of pavement thickness
- Elimination of excavation, exporting unsuitable material and importing new materials
- Aids compaction
- Provides "all-weather" access onto and within project sites

In addition, there are several environmental advantages. When unimproved roadways are stabilized and treated with the right additives, run-off of storm water will not cause erosion, which in turn sends thousands of tons of silt into our rivers and bays. This erosion clogs and silts vital waterways and fish habitat that would have been spawning grounds for future generations. Our Soil Stabilization methods help to preserve soils, water ways, unimproved roadways and much more.

3.4 METHODS OF SOIL STABILISATION

- Mechanical stabilization
- Chemical stabilization
- Soil lime stabilization
- Soil bitumen stabilization
- Soil cement stabilization

3.4.1 Mechanical stabilization

⇨ In this method the stability of the soil is increased by blending the available soil with imported soil or aggregates so as to obtain a desired particle size distribution and by compaction of the mixture to achieve the desired density.

⇨ This method is generally adopted for construction of sub-base and base-course. It is also useful for construction of surface course of low cost roads such as village roads when the traffic and rainfall are low.

3.4.2 Chemical stabilization

⇨ Granular soils lack stability when they are too dry.If their moisture content is stabilized by addition of some chemicals,then these soils can be used successfully.Chlorides of calcium and sodium are the most popular salts used for this purpose.A number of other chemicals/materials such as sodium silicate,lignin,resins,molasses etc,are used for chemical stabilization of soils.

⇨ Addition of chemicals with the soil helps to retain moisture and to impart some cohesion and thus retain the stability.These chemicals also reduce the dust nuisance in un-surfaced roads.

3.4.3 Soil Lime Stabilization

⇨ Soil-lime is widely used either as modifier for clayey soil or as a binder.When clayey soil with high plasticity are treated with lime,the plasticity index is decreased and the soil becomes brittle and easy to be pulverized having less attraction with water.Lime also imparts some binding action. In fine grained soil lime imparts pozzolanic action which increases the strength.All these modifications are considered desirable for stabilization work.

⇨ Soil lime is quite suitable as sub-base course for high type of pavements with low traffic.But this method can not be used as surface course due to its poor resistance to abrasion and impact.This method is quite suitable in warm regions, but not very suitable under freezing temperature.

3.4.4 Soil Bitumen Stabilization

⇨ The basic principles in bituminous stabilization are water proofing and binding.Generally both the binding and water proofing actions are provided to the soil by adding bituminous material.Most commonly used bituminous materials are cutback and emulsion.

⇨ Addition of chemicals with the soil helps to retain moisture and to impart some cohesion and thus retain the stability.These chemicals also reduce the dust nuisance in un-surfaced roads.

3.4.5 Soil Cement Stabilization

⇨ Soil-cement is an intimate mix of soil, cement and water which is well compacted to form a strong base course. Addition of cement in small proportion to soil improves its strength and modifies the properties of soil.

⇨ Soil-cement stabilization can be used as a sub-base or base-course of all types of payments.But this method can not be used as surface course due to its poor resistance to abrasion and impact .

⇨ This method is costly and needs high degree of quality control as compared to soil-lime stabilization.

3.5 A STUDY ON THE USE OF POLYURETHANE FOR ROAD FLOOD DAMAGE CONTROL

Polyurethane is produced by mixing polyol and polyisocyanates at ratio 1:1.2 and the cured material is cut into sizes and placed in CBR mould along with subgrade soil samples and CBR test is conducted under soaked condition. This experimental study had been conducted in order to determine the strength of soil sample containing polyurethane and its capability to maintain the strength when the soil samples are kept in different inundation conditions. From the result of this study, it can be concluded that the soil samples that have been kept in longer duration of inundation tends to loss the strength as expected. Polyurethane that was placed in the soil.

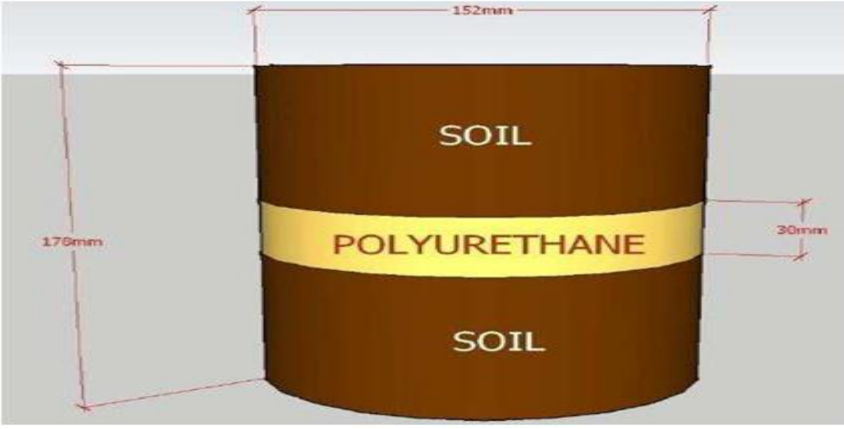

Fig 2:- Placement of Polyurethane Layer

Samples and tested in the different days of inundation indicated that it can help to increase and maintain the strength of the soil. The reduction of subgrade strength once it is inundated can be very significant. In this study, polyurethane layer helps recover at least 3% of the strength loss due to inundation.

3.6 ROAD SUBMERGENCE STRENGTH UNDER VARIOUS FLOODING EVENT

Subgrade is a significant part of the road structural system. When roads are inundated for a long time or repeatedly, the materials in each layer of road structure become saturated, and the original condition of subgrade soils will be compromised. California Bearing Ratio (CBR) test and consolidation settlement test were carried out on various categories of inundation and loading conditions including repeated inundation. The findings indicated that the strength of subgrade soil further decrease when they are inundated for a longer period. Similarly, consolidation test also shows that a quick and higher settlement could occur when the soil is inundated for a longer period.

3.7 STABILIZATION OF SOFT SOIL USING CHICKEN FEATHERS AS BIOPOLYMER

Standard proctor test and compression test are done to find the maximum dry density and deflection of the soil .compression strength of the soft soil increases up to 5 % addition of chicken feathers and then decreases as the quantity of the chicken feathers are increased further also the maximum dry density value show higher value when adding 5% and 10% of chicken feather fibre

CHAPTER 4

EXPERIMENTAL INVESTIGATIONS

4.1 GENERAL

The soil tests were conducted in order to study the various properties of soil and also CBR test is conducted on soil to find the strength of the soil. CFF is mixed with soil and then CBR test is conducted for various soaked conditions and then it is compared with CBR test performed on virgin soil under 1 day and 3 day soaked conditions.

4.2 SOIL

Expansive soil samples were obtained from an open cut on the site from Jyothi Engineering College Campus, sheltered in plastic bags, and transported to the laboratory to be tested.

4.3 CHICKEN FEATHER

Chicken feathers are obtained as a waste from the poultry farms. These are generally used as animal feeder in other countries and also as a nitrogen source (12%). Chicken feathers has protein content 70% to 80%. Chicken feathers mainly have three parts barbs, quills and rachis. Chicken feathers are very light in weight, the diameter of the quill is less than 4 mm. and the length of barbs are from 1 cm. to 4 cm. These chicken feathers easily combine with others materials and are biodegradable. These are collected from the poultry farms and are kept in a safe place from the reach of animals and birds.

4.4 PROCESSING OF CFF

Later these chicken feathers are washed with water, rinsed with detergent and are oven dried to remove the odour. Due to this heat bugs in the chicken feathers die.

Fig 3:- taking optimum percentage of CFF

4.5 SOIL CFF MATRIX

Soil samples are collected and value adopted in the present study for the percentage of fiber reinforcement are 0.25 When fiber reinforcement was used, the adopted content of fibers was first mixed into the air-dried soil in small increments by hand, making sure that all the fibers were mixed thoroughly, so that a fairly homogenous mixture is obtained, and then the required water was added.

Fig 4:- soil CFF mixing

4.6 LABORATORY TESTS CONDUCTED

1. Sieve analysis
2. Determination of water content
3. Liquid limit
4. Plastic limit
5. California Bearing Ratio test (CBR)

4.6.1 SIEVE ANALYSIS TEST

4.6.1.1 General

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. For analysis of the particle distribution, we sometimes use D10, D30, and D60 etc. terms which represents a size in mm such that 10%, 30% and 60% of particles respectively are finer than that size. The size of D10 also called the effective size or diameter is a very useful data. There is a term called uniformity coefficient Cu which comes from the ratio of D60 and D10, it gives a measure of the range of the particle size of the soil sample.

4.6.1.2 Procedure

1. Take a required quantity of soil.
2. Sieve the sample through a set of coarse sieve by hand power. While sieving the sieves should be arranged in descending order.
3. Determine mass of material retained on each sieve.
4. Calculate the percentage of soil retained on each sieve. Determine Percentage Finer.
5. Take required quantity of sample and sieve it through 4.75 mm sieve.
6. Sieve the soil through set of fine sieves. The sieves should be agitated so that the sample rolls in irregular motion over the sieves.
7. Take material retained on various sieves in a mortar. Rub it with rubber pestle.
8. Determine percentage Retained cumulative percentage and percentage finer.

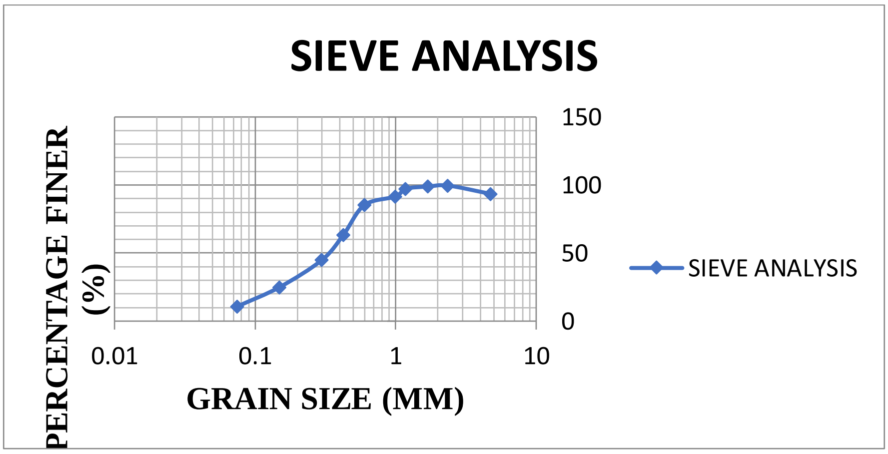

Fig 5

4.6.1.3 Result

Effective size of particle = .72mm

Uniformity Co-efficient = 5.3

Co-efficient of curvature = 1.4

% Finer = 3.8

4.6.2 DETERMINATION OF LIQUD LIMIT

4.6.2.1 General

The liquid limit (LL) is conceptually defined as the water content at which the behavior of a clayey soil changes from the plastic state to the liquid state. Those limit of soil are very important property of fine grained soil and its Value is used to classify fine grained soil and calculate activity of clays and toughness index of soil. Moreover, it also gives us information regarding the state of consistency of soil onsite. In addition, it also can be used to predict the consolidation properties of soil while calculating allowable bearing capacity & settlement.

4.6.2.2 Procedure

1. Put 250 gm of air-dried soil, passed thorough 425 mm sieve, into an evaporating dish.
2. Add distilled water into the soil and mix it thoroughly to form uniform paste.
3. Place a portion of the paste in the cup of Liquid Limit device and spread it with a few strokes of spatula.
4. Trim it to a depth of 1 cm at the point of maximum thickness and return excess of soil to the dish.
5. Using the grooving tool, cut a groove along the centre line of soil pat in the cup, of proper dimension is formed.
6. Lift and drop the cup by turning crank at the rate of two revolutions per second until the two halves of soil cake come in contact with each other for a length of about 13 mm by flow only, and record the number of blows, N.
7. Take a representative portion of soil from the cup for moisture content determination.
8. Repeat the test with different moisture contents at least four more times for blows between10 and 40.

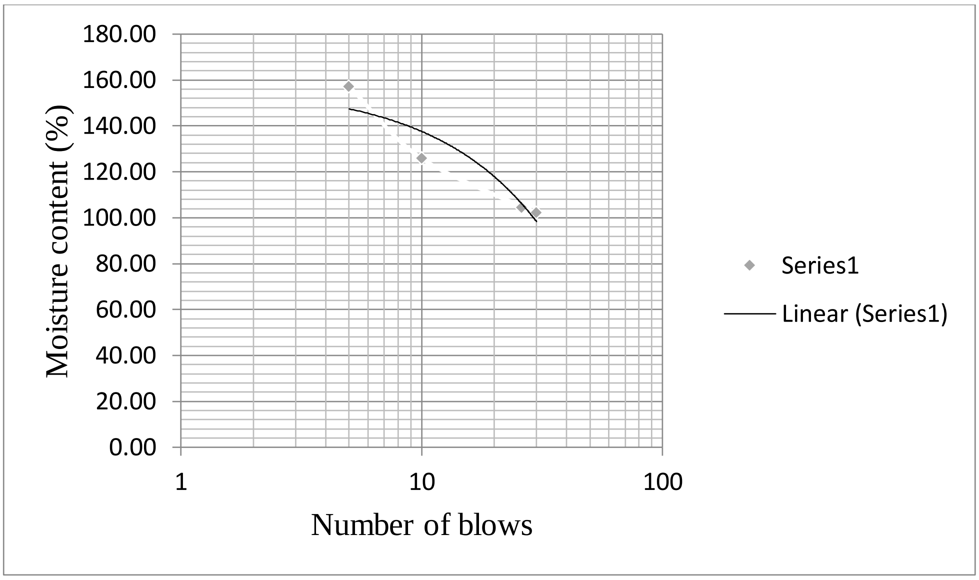

Fig 6:- Graph of moisture content v/s number of blows

4.6.2.3 Result

Liquid limit=104.46%

4.6.3 DETERMINATION OF PLASTIC LIMIT

4.6.3.1 GENERAL

Plastic limit is the constant defined as the lowest moisture content and expressed as a percentage of the weight of the oven dried soil at which the soil can be rolled into threads one-eighth inch in diameter without the soil breaking into pieces, also the moisture content of a solid at which a soil changes from a plastic state to a semisolid state. Those limit of soil are very important property of fine grained soil and its Value is used to classify fine grained soil and calculate activity of clays and toughness index of soil. Moreover, it also gives us information regarding the state of consistency of soil onsite. In addition, it also can be used to predict the consolidation properties of soil while calculating allowable bearing capacity & settlement.

4.6.3.2 procedure

1. Put 20 gm of air-dried soil, passed thorough 425 mm sieve, into an evaporating dish. Add distilled water into the soil and mix it thoroughly to form uniform paste (the soil paste should be plastic enough to be easily moulded with fingers.
2. Prepare several ellipsoidal shaped soil masses by squeezing the soil between your fingers.Take one of the soil masses and roll it on the glass plate using your figures.

3. The pressure of rolling should be just enough to make thread of uniform diameter throughout its length. The rate of rolling shall be between 60 to 90 strokes per min.
4. Continue rolling until you get the thread diameter of 3 mm.
5. Continue the process until the thread crumbles when the diameter is 3 mm.
6. Collect the pieces of the crumbled thread for moisture content determination.
7. Repeat the test to at least 3 times and take the average of the results calculated to the nearest whole number.
8. Eject out the soil sample from the mould cut it in the middle and keep a representative soil specimen for water content determination.
9. Repeat the steps 5 to 7 for about 6 times using a fresh part of the soil.

4.6.3.3 Result

Plastic limit (Wp) = 25.92%

Plasticity index (Ip) = WL-Wp= 104-25.92 = 78.08%

4.3.3.4 Inference

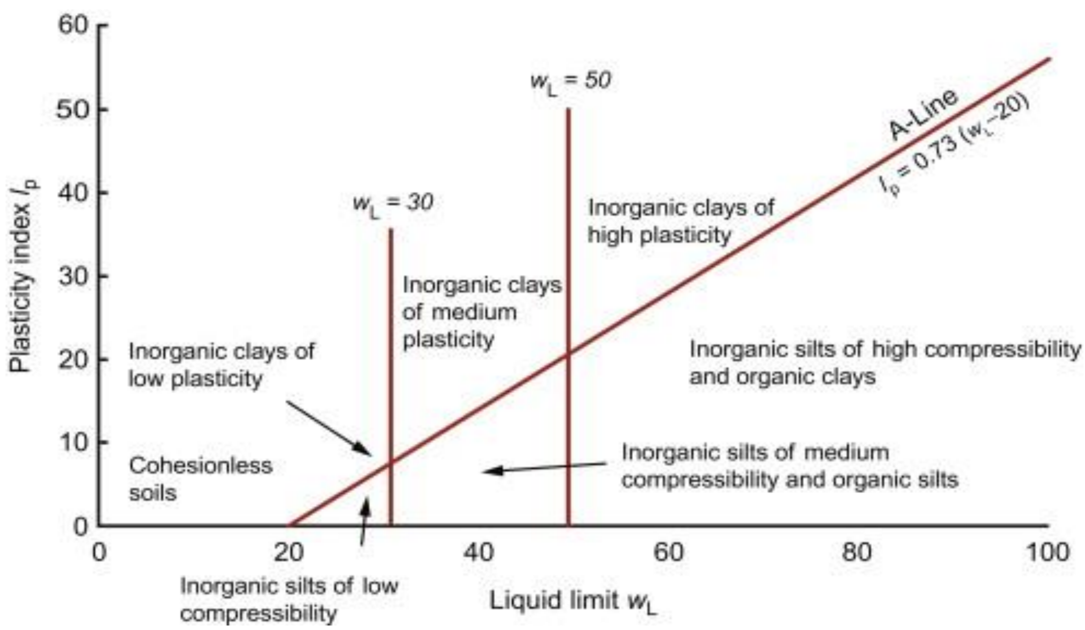

Fig 7

From the above graph corresponding to the liquid limit of 104.46 and plasticity index of 78.08% the soil is inorganic clays of high plasticity.

4.6.4 DETERMINATION OF WATER CONTENT

4.6.4.1 General

Water content or moisture content is the quantity of water contained in soil and is expressed as a ratio, which can range from 0 (completely dry) to the value of the materials' porosity at saturation.

4.6.4.2 Procedure

1. Clean, dry and weigh the container with lid.
2. Take the required quantity of soil specimen in the container and weigh the lid.
3. Maintain the temperature of oven between 105ÂžC to 110ÂžC.
4. Dry the sample in the oven to its mass becomes constant.
5. After drying remove the container from the oven. Replace the lid and allow to cool.
6. Weigh the dry soil in the container with lid.

4.6.4.3 Result

Water content=18%

4.6.5 CALIFORNIA BEARING RATIO TEST

4.6.5.1 General

CBR test, an empirical test, has been used to determine the material properties for pavement design. Empirical tests measure the strength of the material and are not a true representation of the resilient modulus. It is a penetration test wherein a standard piston, having an area of 3 in or 76 mm diameter, is used to penetrate the soil at a standard rate of 1.25 mm/minute. The pressure up to a penetration of 12.5 mm and the ratio to the bearing value of a standard crushed rock is termed as the CBR. In most cases, CBR decreases as the penetration increases.The CBR is a measure of resistance of a material to penetration of standard plunger under controlled density and moisture conditions.The CBR test may be conducted in re-molded or undisturbed specimen in the laboratory. The test is simple and has been extensively investigated for field correlations of flexible pavement thickness requirement.

4.6.5.2 Procedure

1. The laboratory CBR apparatus consists of a mould 150 mm diameter with a base plate and acollar, a loading frame and dial gauges for measuring the penetration values and the expansion on soaking.

2. The specimen in the mould is soaked in water for four days and the swelling and water absorption values are noted. The surcharge weight is placed on the top of the specimen in the mould and the assembly is placed under the plunger of the loading frame.
3. Load is applied on the sample by a standard plunger with diameter of 50 mm at the rate of1.25 mm/min. A load penetration curve is drawn. The load values on standard crushed stones are 1370 kg and 2055 kg at 2.5 mm and 5.0 mm penetrations respectively.
4. Test result is compared with standard penetration values and suitable readings are adopted.

4.6.5.3 Result

CBR value of virgin soil=43.89

4.6.6 Procedure for soaked condition

Step 1 : If a solid baseplate have been used. This shall he removed from the mould and replaced with a perforated base plate.

Step 2 : Fit the collar to the other end of the mould. packing the screw threads with petroleum jelly to obtain a watertight joint.

Step 3 : Place the mould assembly in the empty soaking tank. Place a filter paper on top of the sample followed by the perforated swell plate. Fit the required number of annular surcharge discs around the stem on the perforated plate.

Step 4 : Mount the dial gauge support on top of the extension collar, secure the dial gauge in place and adjust the stem on the perforated plate to give a convenient zero reading.

Step 5 : Fill the soaking tank with water to. Just below the top of the mould extension collar. Start the timer when the water has just covered the baseplate.

Step 6 : Record readings of the dial gauge each day.

Step 7 : Take off the dial gauge and its support. Remove the mould assembly from the soaking tank and allow the sample to drain for 15 min.

Step 8 : Remove the surcharge discs, perforated plate and extension collar, Remove the perforated baseplate and relit the solid baseplate if available.

Step 9 : lf the sample has swollen. Trim it level with the end of the mould.

The sample is then ready for test in the soaked condition.

Fig 8:- showing Soil sample under soaked condition

4.6.6.1 Results

CBR value of virgin soil=43.89

CBR value of soil with 1 day soaked condition =27.07

CBR value for virgin soil with 3 day soaked condition=3.28

CBR value for .25% CFF with 1 day soaked condition=27.48

CBR value for .25% CFF with 2 day soaked condition=16.81

CBR value with .25% CFF under 3 day soaked condition=3.69

CHAPTER 5

RESULT

Liquid limit=104.46%

Plastic limit== 25.92%

Plasticity index (Ip) = WL-Wp= 104-25.92 = 78.08%

Water content=18%

CBR value of virgin soil=43.89

CBR value of soil with 1 day soaked condition =27.07

CBR value for virgin soil with 3 day soaked condition=3.28

CBR value for .25% CFF with 1 day soaked condition=27.48

CBR value for .25% CFF with 2 day soaked condition=16.81

CBR value with .25% CFF under 3 day soaked condition=3.69

5.1 STRENGTH COMPARISON

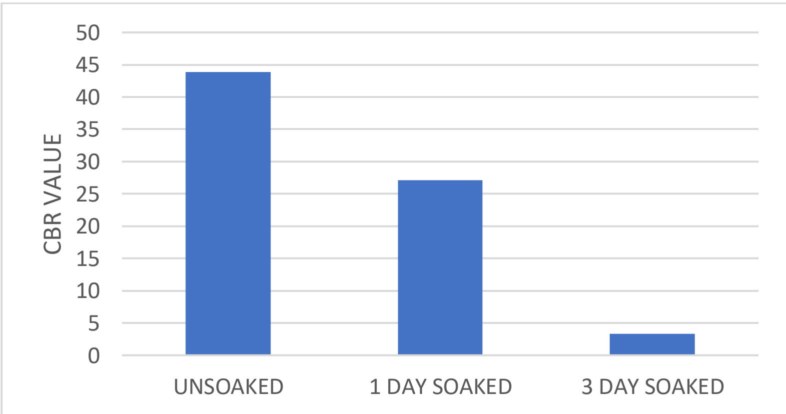

Fig 9:- Comparison of CBR for soaked and unsoaked condition

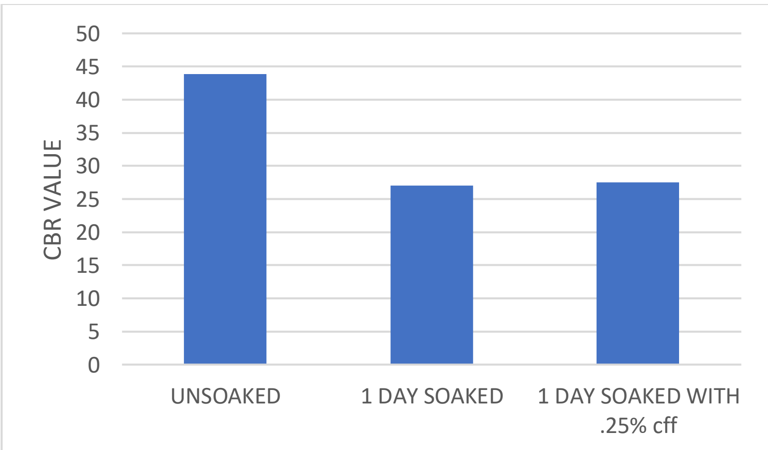

Fig 10:- Comparison of CBR for 1 day submerged condition with and without .25% CFF

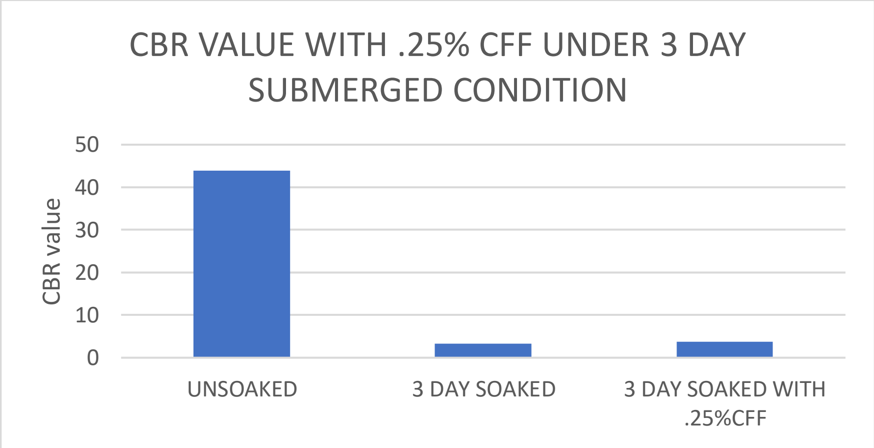

Fig 11:- Comparison of CBR for 3 day submerged condition with and without .25%CFF

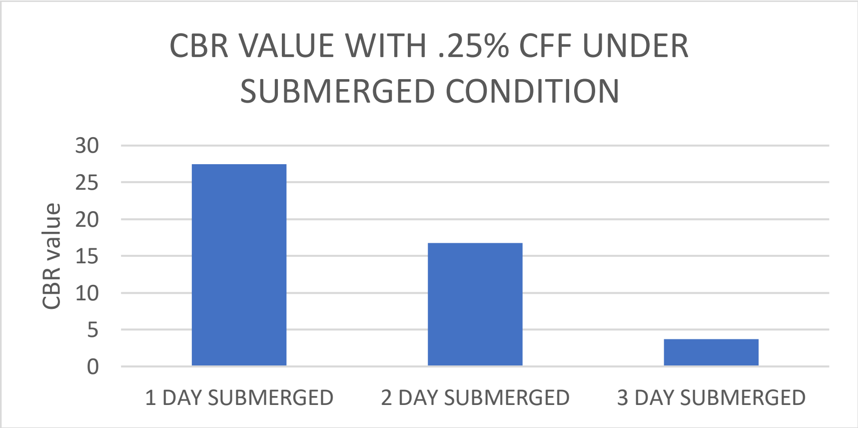

Fig 12:- Comparison of CBR for .25% CFF under varying submerged condition

CHAPTER 5
CONCLUSION

- This experimental study had been conducted in order to determine the strength of soil sample containing CFF and its capability to maintain the strength when the soil samples are kept in different inundation conditions.
- From the result of this study, it can be concluded that the soil samples that have been kept in longer duration of inundation tends to loss the strength as expected.
- An optimum percentage of .25% of CFF was added and tested in the different days of inundation indicated that it can help to increase and maintain the strength of the soil.
- The reduction of subgrade strength once it is inundated can be very significant.
- In this study, CFF helps recover strength loss due to inundation of 1 day submerged condition by 1.5%
- For 3 day submerged condition it helps to recover 12.5% strength
- Hence it is concluded that it would be effective under extreme flooding events.

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APPENDIX

I s sieve size	wt. retained in gm	% wt retained	Cumulative % wt retained	%PASSING
4.75	0.1	0.0033	0.0033	93.5
2.36	12	0.4	0.4	99.6
1.7	21	0.7	1.1	98.9
1.18	50	1.67	2.8	97.2
1	170	5.67	8.4	91.6
0.6	358	11.9	14.7	85.3
0.425	658	21.9	36.64	63.36
0.3	550	18.33	54.97	45.03
0.15	600	20	75	25
0.075	425	14.2	89.14	10.86
Pan	155.9	5.2	94.33	5.67

Table 1:- Observation of sieve analysis test

Container Number	**1**	**2**	**5**	**6**
Number of blows	26	30	10	5
Weight of container(w1)	35.57	30.11	33.78	36
Weight of container +wt. of wet soil(w2)	37.68	33.45	35.73	38.2
Weight of container +wt. of dry soil(w3)	37.59	33.38	35.33	37.4
Weight of dry soil w3-w1	2.02	3.27	1.55	1.4
Weight of water w2 -w1	2.11	3.34	1.95	2.2
water content=(w2 -w1)*100/(w3 -w1)	104.46	102.14	125.81	157.1

Table 2:- Observation of liquid limit

Container Number	1	2	3
Weight of the container (M1)	35.56	30.12	36.32
Weight of the container + wet wt of the soil(M2)	37.27	31.66	37.58
Weight of the container + dry wt (M3)	36.92	31.33	37.33
Mass of the water(M2-M3)	0.35	0.33	0.25
Mass of dry soil (M3-M1)	1.36	1.21	1.01
Water content (W)	0.26	0.27	0.25
Average	25.74	27.27	24.75

Table 3:- Observation of plastic limit

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Penetration in mm	Proving ring reading	Load in kg
0.5	31	174.22
1	50	281
1.5	65	365.3
2	82	460.84
2.5	107	601.34
3	110	618.2
4	131	736.22
5	151	848.62
7.5	199	1118.38
10	241	1354.42
12.5	282	1584.84

Table 4:- CBR reading of virgin soil

penetration in mm	proving ring reading	load in kg
0.5	31	174.22
1	50	281
1.5	65	365.3
2	82	460.84
2.5	107	601.34
3	110	618.2
4	131	736.22
5	151	848.62
7.5	199	1118.38
10	241	1354.42
12.5	282	1584.84

Table 5:- CBR reading of virgin soil

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penetration in mm	proving ring reading	load in kg
0.5	11	2.2
1	23	129.26
1.5	31	174.22
2	48	269.76
2.5	66	370.92
3	70	393.4
4	85	477.7
5	98	550.76
7.5	144	809.28
10	176	989.12
12.5	206	1157.72

Table 6:- CBR reading of virgin soil with 1 day soaked condition

penetration in mm	proving ring reading	load in kg
0.5	1	5.62
1	2	11.24
1.5	4	22.48
2	6	33.72
2.5	8	44.96
3	9	50.58
4	10	56.2
5	11	61.82
7.5	13	73.06
10	15	84.3
12.5	18	101.16

Table 7:- CBR reading of virgin soil with 3 day soaked condition

penetration in mm	proving ring reading	load in kg
0.5	11	61.82
1	23	129.26
1.5	36	202.32
2	48	269.76
2.5	67	376.54
3	70	393.4
4	80	449.6
5	98	550.76
7.5	140	786.8
10	176	989.12
12.5	206	1157.72

Table 8.CBR reading of soil with .25% CFF and under 1 day soaked condition

penetration in mm	proving ring reading	load in kg
0.5	0	0
1	11	61.82
1.5	21	118.02
2	30	168.6
2.5	41	230.42
3	52	292.24
4	65	365.3
5	72	404.64
7.5	83	466.46
10	96	539.52
12.5	101	567.62

Table 9:- CBR reading of soil with .25% CFF and under 2 day soaked condition

penetration in mm	proving ring reading	load in kg
0.5	2	11.24
1	3	16.86
1.5	5	28.1
2	7	39.34
2.5	9	50.58
3	10	56.2
4	11	61.82
5	12	67.44
7.5	13	73.06
10	14	78.68
12.5	15	84.3

Table 10:- CBR reading of soil with .25% CFF and under 3 day soaked condition