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Experimental Investigation for Canal Bank Stabilization using Waste Carpet Fiber and Coconut Coir Fiber

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Abstract : When subjected to heavy stresses, soil is typically fragile and prone to instability. A literature evaluation on soil stabilization through low-cost technology was supposed to be the result of this research. Many different reinforcing techniques can be utilized to bring expansive soils under control. These techniques include stabilization through the use of chemical inclusions, rewetting, soil replacement, compression control, humidity, surcharge loading, and heat processes. There is a possibility that none of these approaches will work and will be quite expensive. Even when subjected to moist conditions, coir fibers can keep their tensile strength, especially with their high lignin concentration. The soil was gathered from the area near the canal breach in Fatehgarh Sahib, located in Punjab. It was discovered that the soil index qualities were like, including its specific gravity, water content, and compaction effect, among other things. It refers to the feasibility of stabilizing soil with Carpet Waste Fiber (CWF) and Coconut Coir Fiber (CCF), reusing waste materials, and providing an efficient and eco-friendly alternative. Soil stabilization improves soil performance. CWF's ability to improve expansive soil engineering qualities is tested. Natural fibers are affordable, locally available, disposable, and friendly in civil engineering building and CCF are a popular natural fiber in India. This study evaluates the impact of CWF and CCF on soil liquid limit, swelling capacity, plastic limit, plasticity index, cohesion, and compaction. Various stabilization procedures can be used on unstable soil. CWF and CCF proportions done by 0%, 0.25%, 0.50%, 0.75%, 1%, and 0%, 0.50%, 1%, 1.5%, 2%, by weight of dry soil respectively. Liquid Limit, Plastic Limit, Compaction (OMC & MDD), and California Bearing Ratio are performed on clayey soil combined with CWF and CCF.

IndexTerms **- Liquid Limit, Plastic Limit, OMC, MDD, California Bearing Ratio**

I. INTRODUCTION

There are many distinct types of soil, each of which, among other characteristics, has its unique color, texture, structure, and composition of minerals. The soil is also different in how deep it is. Slowly, the soil is made when rock near the surface of the Earth breaks up into small pieces. Organic matter breaks down and interacts with rock, minerals, and water to form soil. Sand, loam or peat, and clay or silt are the three fundamental soil types. Sand is easy to deal with but lacks water and nutrients. Loam is nutrient-poor, easy to deal with, and holds water effectively. Clay is hard to work with and hardens quickly, but it holds water and nutrients well and doesn't want to give them to plants. Soil problems consistently arise in engineering construction, whether during construction or after. This problem happens because the soil doesn't meet the requirements, like if it doesn't have enough strength to hold up the building on top of it [1]. Construction sites don't always have ideal soil for supporting buildings, bridges, roads, and dams. If the building is on bad soil, it will have many challenges. Sinking ground will cause building fissures. A building often settles because the soil moves because of a surcharge or a change in the ground water table. If the settlement keeps advancing, the walls will crack, and the building will start to move. Settlement problems can be avoided by figuring out what kind of soil a foundation rests on, how different types of soil respond to building loads, and what problems could happen. In India, soil stabilization began in the 1970s [2]. At that time, there was a general lack of petroleum and aggregates, so engineers had to look for ways to improve soil other than just replacing the lousy soil at the building site. Soil stabilization was widespread, but it fell out of favor because old methods were used, and there wasn't an excellent way to do it. As the need for infrastructure, raw materials, and fuel has grown recently, soil stabilization has begun to take on a new form. As more research, materials, and tools become available, it is becoming a popular and cost-effective way to improve the soil. In this project, the soil was made more stable by scattering polypropylene fibers from waste materials differently [3]. There has been much focus on improving the shear strength parameters, and studies have been done to compare the different ways of measuring shear resistance. To fix this soil problem, you must use particular ways to improve the soil. There are many ways to improve soil, such as by compacting it, making it more stable, or making it denser. Soil consolidation is the process of taking water out of the soil. It removes water to harden it. Densification increases weight per unit area and shear strength. In-situ soil is usually highly loose when granular material is placed,

causing site building settlement. Reduce the distance between particles by densifying the soil[4]. Soil stabilization is essential in the building process because of this. The main goals of stabilizing the soil are to change, speed up construction, and make the soil more substantial and last longer. Soil stabilization is also the process of changing the properties of the soil to improve its engineering performance. For example, the density of the soil can be increased by mixing it with additives that change its chemical and physical properties like stiffness, compressibility, permeability, and workability. The ground water level can be lowered, and weak soil can be removed. Any land-based building needs a solid foundation to support it. The soil around the foundation is an essential part of its strength. So, to work with soils, you need to know their properties and the things that affect how they act. Stabilization refers to the methods used to improve the soil's properties. In this study, CWF (RHA) and CCF were looked at to see if they could help stabilize the red soil. Different proportions of CWF and CCF were mixed to determine the basic geotechnical parameters of red soil, such as specific gravity, compaction, unconfined compressive strength, and maximum dry density. It has been seen that adding CWF (RHA) and CCF did not change the soil's ability to be flexible. After adding these two admixtures, tests showed that the maximum dry density and optimal moisture content went up. At one point, adding CWF and CCF makes the maximum dry density and ideal moisture content go down [5]. To see this change as an alternative to its last air with natural preference is an alternative. Auxiliary structure adventures in areas with weak soils have often used various methods to improve the soil's properties. Soil change is used for a variety of planning projects. The most common use is in building roads and sidewalks, where the goal is usually to improve the soil's quality and lower the building cost by using materials already there. Over time, bond and lime have become the two most important materials for making soils even. Clayey soil comprises tiny pieces, usual silicates of aluminum, iron, and magnesium. Most of the time, water can't flow through clayey soil because it absorbs water slowly and keeps it for a long time. The main thing about clayey soil is that it swells when it gets wet and shrinks when it gets dry[1]. Geotechnical engineering says that soil stabilization improves one or more of the soil's chemical and mechanical properties for different engineering projects. Stabilization of soil can also be thought of as the process of mixing the soil with different stabilizers in the right amounts so that there is no change in volume [3]

II. LITERATURE

2.1 Problem Statement

Residents of Sehajadpur village and other nearby villages in the district are worried that the Bhakra canal main line will break because of soil erosion under sandbags that the Irrigation Department put there a while ago. Many people gathered at the canal's damaged part and told the people in charge. Later, XEN Hakam Singh and SDO Gursharan Singh, both from the department, got a better idea of what was happening. Residents said cracks had appeared in the bank before, and the department had put sandbags over them to stop further erosion. But the soil under the sacks was constantly washing away, which made it more likely that a hole would appear. The canal water could get into Mandi Gobindgarh town, hurting people and property. They said the people in charge of the department didn't care about their worries because they didn't take the threat seriously. They wanted the water to stop going into the canal immediately so that the damaged part could be fixed. The XEN said that the fast water current was making the soil eroded. He said that sandbags had been put in place, and every other safety measure had been taken. The same thing happened at the same spot in October 2019, but the needed repairs were made, and more bags were put there.

Soft soil makes it hard for geotechnical engineer to do their job because it causes problems with stability and settlement. Most of the time, this deposit comprises a thick layer of loose soil layers, mostly soft marine clays, and silts. As most of the country's economic and social growth is happening along the coast, the construction industry must deal with problems caused by building on soft soil. Soft soil has high compressibility and low shear strength and doesn't let much water through. Compared to other types of soil, the strength of soft soil grows over time. The main problems with building in this deposit are that it doesn't have enough bearing capacity, that it settles too much after it's built, and that it's unstable when it's being dug out and when it's Through research and field tests, we know a lot about the engineering properties of soft soil [6].

The results of full-scale trial embankments erected on soft soils in this location. With the rapid rise of highway and building construction, soft soil foundation settlement has emerged as one of the most pressing foundation design issues. Generally, the foundation that controls the design is not strong enough for the settlement. Because the ground is soft, a shallow foundation can't be used for building on soft ground. Another method, such as the piling method, should be used in this case. When compared to a shallow foundation, this method is more expensive. So, soft soil stabilization should be considered to keep this from happening and cut down on the project's cost. If not, there is a surcharge or an increase in stress in the soft ground when a road embankment is built, which might cause it to settle or strain. If the extra load is due to filling and building, When the amount of traffic load is close to the soft ground's ultimate bearing capacity, considerable yielding or plastic deformation will occur in both the vertical and horizontal directions. When the deformation is significant and broad, this will be followed by the creation of tension cracks, as well as deep-seated rotational or translational slides. When an embankment on the road collapses onto softer land, it is because the soft soil under the toes of the embankment is slowly moving to the side, and the ground is slowly rising. As the point of failure gets closer, the rate of movement will also speed up. Most of the time, this kind of failure happens during or right after construction. As pore water pressure lowers and deformation or filling is done slowly and gradually, soft ground's shear strength gradually increases owing to consolidation [7].

2.2 Need and Advantages

How much weight a soil can hold affects building construction. Stabilizing the soil makes it easier to forecast how much weight it can hold and improves it. When working with dirt, remember how it varies. Well-graded soil has fewer holes than equally graded soil, which has more. Mixing soil types strengthens it. Lousy soil is expensive to replace; thus, stabilization is needed.

1. It enhances the ground's stability, ultimately increasing the bearing capacity of the soil.
2. It is more cost-effective and uses less energy to enhance the bearing capacity of the soil as opposed to constructing a deep foundation or a raft foundation—both in terms of the cost of the project and the energy it requires.
3. It is also used to provide additional stability to the soil in slopes and other similar situations where it is applied.
4. Sometimes soil stabilization is also used to prevent soil erosion or the creation of dust, which is highly important, especially in dry weather.

5. The stabilization process can also be used to waterproof the soil; this stops water from seeping into the ground, preventing the soil from becoming weaker over time.
6. It assists in decreasing the change in soil volume caused by changes in temperature or the amount of moisture in soil.

The durability and workability of the soil are both improved through stabilization

2.3 Objectives

This study aims to find out how soft solid soil with CWF and CCF added to it is. The following goals will be reached if this study is done:

1. To compare the strength of soft soil that has been treated and soft soil that has not been treated.
2. To find out how well CWF and CCF work in soft soil.
3. Review the latest research on soil, fiber-soil reinforcement, fiber, clayey soil, and unsaturated soil—the mechanical behavior of clay can be seen when it is dry and has a different suction value.
4. Suction, volume change, and shear strength are some of the physical qualities that may be determined by using the conventional triaxial testing method on soils that are fully saturated and unsaturated.
5. Study how waste CWF and CCF affect the shear strength of clayey soil samples made with different amounts of fiber inclusion.
6. To stabilize the canal lining in Fatehgarh Sahib by implementing CWF and CCF.

2.4 Scope of the study

The material prepared for this study is a soft soil and coir fiber sample. There are two types of soil samples collected: undisturbed and disturbed. Near-normally, cemented clays and clayey silts constitute the soil. In this study, "soil" refers to clays with high moisture content, close to the liquid limit, and a high degree of sensitivity. Soil samples are collected from locations close to Fatehgarh Sahib.

2.5 Significance of Study

The CCF is also easy to find in India, the Philippines, Thailand, Indonesia, and Punjab. The CCF is also strong and long-lasting so that it can be used in a cementitious matrix for a high performance structural element. Flexural properties are essential for building materials, mainly used in places like country roads or pavement. When natural fibers are used as reinforcements, the bending strength, post-crack load-bearing capacity, and energy absorption all get better. The CCF is an excellent way to strengthen and stabilize soft soil because it is strong and made of biodegradable organic fibers that are also the hardest of all-natural fibers. The CCF is also a product that doesn't harm the environment too much, so its use won't cause any harm and won't cause any resentment. This method will stop the failure of road embankments, prevent settlement, protect stream banks, and keep pond liners from breaking. Also, this method will improve the shear strength of soft soil.

III. RESEARCH METHODOLOGY

Table 1 IS Code used in the study

SL.NO.	Properties	Confirming to IS Code
1	Proctor Test	IS 2720: Part VIII: 1983
2	Atterberg Limits	IS 2720: Part V: 1985
3	Grain Size Analysis	IS 2720: Part IV: 1985
4	Determination of Free Swell Index	IS 2720: Part XL: 1977
5	Determination of CBR	IS 2720: Part XVI: 1987
6	Direct Shear Test	IS 2720: Part XIII: 1986

3.1 Materials

3.1.1 Clay Soi: Clay is a natural material found in fine-grained rocks or soil and is formed when one or even more clay minerals, trace amounts of metal oxides, and organic materials are combined. The clay soil was collected and located nearby the Fatehgarh Sahib canal bank river. Its composition was clay soil. Clays are malleable because of their amount of water, but they can be dried or fired to make them rigid, brittle, and non-plastic. Clay layers in the Earth's crust are almost entirely made up of phyllosilicate minerals, which can contain varying amounts of water inside their crystal structures. Clay can appear in a wide range of hues, from white through dull grey or brown to a vivid orange-red, depending on the soil's composition.

3.1.2 Waste Carpet Fiber: Carpet is by far the most popular choice for use as a floor covering. The market for floor covering in square feet worldwide was dominated by carpets and area rugs, accounting for 73.2% of the total share. Around four million to eight million tonnes of carpet are discarded each year across the world. Currently, most post-consumer carpets are disposed of in landfills, burned at incineration plants or cement kilns, or otherwise incinerated. Finding a sufficient disposal location will be difficult, resulting in significant environmental concerns that may have unfavourable repercussions on the carpet business.

Dumping waste in landfills has a wide range of unfavourable effects on the environment and the economy. When disposed of in landfills, synthetic carpets decompose very slowly, contribute to methane production, take up space, and potentially absorb harmful chemicals.



Figure 1 Waste Carpet Fiber

3.1.3 Coconut Coir Fiber: Coir is a natural fiber that can be used in various applications. It is taken from the mesocarp tissue, often known as the husk of the coconut fruit. Because the fiber typically has a golden hue when it has been washed and freed from the coconut husk, it is referred to as "The Golden Fiber."

The fibrous husk removed from a coconut's outside is known as coir. Because it is hardy and naturally resistant to seawater, the coir protects the fruit to the extent that it can survive months of floating on ocean currents until it is washed up on a sandy shore where it may sprout and grow into a tree, as all of the Other essential nutrients have been transported with the seed. It is true even if it lacks fresh water, as the seed contains all the other nutrients it requires. As a result of these properties, the fibers can be used for vari ous purposes, such as floor and outdoor mats, aquarium filters, cordage and rope, and garden mulch.



Figure 2 Coconut Coir Fiber

3.1.4 Coir Fiber Structure: The individual cells that make up the fiber are thin and hollow; their cell walls are thick and composed of cellulose. They are white while they are juvenile, but as time goes on, a layer of lignin is developed on their walls, which causes them to harden and turn yellow. Because mature brown coir fibers are higher in lignin content and lower in cellulose content than other types of fibers, such as flax and cotton, they are more rigid and less pliable. They are comprised of excellent threads, each measuring less than 0.05 inch (1.3 mm) in length and ranging in diameter from 10 to 20 micrometres. White fiber is more refined and smoother, but it is also thinner and less intense. In addition to being partially waterproof, the coir fiber is the only natural fiber resistant to salt water harm [22].

White fibers that are easily bendable can be seen inside green coconuts after spending around six to twelve months on the plant when the nutrient-rich layer surrounding the seed is prepared to be processed into copra and desiccated coconut results in the production of brown fiber. After that, By pressing the fruit onto a spike, the fruit's fibrous layer is physically separated from the fruit's hard shell. It allows the fibrous layer to be removed (De-husking). Currently, machines can smash the entire fruit to extract the free fibers.

3.2 Methods

3.2.1 A method of stabilization that is mechanical

During this procedure, several soils of differing gradations are mixed to produce soil with the desired quality. A method of stabilization refers to producing soil with the desired quality. It can be done at the venue or at another location where it can be swiftly transported. Either way, it can be done. The finished mixture is subjected to conventional compression methods at the beginning of the process to get the desired density.

3.2.2 Method of stabilization based on addition

It refers to incorporating artificial items into the soil, which can improve the soil's overall quality when applied in the appropriate amounts. As chemical additions, materials like cement, lime, bitumen, fly ash, and other similar substances are utilized. In other instances, various fibers are also utilized in reinforcing components within the soil. Two different approaches are utilized to include these fibers.

3.2.3 Reinforcement made of oriented fibers

The fibers are laid out in some order and oriented in the same direction. In this particular orientation, the fibers are arranged in a layer-by-layer fashion. In this kind of arrangement, continuous threads are used methodically. These fibers can be paper, strips, or bars, among other things.

3.2.4 Reinforcement using random fiber placement

This configuration consists of discrete fibers randomly dispersed across the soil mass. The mixing continues until the soil and the reinforcement comes together to form a more or less homogenous mixture. Paper, Nylon, metals, or other materials with a wide range of different physical qualities may be utilized to derive the materials that go into making this type of reinforcements. Various benefits are associated with randomly scattered fibers compared to regularly distributed fibers. This reinforcement method is comparable, in some sense, to adding admixtures such as cement, lime, and other similar substances. This strategy not only makes adding and combining components simple but also gives the soil ductility, reducing the risk of potential weak planes occurring due to the alternative, and delivering isotropic strength.

3.3 Geotechnical properties of materials

Important geotechnical properties of the soil sample have been discussed below:

Soil Sample: The Soil Mix Collect from the Fatehgarh Sahib Canal Bank and its geotechnical properties are shown below.

Table 2 Material Properties

Serial no.	Property	Results
1	Optimum Moisture Content	Mix D
2	MDD	1.708 gm/cc
3	Liquid Limit	27.00%
4	Plastic Limit	Nil
5	Free swell index	0.00%
6	Grain Size Analysis	Gravel - 00%, sand - 81.00% silt & Clay - 19.00%
7	California Bearing Ratio	5.21%

3.4 Sample Types

MIX A*: Mixing of CWF 0.25% and CCF 0.50% in soil*
MIX B*: Mixing of CWF 0.50% and CCF 1% in soil*
MIX C*: Mixing of CWF 0.75% and CCF 1.5% in soil*
MIX D*: Mixing of CWF 1% and CCF 2% in soil*

IV. EXPERIMENTAL TEST AND ANALYSIS

Proctor Test: The Proctor compaction test is a standard procedure for determining the optimal amount of moisture at which a given soil type becomes most dense and reaches its maximum dry density experimentally.

Atterberg Limit

The Atterberg limits are a fundamental measure of a fine-grained soil's critical water content: its shrinkage, plastic, and liquid limit.

Free Swell Index

The Free Swell Index measures the volume increase in soil caused by submersion in water without any external constraints. Free swell index test of soil(IS-2720-PART-40-1970)

Grain Size Analysis

Grain size analysis is a standard laboratory test in soil mechanics. The analysis's objective is to determine the distribution of soils. Sieve Grain Size Analysis can determine the size of particles ranging from 0.075 mm to 100 mm.

The test is conducted using a collection of sieves with varying mesh sizes. Each sieve has a specific number of square-shaped openings of varying sizes. The sieve segregates more significant from more acceptable molecules, resulting in a two-part distribution of the soil sample.
The sieve retains grains with diameters more significant than the size of the openings, while grains with smaller diameters pass through. The test is conducted by stacking successive sieves with decreasing mesh sizes and having to pass the soil through the layered sieve "tower." As a result, the soil is distributed according to its retention by the various sieves. Additionally, a pan collects particles that move through the final sieve.

California Bearing Ratio
It is the ratio of the force required per unit area to penetrate the soil with a circular piston at a rate of 1.25 mm/min. To the force required to penetrate a standard material at the same rate.

Direct Shear Test
The direct or box shear tests are used to determine the soil's shear strength. It is more suited to non-cohesive soils. The Direct Shear Test is a laboratory experiment used in geotechnical engineering and research to determine the ultimate capacity of soil materials. The term "shear strength" refers to the maximum susceptibility that a structure can withstand when sheared. In general, the Direct Shear Test is one of the most widely used and straightforward methods for determining soil strength. It can be performed on uninterrupted or remoulded samples. This test is utilized to discover the union (c) and the point of inward contact (φ) of the dirt, which is the dirt shear strength boundaries.

Nomenclature
The nomenclature of the sample is shown in table 3

Table 3 Nomenclature

Name	***Mixing amount in percentage soil***	
	CWF	***CCF***
Control Mix	*0*	*0*
Mix A	*0.25*	*0.50*
Mix B	*0.50*	*1*
Mix C	*0.75*	*1.5*
Mix D	*1*	*2*

V. RESULT AND DISCUSSION

4.1 Proctor Test
Table 4.1: Consolidated Result of Proctor Test

Replacement	Control Mix	Mix A	Mix B	Mix C	Mix D
OMC (%)	13.50	12.20	12.00	12.00	11.00
MDD (gm/cc)	1.708	1.738	1.762	1.758	1.736

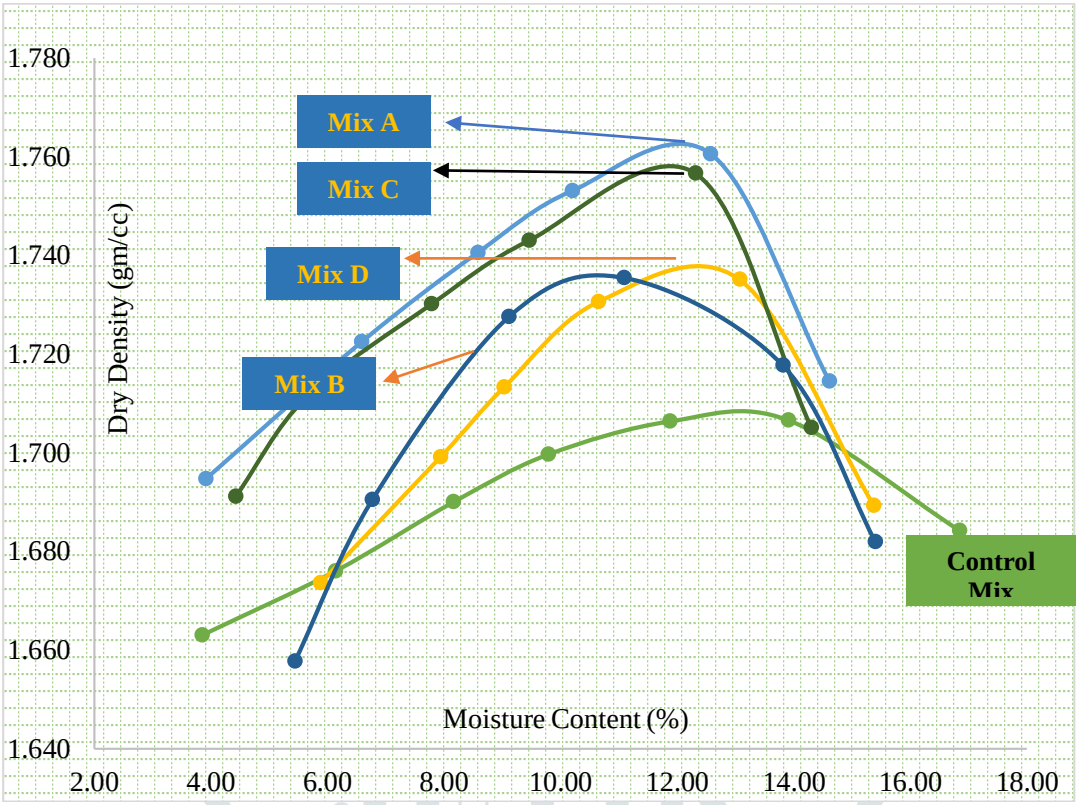

Figure 3 Consolidated Result of Proctor Test

The maximum Dry density is recorded at Mix A, so the next test is to be carried out on this variation.

Table 4.2 Consolidated result of Liquid Limit Test

Replacement	**Control Mix**	**Mix A**	**Mix B**	**Mix C**	**Mix D**
OMC (%)	27	26.5	28	28.5	29.5

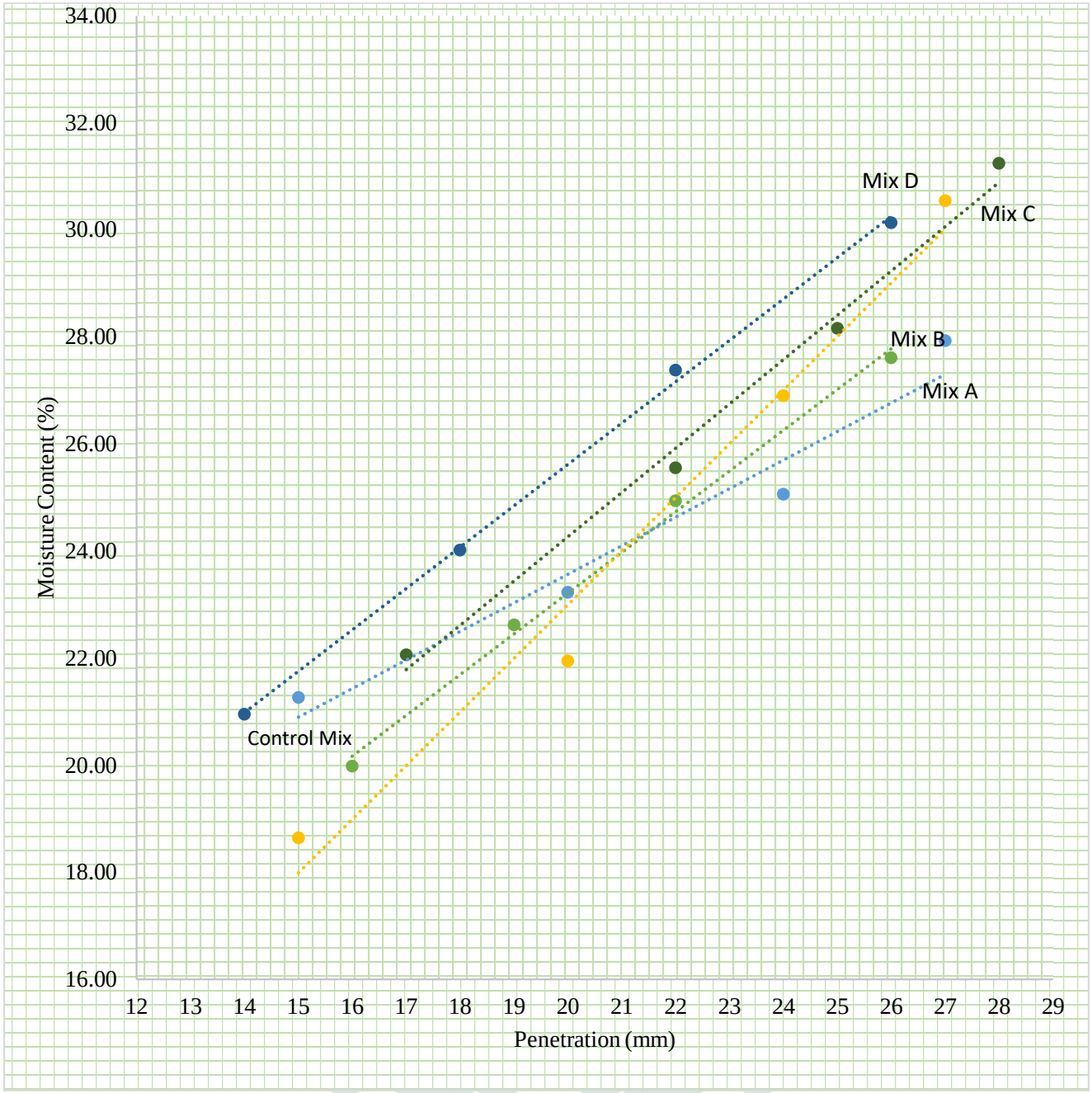

Figure 4 Consolidated result of liquid limit

2. Free Swell Index

Table 4 Free swell index

Soil Sample	Test no.01			Test no.02			Average FSI (%)
	The volume of soil in		FSI	Volume of soil in		FSI	
	Water	Kerosene		Water	Kerosene		
Control Mix	10	10	0.00	10	10	0.00	0.00
Mix A	10	10	0.00	10	10	0.00	0.00
Mix B	10	10	0.00	10	10	0.00	0.00
Mix C	10	10	0.00	10	10	0.00	0.00
Mix D	11	10	0.00	10	10	0.00	0.00

Non-cohesive soil, so FSI is found to be zero. It is considered free from swelling for all replacements.

3. Grain Size Analysis

Table 5 Comparative analysis of percentage of Silt and Clay

Mixing	Gravel (%)	Sand (%)	Silt and clay (%)
Control Mix	0	88	12
Mix A	0	89	11
Mix B	0	88.4	11.6
Mix C	0	89.8	10.2
Mix D	0	90.6	9.4

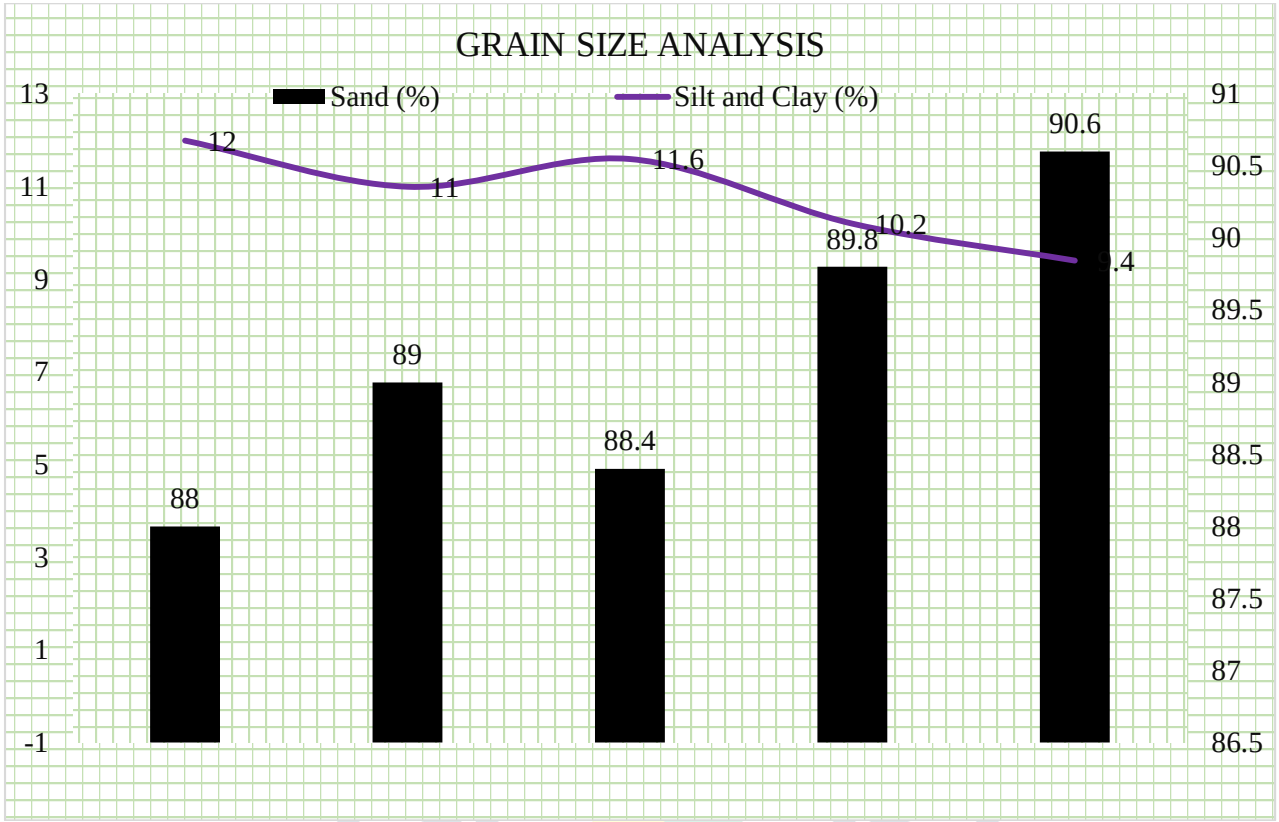

Figure 5 Comparative analysis of grain size

The above graph illustrates the grain size distribution of soil with the mixing of CCF and CWF, and it is visible in a graph that silt and clay content is decreasing gradually with increasing the mixing fiber.

Similarly, the sand particle increased with mixing and recorded as high as 90.6 at 12.5% mixing of fiber. There is a reason sand content is increasing due to the more granular size of particles availability

4 . California Bearing Ratio Test

Table 6 Consolidated CBR Test

Replacement	Control Mix	Mix B	Mix C
CBR VALUE (%)	4.09	9.02	9.92

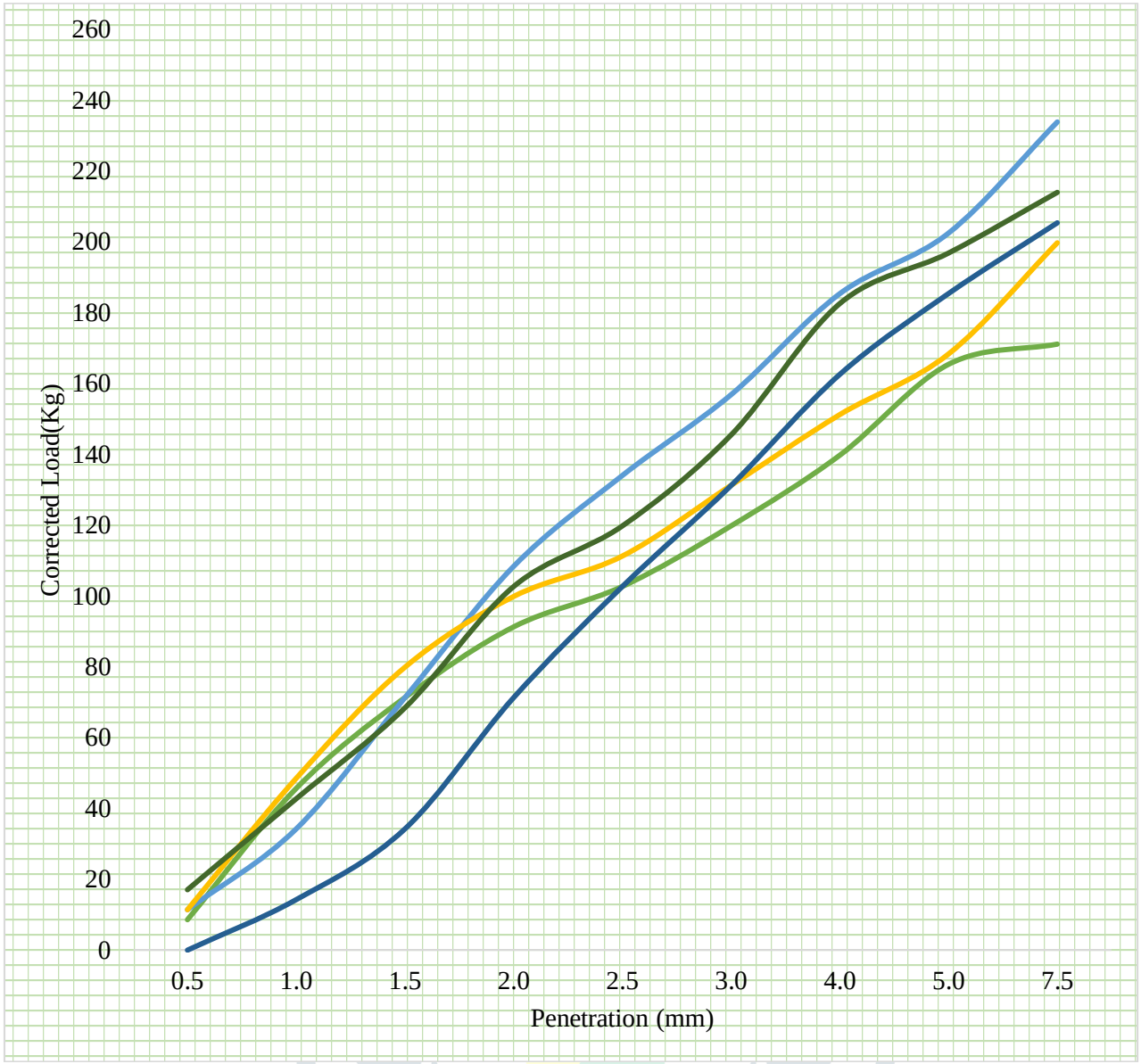

Figure 6 Consolidate CBR value (%)

It can be observed from figure 4 that the variation in CBR value is only due to the effect of soil characteristics rather than another factor.

5. Direct shear test

Table 7 Consolidate Data for direct shear test

Replacement	Mix B	Mix C
COHESION (kg/cm^2)	0.25	0.21
ANGLE OF FRICTION(φ)	17°57'	18°33'24.84"

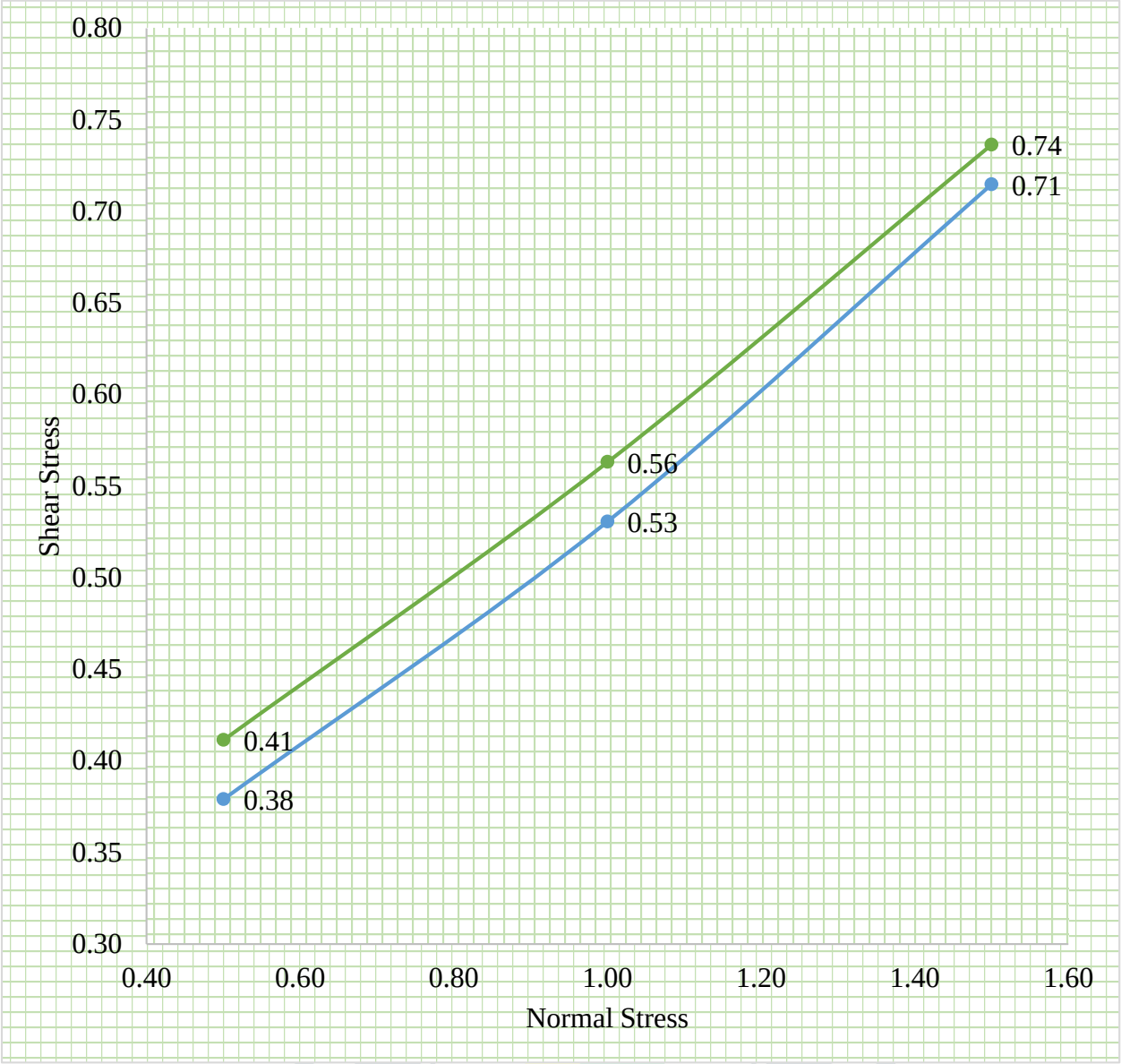

Figure 7 Consolidate Data for direct shear test

VI. Conclusion And Future Scope

Conclusion

- The maximum liquid limit is recorded at Mix D due to high availability moisture content in soil.
- In the proctor test the maximum dry density is recorded 1.762 for Mix B replacement.
- The optimum moisture content is recorded 13.50% at Control mix replacement with CCF and CWF.
- The result of the grain size distribution of soil with mixing CCF and CWF, and it is clearly visible in graph that silt and clay content is decreasing gradually with increasing the mixing of fiber content.
- Similarly, the soil strength is increasing with mixing of CCF and CWF and recorded as high as 90.6 at Mix D mixing. There is a reason for soil strength is increasing due to more fiber contents.
- The maximum value of CBR 9.92 recorded at Mix C replacement.
- The maximum cohesion is recorded 0.25 and 0.21 for Mix B and Mix C replacement of fiber waste respectively.
- Similarly, the friction angle is 17°57’ and 18°33’24.84’’ for Mix B and Mix C of fiber contents respectively.

Recommendation

From the above conclusion it can be stated that

1. Mix B replacement is useful for best stabilization of while neglecting the shear strength.
2. Mix C replacement is useful for best stabilization of while neglecting the shear strength.

This study aims to find out how soft solid soil with CWF and CCF added to it is. The following goals will be reached if this study is done:

- To find out how well CWF and CCF work in soft soil.
- Review the latest research on soil, fiber-soil reinforcement, fiber, clayey soil, and unsaturated soil—the mechanical behavior of clay can be seen when it is dry and has a different suction value.

- Suction, volume change, and shear strength are some of the physical qualities that may be determined by using the conventional triaxial testing method on soils that are fully saturated and unsaturated.
- Study how waste CWF and CCF affect the shear strength of clayey soil samples made with different amounts of fiber inclusion.
- To stabilize the canal lining in Fatehgarh Sahib by implementing CWF and CCF.

Future Scope

- Although, this study has shown that different ash can aid in stabilizing soils by blending.
- Municipal Waste can be used to improve soil stability of fertility.
- Different types of plastic waste are also helpful in eco-friendly stabilization.
- Some other stabilizing additives like lime, rice bran, sugar mill waste, and foundry waste be used.
- Sludge is to be added to soil to improve the strength of weak soil with a deficient bearing capacity.
- Variation in fiber % can be carried out.

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