Experimental Insights Into The Application Of Discarded Shrimp Mesh To Vitalize Swell And Shrink Characteristics Of Expansive Soils

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Abstract
The capacity of expansive soils to expand and contract is widely recognized, and as a result, these volumetric changes seriously damage civil infrastructures. Due to subgrades composed of expansive soils, similar pavement serviceability problems arise in various parts of Pakistan as well as throughout the world. The utilization of used fishing nets to improve the engineering qualities of a neighboring expansive soil is described in this study. This study looked at the moisture-density (OMC and MDD) connection, (UCS), and (CBR) of the soil treated with 0%, 0.4%, and 0.8% WFN. According to the test results, the soil sample's MDD decreased by 8.5%. The average density of the reinforced soil sample may have increased the percentage of WFN in the soil sample, which could explain the decrease in MDD. Denser soil particles (Gs = 2.69) are replaced with WFN with low specific gravity in a unit volume, lowering the soil sample's total unit weight. The OMC of the soil sample with the reinforced soil sample was found to be significantly higher, indicating a significant rise in OMC. This might be due to the expanding nature of the soil, which observed more water, or the nature of WFN, which was unable to observe water into it. UCS has shown a notable improvement. Without WFN reinforcement, the soil's unconfined compressive strength is determined to be 76.2 kPa. When 0.4% WFN was added to soil samples, the unconfined strength of the soil increased to 85.3 kPa, indicating a 10.6% increase, and when 0.8% WFN was added, the unconfined compressive strength of the soil increased to 102.1 kPa, indicating a 30% increase. When 0.4% WFN is added to the soil, the CBR value increases by 8%, and when 0.8% WFN is added, the CBR value increases by 16%, which is twice as much as 0.4% reinforced soil against a penetration of 0.1 inch. This results in a higher-quality subgrade for pavement building on such soils. The experimental calculations show that WFN has great potential as an inexpensive, long-term stabilizing component for often inflated soils.

Keywords: Expansive soil, Soil Stabilization, Waste Fish Net, CBR, UCS, XRD.

1. Introduction

Soil engineers did not recognize the problem of swelling soils until the latter part of 1930. Edge abodes made up the great bulk of the delicately stacked buildings in the United States before to 1920. These designs could be developed over a long period of time without exhibiting noticeable breakdowns. Block facade residences became widely used by 1930. The owner discovered that breaks were being made in the block course at that point. Without acknowledging the role of vast soils, the damages were attributed to the awful development and settlement of the installation at one corner. When the U.S. Department of Reclamation established a steel guide at their Owyhee Project in Oregon in 1938, they first saw the growing dirt problem. Since then, engineers have realized that the cause of damage was occasionally not settlement. The damage to buildings caused by sweeping soils has also increased after 1940 due to the very widespread use of large pieces on-ground [1]. In places like Kohat, Karak, Nowshera Bunnu, Charassada, and Dera Ismail Khan in Khyber Pakhtunkhwa Province (KP), Pakistan, there has been evidence of growing mud. These dirt particles have caused some damage to the limit walls of various buildings and flexible asphalts. Focusing on the growth and pull lead of broad soil is crucially supported by the fact that both of these elements are highly dependent on the physical, mineralogical, and normal characteristics of the soil. The addition of both of these features with the change of sogginess content because of the change of atmospheric conditions is especially depicted previously [2].

One of the biggest problems facing the world today is marine waste. For the ocean and its ecosystem, it is a major problem. Waste fishing nets make up almost half of all the garbage dumped into the ocean. This problem poses a threat to the survival of nearly all marine animals. The majority of marine animals died as a result of being discovered strangled in the trash fishing nets [3]. The sea's environment has also been impacted by the act of discarding all the trash and fishing nets. The lives of marine plants have been disrupted by it [4]. The scope of the issue has only lately come to our attention, and despite its seeming strength, fishermen's equipment deteriorates swiftly due to the conditions in which it operates. There hasn't been a method in place up until now for truly disassembling it and recycling what you can from it. We were unaware of it until recently, and up until then, it was being dumped in landfills, which terrified us since it would continue to pollute the ecosystem and never decompose. It will continue to do so for thousands of years until anything happens to it. An estimated 640,000 tons of fishing gear are dumped into the ocean annually, polluting the water and killing marine life [5]. Because they affect the structural stability of buildings constructed on them, expansive soils are regarded as problematic soils. Therefore, the ability to accurately identify and classify such soils is essential for a practicing geotechnical engineer. This will therefore help with the management of resources materials, time, money, and people all of which are essential elements of project management [6]. Because of their clay mineral component, which causes them to expand and compress, expansive soils are complex. Expansive soils in their original state are unsuitable for direct technical applications because of their shrink-swell tendencies. To improve the soil's suitability for construction, a variety of materials and methods have been used to stabilize it [7].

Other names for expansive soils include swelling soils, shrink-swell soils, and heaving soils. These soils show notable variations in soil moisture and volume. These soils become sticky and grow in volume when they absorb water. Their volumes rise in proportion to the amount of water they take in [8]. Additionally, as moisture levels drop, they shrink and seem puffy or have large surface fissures. When moist circumstances arise, these fissures allow water to penetrate deeply. Structures constructed on such soils experience recurring strains as a result of this cycle of shrinkage and swelling [9]. Because they affect the structural stability of buildings constructed on them, expansive soils are regarded as problematic soils. Therefore, the ability to accurately identify and classify such soils is essential for a practicing geotechnical engineer. Consequently, this will facilitate the management of materials, time, money, and human resources all of which are essential elements of project management [6].

The clay mineral component in expansive soils causes them to expand and contract, making them problematic. Expansive soils in their native state are unsuitable for direct engineering applications because to their shrink-swell characteristics. Numerous strategies and tactics have been employed to stabilize soil in order to improve its suitability for building [7]. Fishing nets are made of nylon since it is a much more durable and affordable material. One synthetic substance that doesn't break down is nylon. This suggests that fishing nets known as "ghost nets," which have sunk to the ocean floor, continue to catch fish for many years. Because of this, hundreds of millions of marine animals are killed or harmed annually by fishing net pollution. For instance, when dolphins become caught in abandoned fishing nets, they choke. When fish are caught, they starve to death. All of these victims are therefore easy pickings for other animals. Because of this, there is a lot of life close to abandoned fishing nets, which raises the possibility of more casualties in the future [10]. Over 640,000 tons of commercial fishing nets, lines, pots, and traps are thrown into the ocean each year. Small fish, crustaceans, endangered turtles, seabirds, and even whales can become entangled in nets and lines, endangering animals for years or decades. Thanks to tides and currents, lost and abandoned fishing gear is rapidly finding its way to Arctic coastlines, washing up on isolated Pacific islands, becoming tangled on coral reefs, and clogging the deep abyss. Despite making up the majority of large plastic-fouling seas, ghost gear is estimated to be responsible for 10% of ocean plastic pollution [11].

Soils are categorized as coarse-grained or fine-grained based on particle size. These are separated into other groups. Different kinds of mineral deposits make up each of these soils. Rock-forming minerals like quartz and feldspar make up the majority of gravel, sand, and silt soils. Because these minerals are solid and electrically inert, their nature has no bearing on the engineering properties of these soils, such as cohesiveness, permeability, and compressibility. On the other hand, fundamental rock-forming minerals underwent chemical weathering to produce the minerals that make up clay soils. The physical, chemical, and biological processes that change the content and structure of rocks are known as weathering. Particles of the mineral clay are small, flaky, crystalline solids. These are tiny particles. When we think of clay, we usually think of clay soil, which is made up of clay minerals and has characteristics like cohesion and plasticity. Some granules might not be suitable for clay, but others might. Rock can be ground into a powder in our lab that is no larger than two microns. These pieces won't be clay soil particles, but they will be about the size of clay. These particles are too tiny to contain enough clay minerals to produce a soil with plastic qualities. Clay minerals differ from materials like gravel, sand, and silt in that they have electrical charges on their surfaces. Significant engineering issues, such as high volume increases when wet and volume decreases when dry, are also impacted by clay soil. Soil fissures caused by these volume changes put the construction of major buildings and highways at risk [12].

Expansive soils are often considered problematic due to their intrinsic characteristics, such as enhanced swelling and shrinking. They expand when water is absorbed during the rainy season and contract as water evaporates during the dry season. Seasonal fluctuations cause soil to undergo cyclic swell-shrink movement, which leads to undesired volume alterations. As a result, the overhanging construction on expansive soil causes significant distress and damages [13-15]. Existing water molecules are pulled into the gaps between the soil plates when water is introduced to expansive soils. As more water is absorbed, the plates are forced apart, increasing the pore pressure in the soil. The soil will expand in volume until the pressures are once again balanced if the additional pressure exceeds the surcharge pressure, which takes into account the weight of the underlying pavement. Swelling pressures have been reported to reach 1000 kPa (145 psi) and can vary from 100 to 200 kPa (14.5 to 29 psi) [16]. Kaolinitic clays that have undergone partial or complete alkali transformation exhibit swelling and mineralogical characteristics that emphasize the later effects of alkali contamination. One-dimensional free swell tests are used to gauge the amount of swelling on alkali-transformed kaolinite clays submerged in water and 4N Noah. As the degree of transformation increases, transformed clays swell more when submerged in water. Swelling diminishes with increasing transformation degree when alkali-transformed clays are submerged in 4 N NaOH; nevertheless, swelling increases with increasing transformation degree when submerged in water. This is largely due to mineralogical alterations in modified clays.

The goals of this study are as follows:

The overall goal of this experimental study is to increase the strength of expanding soil by stabilizing it with WFN. Research has shown that the marine ecosystem is being contaminated by a particular type of plastic. Over 46% of marine debris is made up of fishing nets. Our goal is to employ WFN to enhance soil that will benefit the marine environment and improve field soil mechanics in order to prevent marine pollution.

2. Materials and Method

The samples were taken from Nandipur Town's Potential Swelling District, which is close to Gujranwala, Punjab. After then, a thorough laboratory study was conducted. Preliminary geotechnical tests, such as liquid limits, specific gravity, and sieve analysis, were carried out to determine the characteristics and categorization of expansive soils. SEM and XRD analysis were used to examine the mineralogy and morphology [17], [18].

The dirt used in this study came from Nandipur town in Punjab, Pakistan, which is located at latitude 32.257703 and longitude 74.257805, close to the Gujranwala region. A sample of soil was already dug up to a depth of one foot and put in 50-kg plastic bags. In order to conduct this study, 150 kg of expansive soil were gathered on location and put in the University of Management and Technology's (UMT) geotechnical laboratory in Lahore, Pakistan. In order to prepare soil samples for laboratory testing, they were air-dried and then ground into a 7µm particle size. The physical characteristics of soil include moisture content, specific gravity, liquid limit, plastic limit, plasticity index, (MDD), (OMC), and soil classification. Waste fish nets were obtained for this investigation from local markets in Lahore, Punjab, Pakistan, and processed for use as a stabilizing agent in expansive soil treatment.

3. Results & Discussions

3.1. Effect of WFN on CBR of the soil

In order to determine the resistance capacity of expansive soil (swelling soil, high clay soil) against 0.1-inch and 0.2-inch penetration, a CBR test was carried out in accordance with ASTM D1883 2016. Normal values for this type of soil are typically 2%. To provide better results for comparison, the CBR test was carried out in a wet environment. The results of the CBR test are displayed as load penetration. The load-bearing capacity of the soil is visible in the curve obtained under wet conditions. Under soaking conditions, the sample reinforced with WFN (0%, 0.4%, and 0.8%) rose greatly. The optimal dosage of WFN was discovered to be 0.8%, and it is increasing significantly. CBR percentages for 0%, 0.4%, and 0.8% WFN as soil reinforcement have been computed against penetration of 0.1 and 0.2 inches. The CBR results for the WFN-reinforced soil in this study demonstrate that, in comparison to 0.2 inch penetration under damp conditions, 0.1 inch CBR is higher in percentage. It demonstrates that WFN soil reinforcement is more successful in increasing soil strength at smaller penetrations than at larger penetrations overall. The CBR value is applied against the 0.1-inch penetration. The test results are displayed in the table, and the load penetration curve for the soil reinforced at 0%, 0.4%, and 0.8% is shown in the picture. When 0.4% of WFN is added to the soil, CBR value increases by 8%. When 0.8% WFN is added, the CBR value increases by 16%, which is twice as much as when 0.4% reinforced soil is added against the penetration of 0.1 inch.

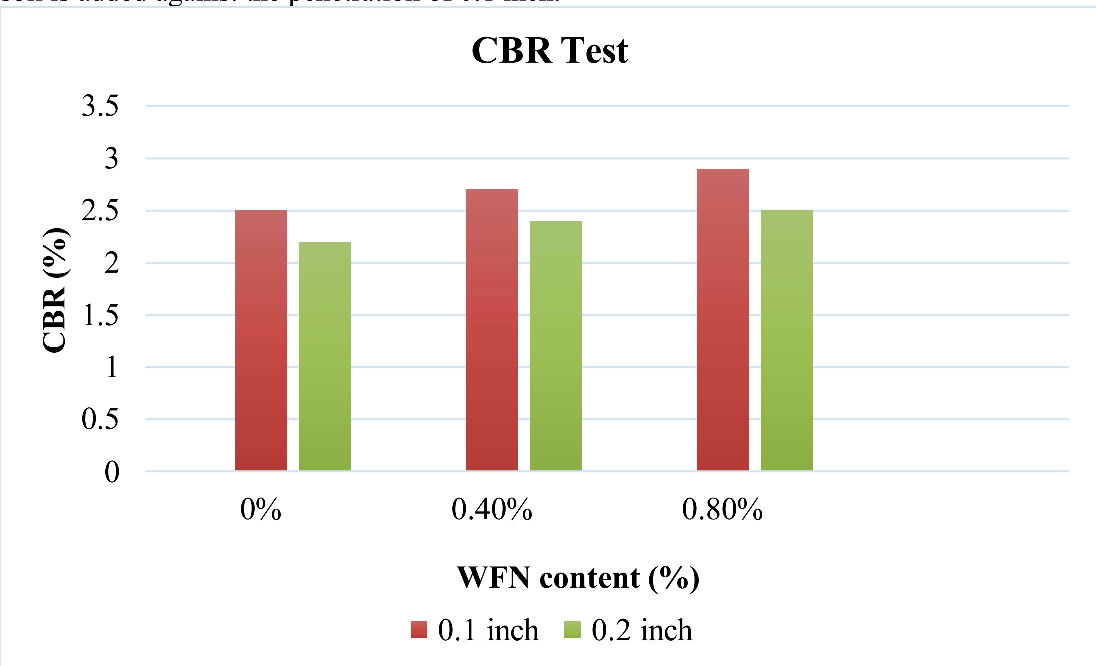

Figure 1: CBR test Results for soil samples

Table 1: CBR test results of soil Samples
Ring Load =2.204 lbs/div

0.0%	**Penetration (in.)**	0.000	0.025	0.050	0.075	0.100	0.150	0.200	0.250	0.300	0.350	0.400	0.450	0.500	Swell %
	Dial reading	0	11	21	28	34	40	45	49	54	58	62	66	70	115
	Load (lbs)	0	24	46	62	75	88	99	108	119	128	137	145	154	
	CBR (%)					2.5		2.2							0.91
	Corrected CBR					2.5		2.2							
0.4%	**Penetration (in.)**	0.000	0.025	0.050	0.075	0.100	0.150	0.200	0.250	0.300	0.350	0.400	0.450	0.500	
	Dial reading	0	14	25	32	37	43	48	53	58	62	67	71	74	108
	Load (lbs)	0	31	55	71	82	95	106	117	128	137	148	156	163	
	CBR (%)					2.7		2.4							0.85
	Corrected CBR					2.7		2.4							
0.8%	**Penetration (in.)**	0.000	0.025	0.050	0.075	0.100	0.150	0.200	0.250	0.300	0.350	0.400	0.450	0.500	
	Dial reading	0	17	28	35	40	46	51	56	61	65	70	74	77	101
	Load (lbs)	0	37	62	77	88	101	112	123	134	143	154	163	170	
	CBR (%)					2.9		2.5							0.80
	Corrected CBR					2.9		2.5							

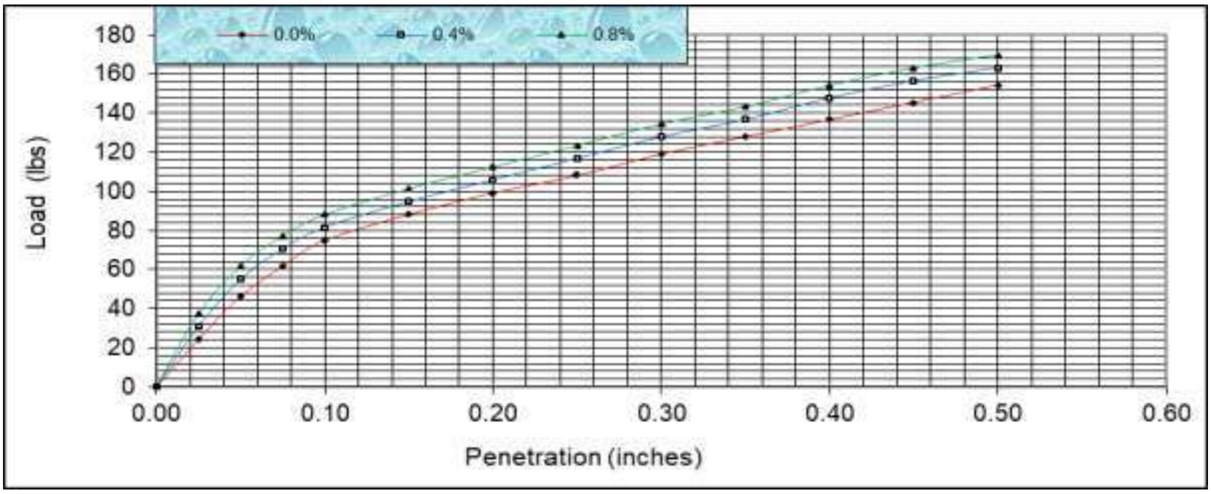

Figure 2: Load Penetration Curve

3.2. Effect of WFN on UCS of the Soil

The stress-strain relationship between unreinforced (0%) and reinforced (0.4% and 0.8%) soil samples from UCS testing demonstrates that the addition of WFN considerably raises the soil's UCS (qu) and strain. It is possible to get a noticeable improvement in resistance compared to soil without reinforcement by increasing the percentage of reinforcement by 0.4% and 0.8%. It is discovered that the unconfined compressive strength of soil without WFN reinforcement is 76.2 kPa. When soil samples were reinforced with 0.4% WFN addition, the unconfined strength of the soil increased by 10.6% to 85.3 kPa, and when it was reinforced with 0.8% WFN, the UCS of the soil increased by 30% to 102.1 kPa. It demonstrates that adding WFN has a positive effect on the soil's compressive strength. Conversely, the addition of WFN also raised the soil's failure strain. The failure strain was found to be 2.9% when the soil was tested using an unreinforced sample, 3.5% when it was reinforced with 0.4% WFN addition, indicating a 0.6-fold increase, and 4.1% when it was reinforced with 0.8% WFN addition, indicating a 1.2-fold increase. Thus, it may be said that adding WFN to soil causes it to behave more ductility than unreinforced soil. The test description, results, and graph are provided below.

Table 2: UCS test Description for 0% Reinforced WFN

Sample No. UDS 0.0%		
Sample type: Remolded		
Length	7.80	Cm
Dia (Avg)	3.75	Cm
Weight	153.6	G
Volume	86.2	cm^3
Area(Avg)	11.05	cm^2
Bulk Density	1.782	g/cm^3
OMC	8.9	%
Dry Density	1.636	g/cm^3
Unconfined Compressive Strength	76.2	kPa
Strain	2.9	%

Table 3: Readings of UCS Test on Soil Sample of 0% reinforced WFN

Def. Gauge	Load Gauge	Strain (%)	Stress (kPa)
0	0.0	0.000	0.000
25	1.0	0.321	8.850
50	2.0	0.641	17.643
75	3.0	0.962	26.380
100	4.0	1.282	35.059
125	5.0	1.603	43.681
150	6.0	1.923	52.247
175	7.0	2.244	60.755
200	8.0	2.564	69.207
225	8.8	2.885	75.877
250	8.5	3.205	73.049

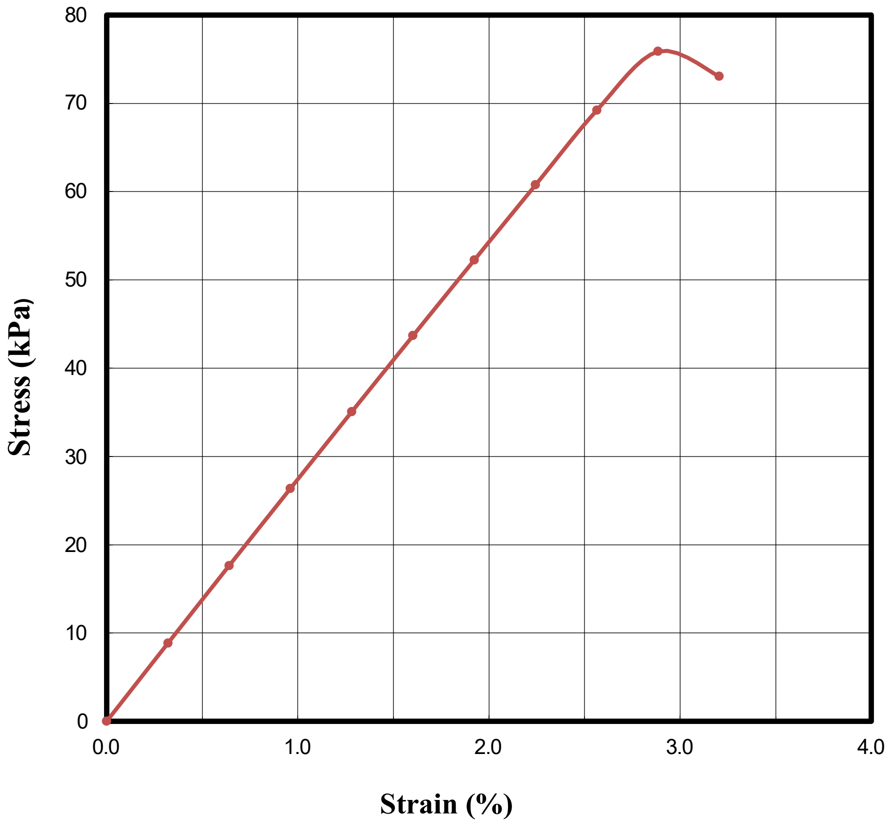

Figure 3: Stress and Strain Curve for UCS test on soil 0 % reinforecd WFN

Table 4: UCS test Description for 0.4 % Reinforced WFN

Sample No. UDS 0.4%		
Sample type: Remolded		
Length	7.20	Cm
Dia(Avg)	3.75	Cm
Weight	140.49	G
Volume	79.6	cm^3
Area(Avg)	11.05	cm^2
Bulk Density	1.766	g/cm^3
OMC	9.3	%
Dry Density	1.615	g/cm^3
UCS	85.3	kPa
Strain	3.5	%

Table 5: Readings of UCS Test on Soil Sample of 0.4 % reinforced WFN

Def. Gauge	**Load Gauge**	**Strain (%)**	**Stress (kPa)**
0	0.0	0.000	0.000
25	1.0	0.347	8.848
50	2.0	0.694	17.634
75	3.0	1.042	26.358
100	4.0	1.389	35.021
125	5.0	1.736	43.622
150	6.0	2.083	52.161
175	7.0	2.431	60.639
200	8.0	2.778	69.055

225	9.0	3.125	77.410
250	10.0	3.472	85.703
275	9.6	3.819	81.979

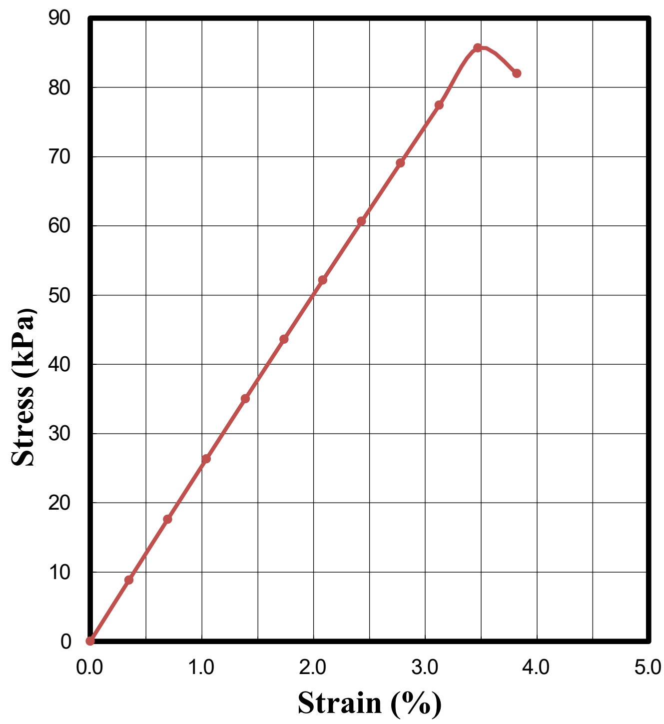

Figure 4: Stress and Strain Curve for UCS test on soil 0.4 % reinforced WFN

Table 6: UCS test Description for 0.8 % Reinforced WFN

Sample No. UDS 0.8%		
Sample type : Remolded		
Length	7.40	Cm
Dia (Avg)	3.75	Cm
Weight	149.37	G
Volume	81.8	cm^3
Area(Avg)	11.05	cm^2
Bulk Density	1.827	g/cm^3
OMC	9.2	%
Dry Density	1.672	g/cm^3
UCS	102.1	kPa
Strain	4.1	%

Table 7: Readings of UCS Test on Soil Sample of 0.8 % reinforced WFN

Def. Gauge	Load Gauge	Strain (%)	Stress (kPa)
0	0.0	0.000	0.000
25	1.0	0.338	8.849
50	2.0	0.676	17.637
75	3.0	1.014	26.366
100	4.0	1.351	35.034
125	5.0	1.689	43.643
150	6.0	2.027	52.191
175	7.0	2.365	60.680
200	8.0	2.703	69.109
225	9.0	3.041	77.477

250	10.0	3.378	85.786
275	11.0	3.716	94.035
300	12.0	4.054	102.223
325	11.5	4.392	97.619

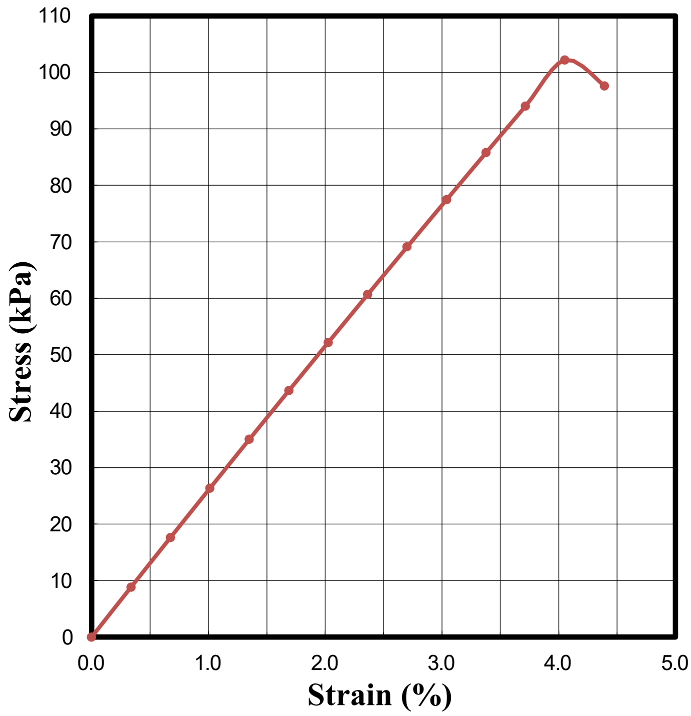

Figure 5: Stress and Strain Curve for UCS test on soil 0.8% reinforced WFN

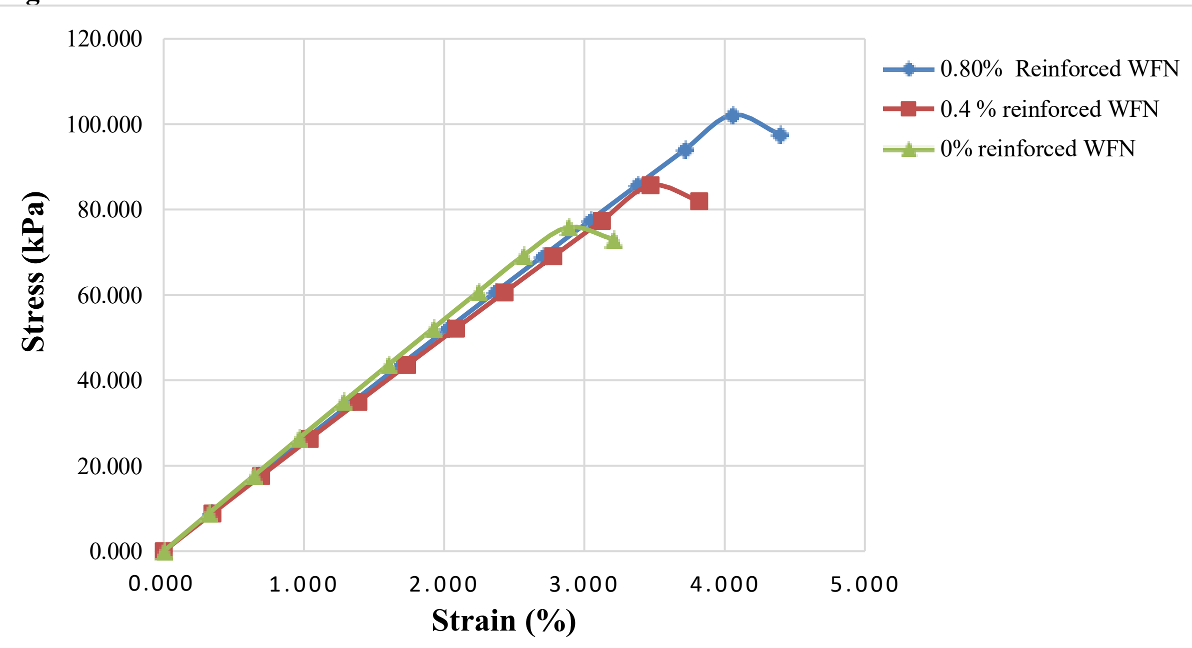

Figure 6: Stress and Strain Curve of UCS Test on soil samples

3.3. Effect of WFN on compaction characteristics

The figure below displays the compaction curve of the soil sample with reinforced and unreinforced WFN obtained using the modified Proctor test MPT. According to the test results, adding WFN up to 0.8% decreased the soil sample's MDD by 8.5%, or from 17.6 to 16.1. The average density of the reinforced soil sample may have increased the percentage of WFN in the soil sample, which could explain the decrease in MDD. Low specific gravity WFN replaces the denser soil particles (Gs=2.69) in a unit volume, lowering the soil sample's total unit weight. The OMC of both reinforced and unreinforced soil samples was found to be significantly higher, ranging from 10% to 17%. The nature of WFN, which prevented it from seeing water, and the nature of expanding soil, which allowed it to see more water, could be the cause of the rise in OMC.

Table 8: Results of MPT on soil Samples

Modified Proctor Test								
0 % reinforced WFN soil sample								
Assumed Water Content	(%)	4	6	8	10	12	14	16
Water Content	(%)	8	8.4	9.7	10	20	20.7	21.7
Weight of soil + mold	Kg	3.45	3.56	3.61	3.67	3.68	3.62	3.58
Weight of soil in mold	G	1750	1860	1910	1970	1980	1920	1880
Wet density	KN/m^3	17.21	18.2	18.78	19.4	19.47	18.9	18.5
Dry density	KN/m^3	15.93	16.78	17.11	17.64	16.32	15.67	15.2
0.8 % reinforced WFN Soil Sample								
Assumed Water Content	(%)	4	6	8	10	12	14	16
Water Content	(%)	10.09	10.93	12.37	16	16.67	16.67	10.25
Weight of soil + mold	Kg	3.38	3.41	3.47	3.5	3.59	3.609	3.51
Weight of soil in mold	G	1680	1710	1770	1800	1890	1909	1810
Wet density	KN/m^3	16.5	16.82	17.41	17.7	18.59	18.78	17.6
Dry density	KN/m^3	15	15.2	15.3	15.5	15.9	16.1	16.1

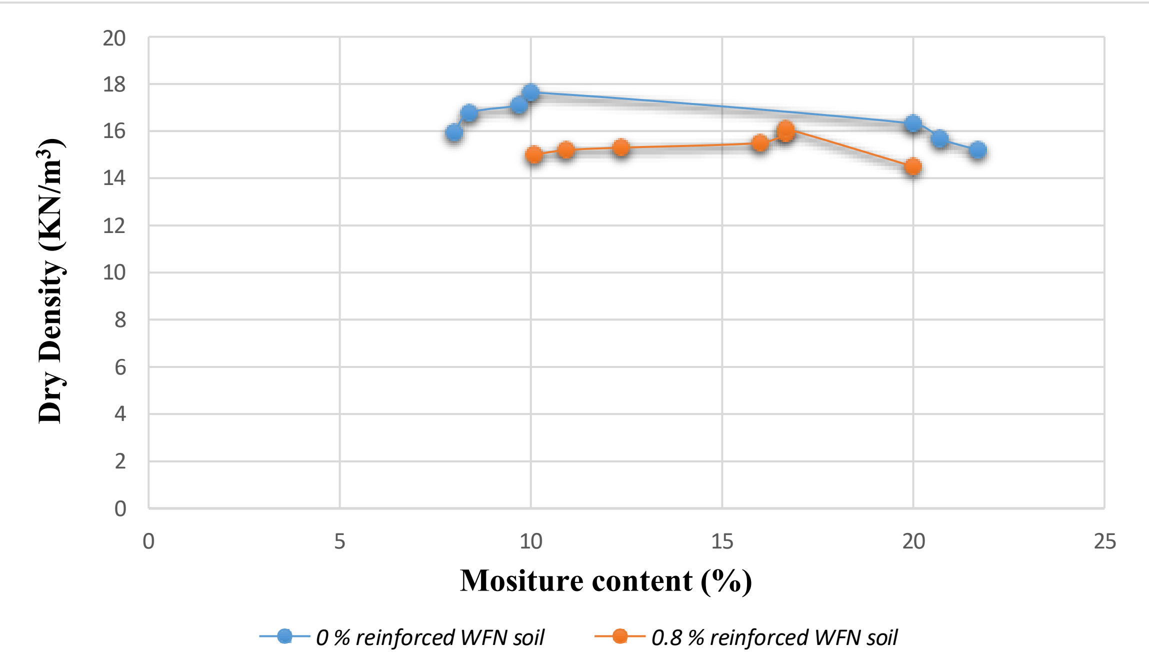

Figure 7: Compaction Curve of soil samples

4. Conclusions & Recommendations

4.1. Conclusion

WFN has a great deal of potential to shed light on the strength and deformation properties of expansive soil, according to the experimental results and evaluation of published literature given in this study. The

efficiency of WFN treatment for illuminating engineering features such compaction characteristics, strength and stiffness, compressibility, and CBR of cohesive soils was determined quantitatively. To enhance soil properties, an ideal fiber level of 0.8% is recommended.
The primary findings of this study are as follows:

- According to the test results, the soil sample's MDD decreased by 8.5%. The average density of the reinforced soil sample may have increased the percentage of WFN in the soil sample, which could be the cause of the decrease in MDD.. WFN having low specific gravity replace the denser particles of soil (Gs = 2.69) in a unit volume decreasing the overall unit weight of the soil sample. The OMC of the soil sample with the reinforced soil sample was found to be significantly higher. This might be due to the nature of the expanding soil, which observed more water, or the nature of WFN, which was unable to observe water into it.
- The unconfined compressive strength of the soil without WFN reinforcement is determined to be 76.2 kPa, indicating a notable improvement in UCS. When 0.4% WFN was added to the soil samples, the UCS of the soil increased to 85.3 kPa, indicating a 10.6% increase, and when 0.8% WFN was added, the UCS of the soil increased to 102.1 kPa, indicating a 30% increase.
- When 0.4% WFN is added to soil, the CBR value increases by 8%, and when 0.8% WFN is added, the CBR value increases by 16%, which is twice as much as 0.4% reinforced soil against the penetration of 0.1 inch. This results in a higher-quality subgrade for pavement building on such soils.

4.2. Recommendations

- Throughout the entire experiment, handling WFN and chopping it into tiny strands was a significant problem. In order to make it easy to use on a large scale, we would advise future researchers to find a solution.
- For field application and quality management of soils treated with WFN, mixing quality is essential to preventing any weak planes (directed reinforcement) or locations with inadequate WFN contents. When it comes to lab mixing of WFN-reinforced soils, the hand mixing method provides easy and consistent mixing and allows WFN to properly meld with soil mass. It can be difficult to establish a consistent soil-fiber matrix in the field, according to some researchers.
- It is also advised that future studies look into the physical characteristics of WFN.

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