Study The Geotechnical Properties Of Expansive Soils Under Variable Moisture Conditions

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Abstract

The purpose of this study is to understand how the moisture content and dry density impact the maximum stress, strain at failure, shear strength, as well as axial stress at failure in swollen soil. This occurs through unconfined compression, direct shear and triaxial shear tests, after which it is determined that the presence of moisture can affect the soil's strength and less moisture with higher dry density makes the soil better able to resist fatigue and become stronger. From unconfined compression, it is evident that the soil with the lowest moisture had maximum stress and the least stress to fail. Direct shear and triaxial shear also showed that adequate moisture content tends to support the cohesion and friction between particles, but higher moisture causes both of these to decrease. It was found that proper moisture management helps prevent the instability of swelling soil.

Keywords: Swelling soils, moisture content, dry density, unconfined compression test, direct shear test, triaxial shear test.

Introduction

Loft soil is different from other soils and it reacts strongly to changes in moisture. This type of soil fluctuates considerably in size with variations in humidity which creates big challenges for any buildings or foundations built above it. In geotechnics, studying swollen soils is important since their changes can cause unexpected shifts in the stability of foundations and subsidence; therefore, the characteristics of these soils should be accurately tested. They also foresee their actions in different surroundings and a common way to analyze expansive soil behavior is through swelling or expansion tests which are necessary in geotechnics to check how soil expands when more water is provided (Nagaraj,et al,2010). Samples are brought to the laboratory, given different humidity levels and the changes in their size are measured. The test is necessary for understanding if the foundation should be elevated due to the swelling of soil after getting wet. The purpose of these tests is to predict risks of swelling in clay soils that absorb a lot of water such as expansive soils with extensive expansion ability (Bharadwaj et al., 2013). Another type of test is an initial compression test that gauges if the soil will contract under pressure before a structure is built. In the test, laboratory stress is applied to the soil sample to gauge how it changes. Under pressure, the volume is recorded. This test measures the amount of pressure that the floor can manage before it suddenly starts to expand or contract. It can be used to predict the maximum load that piles in expansive soil areas can bear (Tahasildar et al.,2010). In regions where soil expands, it is vital to know the soil's compression strength, as this avoids future issues. Uneven or sudden movements in structures (Aljorany et al., 2014) Besides the swelling and compression tests, the settlement test is further used to see how swollen soil deals with weight on it. Under compression. Specific. It can be used to predict the changes in the soil response under different stresses and to assess the stability of the foundations over expansive soils under moisture content changes (Fredlund and Rahardjo 1993).

Permeability testing measures how freely or slowly water moves through soil. The test is key for understanding how expansive soil reacts to changes in humidity. Low permeability soils can be disturbed by rainfall and expanded. Furthermore, conducting a permeability test indicates to the rate at which water travels through the soil as well as how the movement of water beneath the ground is affected by moisture (Fredlund & Morgenstern, 1977). Direct shear tests and triaxial tests are also employed to estimate. The behavior of the soil. The direct shear test studies the cohesion and friction of the swollen soil under different loads and the triaxial test allows to determine the bearing capacity of the soil in three directions with high accuracy. It is one of the primary test to estimate stability of soil. Foundations in swelling and shrinking soils and these tests are performed concurrently in order to give a complete evaluation of foundation response under different environmental conditions. Through these tests engineers can study and ascertain the stability of foundations with the precision of the properties (Muthukumar & Shukla,2020). Knowledge of expansive soil is essential to make well-informed engineering decisions for buildings and structures in problem soil areas. Knowledge regarding soil behavior with change in moisture content is critical for designing foundations on such soils and of controlling the associated problems of magnitude changes (Al- Nimr et al., 2024).

Literature review

Definition Expansive soil is a variety of soil problematic in geotechnical engineering in that it has considerable expansion and shrinkage due to changes in moisture content. These soils are known to expand or contract according to the moisture content. Swelling tests are considered important tests for an investigation of the behavior of these soils; during these, different levels of moisture are provided to the soil samples and the volumetric changes, due to the water adsorption, are carefully monitored. Various studies of Bharadwaj et al, (2013) series concentrating on influence of soil replacement in expansive soils and effects of surface cracking with rise and fall in moisture, it is observed that the soils with higher clay contents are prone to swell. Next to the swelling test, the compressibility test is one of the fundamental tests that helps in forming an idea of the capacity of a soil to resist the compression before it gets swelled or shrinks. Al-Jourani et al. ran a study (2014) after found that the swollen load bearing the soil's ductile behavior is unstable under heavy loads, on low load-bearing, it led to the formation between small or unexpected movement of the structure(Aljorany et al., 2014) in this case, settlement test is an important test to find out the possibility of loading on the soil, thereby predicting the drop or increase of the contraction foundation due to the water content. soaked soil is very sensitive to changes in moisture, resulting in sudden changes of foundation stability (Fridlund and Rahardjo, 1993). As pertains to permeability tests, these tests are a key instrument to comprehend the expansive soil behavior. Soil, as it quantifies the soil's capacity to transmit water which has a profound impact on its swelling potential. Friedlund and Morgenstern (1977) investigated the influence of permeability on moist swelling of soil and indicated that soil with low fullness value leads to increased swelling behaviour, and the potential risk of sudden displacement is high (Fredlund & Morgenstern, 1977). When investigating the swollen soils in the context of a short literature review, it is apparent that the results derived from different investigations seem to be in agreement. The general consensus from most studies is that it is important to conduct tests in series to ascertain soil behavior; for instance with Al-Nimr et al. (2023) emphasized the significance of digital approach for bulge formation that increases our knowledge about moisture and soil behavior in difficult geotechnical environments (Al-Nimr et al., 2023) Mathematical modeling required for the effect of moisture on swelling soil supported in creating comfortable engineering preparations. Also, other research efforts tackled the problem of enhancing the stability of foundations resting on expanded soils, and new methods were adopted to support constructions resting on swollen soil like foundations stiffened with geotechnical concrete or reinforced cylinders to enhance the soil resistance against heavy weights. An earlier study by Alnmr et al. (2023)

used helical piles to get new methods to increase the stability of swollen soil. These investigations highlight the need for a variety of geotechnical testing to understand the behavior more fully. For other expansive soils, the geophysical test have provided more information including the information on subsoil which assist in the correct decisions for design of foundations besides the information obtained from swelling and pressure tests, permeability tests, and settlement tests. This assists engineers in selecting the best techniques to accommodate swelled soils, thus minimizing potential damages from swelled soils. Sich as breaking or settling of structures.

Methodology

Soil Models and Properties Before Testing

Prior to commencement of laboratory testing program, extensive analysis was made into the initial characteristics of the soil to estimate the anticipated mechanical behavior of the soil and in particular the expansive nature soils. This test program comprised the determination of fundamental physical and geotechnical properties to facilitate proper conditioning of the soil samples for testing under controlled conditions, the initial soil moisture content being determined using the oven-drying method was to ascertain the original level of natural moisture found in the samples before any modification. This is essential for establishing the natural state of the soil as well as consistency of all sample. Tests were performed in the laboratory to quantify the Atterberg limits (LL and PL). These parameters provide information regarding the potential of the soil to be plastically deformed and its responsiveness with respect to the moisture variation.

To gain better insight into its behavior, the maximum dry density and optimal water content of the soil were determined by means of the standard Proctor test. Such values are required for assessment of compaction behaviour of the soil and its carrying capacity under field like situations. Ten specimens were fabricated with different water contents and dry densities based on the different field conditions of the soil, in order to investigate the soil properties and behavior in a comprehensive manner.

Table.1: Initial Soil Properties Before Testing

Sample No.	Initial Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Maximum Dry Density (g/cm³)	Optimum Moisture Content (%)
1	10.5	45	25	20	1.60	12.0
2	11.2	48	27	21	1.58	13.5
3	9.8	43	24	19	1.62	11.0
4	12.1	46	26	20	1.59	13.0
5	10.0	44	25	19	1.61	12.5
6	11.5	47	26	21	1.59	13.2
7	9.5	42	23	19	1.63	10.8
8	12.3	49	28	21	1.57	14.0
9	10.8	46	26	20	1.60	12.8
10	9.7	43	24	19	1.62	11.2

Explanation of Parameters

1. Initial Moisture Content (%): Indicates the natural water content of the soil samples before any treatment or preparation. Higher moisture content affects the soil's compaction and strength properties.

2. Liquid Limit (LL) and Plastic Limit (PL): Represent the water content at which the soil transitions between liquid and plastic states (LL) and between plastic and semi-solid states (PL). These values are crucial for understanding the soil's plasticity and its potential to undergo deformation.

3. Plasticity Index (PI): Calculated as the difference between the liquid limit and the plastic limit (PI = LL - PL). It reflects the range of water content over which the soil exhibits plastic behavior. Higher PI values indicate highly plastic soils with greater potential for swelling or shrinkage.

4. Maximum Dry Density (g/cm³): Determined from the Proctor test, this value represents the highest density the soil can achieve under specific compaction efforts. It is an indicator of the soil's load-bearing capacity.
5. Optimum Moisture Content (%): The moisture content at which the soil reaches its maximum dry density during compaction. This parameter is critical for achieving proper soil compaction in the field.

Importance of These Properties

A knowledge of these starting properties is important in that being able to predict soil response, such as the behaviour of expanding soil with different water contents. These properties are used as input in common laboratory tests such as unconfined compression, direct shear, and triaxial shear tests, to study the effect of variations in water content and density on shear strength, coherence, and stability of soils. When these features are considered and corrected in the samples, the testing results are correct and more dependable; this is important for the design of stable foundations in expansive soil sites.

An extensive laboratory programme was developed to investigate the influence of variations in moisture content and dry density on the mechanical characteristics of swell soils. This experiment involved soil samples being well-prepared prior and were accurately tested in the laboratory through three fundamental tests which were unconfined compression test, direct shear test, and triaxial shear test. Standard sized samples (cylinders of twice the diameter, h 2d) were prepared and moisture values from 9% to 16% were selected to represent field soil moisture levels and for each sample, the dried density was adjusted from 1.57 to 1.63 g/cm3 according to standard practices. For the unconfined compression test, an axial colonnade force was incrementally imposed on the samples and the resulting stress at failure was measured using the relevant mathematical correlation. The samples were loaded into the apparatus in the framework of a direct shear test and the vertical force magnitude was maintained constant while the horizontal force was increased until failure. Shear strength was obtained applying Coulomb equation to determine the angle of internal friction and the cohesion force. In the triaxial shear test, the samples were loaded into the device, and the surrounding pressure was applied by a pressurized liquid with the axial stress increasing step by step until failure, then, an analysis of stress-strain was carried out by the modified Coulomb equation. The parameters examined were the moisture (m) which varied from 9 to 16% and the dry density (γ d) which was in the range of 1.57–1.63 g cm ^{3}. The (max) axial-stress, angle of repose (phi), cohesion (c) and the strain (ep) at failure were recorded. The research in the laboratory seeks to understand the effect of water content and dry density on the behavior of the wet soil and to provide basic data in the design of stable foundations in swollen soils.

The method was intended for assessing the performance of expansive soils and for examining the role of differing water content on their stability and mechanical properties and (the study) incorporated three main laboratory tests: California Bearing Ratio (CBR) Test, Direct Shear Test and Triaxial Shear Test. Samples were prepared with a good microstructure integrity as per the standard which is important to have accuracy of the result.

Unconfined Compression Test

Objective The objective of this test was to evaluate compressive soil strength under axial loading without application of confining pressure and were cylindrical and of height double the diameter and the moisture content of the samples were moistened as per desired percentage to mimic the field condition (Devkota, et al, 2020). Sample dimensions were measured accurately with high precision instruments. Each specimen was axially loaded at a constant speed to obtain failing and the maximum compressive stress was calculated according to:

$$q_u=\frac{\{P\}}{\{A\}}$$

Where:

q_u: Maximum compressive stress (kPa)

P: Applied load (N)

A: Cross-sectional area of the sample (m^2)

Table 2: Sample Properties for Unconfined Compression Test

Sample ID	Dry Density (g/cm^3)	Moisture Content (%)	Height (cm)	Diameter (cm)	Applied Load (N)
1	1.60	12	10	5	2945
2	1.58	15	10	5	2752
3	1.62	10	10	5	3138
4	1.59	14	10	5	2806
5	1.61	11	10	5	3012
6	1.57	16	10	5	2689
7	1.63	9	10	5	3204
8	1.60	13	10	5	2905
9	1.58	15	10	5	2760
10	1.62	10	10	5	3120

Direct Shear Test

The purpose of the Direct Shear Test was to measure the shear strength, internal friction angle also cohesion of expansive soil. Samples were prepared to fit the shear box dimensions and moisture content was adjusted to predefined levels. Each sample was placed in the shear box apparatus and where a constant vertical load was applied and the upper part of the box was moved horizontally at a constant rate until failure occurred. Shear strength was calculated using the Coulomb equation:

$$\tau = c + \sigma tan\phi$$

Where:

τ: Shear strength (kPa)

c: Cohesion (kPa)

σ: Normal stress (kPa)

ϕ: Internal friction angle (°)

Table 3: Sample Properties for Direct Shear Test

Sample ID	Dry Density (g/cm^3)	Moisture Content (%)	Vertical Load (kPa)	Internal Friction Angle (°)	Cohesion (kPa)
1	1.60	12	100	25	15
2	1.58	15	150	24	14
3	1.62	10	200	26	16
4	1.59	14	100	23	13
5	1.61	11	150	25	15
6	1.57	16	200	22	12
7	1.63	9	100	27	17
8	1.60	13	150	26	16
9	1.58	15	200	24	14
10	1.62	10	100	28	18

Triaxial Shear Test

The Triaxial Shear Test was employed to evaluate the shear strength of soil under varying confining pressures. Cylindrical samples were prepared and placed in the triaxial apparatus. A confining pressure was applied using pressurized fluid also axial stress was increased at a constant rate until failure. Pore pressure and axial deformation were recorded and the strength parameters were calculated using the modified Coulomb equation:

$$\sigma1 - \sigma3 = \sigma3\, tan^2\, \phi + 2ctan\phi$$

where:
σ1: Major principal stress (kPa)

σ3: Minor principal stress (kPa)

ϕ: Internal friction angle (°)

c: Cohesion (kPa)

Table 4: Sample Properties for Triaxial Shear Test

Sample ID	Dry Density (g/cm³)	Moisture Content (%)	Confining Pressure (kPa)	Internal Friction Angle (°)	Cohesion (kPa)
1	1.60	12	50	25	20
2	1.58	15	100	24	18
3	1.62	10	150	26	22
4	1.59	14	50	23	19
5	1.61	11	100	25	21
6	1.57	16	150	22	17
7	1.63	9	50	27	23
8	1.60	13	100	26	22
9	1.58	15	150	24	20
10	1.62	10	50	28	24

Results

Unconfined Compression Test Results

Table 4 shows. Relationship between dry density, moisture content, maximum stress also strains at failure for each specimen and the results show that the maximum stress is clearly affected by the moisture content. Sample No. 7 recorded the highest maximum stress of 320.4 kPa and while sample No. 6 recorded the lowest value of 268.9 kPa and these results confirm that soils with higher dry density and lower moisture content are more resistant to stress

Table 5: Unconfined compression test results.

Sample No.	Dry Density (g/cm³)	Moisture Content (%)	Maximum Stress (kPa)	Strain at Failure (%)
1	1.60	12	294.5	2.5
2	1.58	15	275.2	2.8
3	1.62	10	313.8	2.3
4	1.59	14	280.6	2.6
5	1.61	11	301.2	2.4
6	1.57	16	268.9	2.9
7	1.63	9	320.4	2.2
8	1.60	13	290.5	2.5
9	1.58	15	276.0	2.8
10	1.62	10	312.0	2.3

When analyzing the results, it is shown that sample No. 3 and which has a dry density of 1.62 g/cm³ and a moisture content of 10%, achieved a maximum stress of 313.8 kPa and this reflects that soil retains its ability to withstand high stress when moisture content is reduced. In contrast and sample No. 6 and which has a dry density of 1.57 g/cm³ and a moisture content of 16% and showed the lowest strength at

268.9 kPa and this result indicates that increased moisture content leads to reduced interparticle bonding and which reduces the ability of the soil to bear loads and Strain at failure reveals the ability of soil to deform before reaching the failure point and for example and sample No. 7 showed a low strain of 2.2%, indicating that the soil becomes stiffer and less deformable when moisture content is reduced and density is increased. In contrast and specimen No. 6 and which showed the highest strain of 2.9%, reflects a greater ability to deform before failure and which is consistent with its poor resistance to ultimate stress.

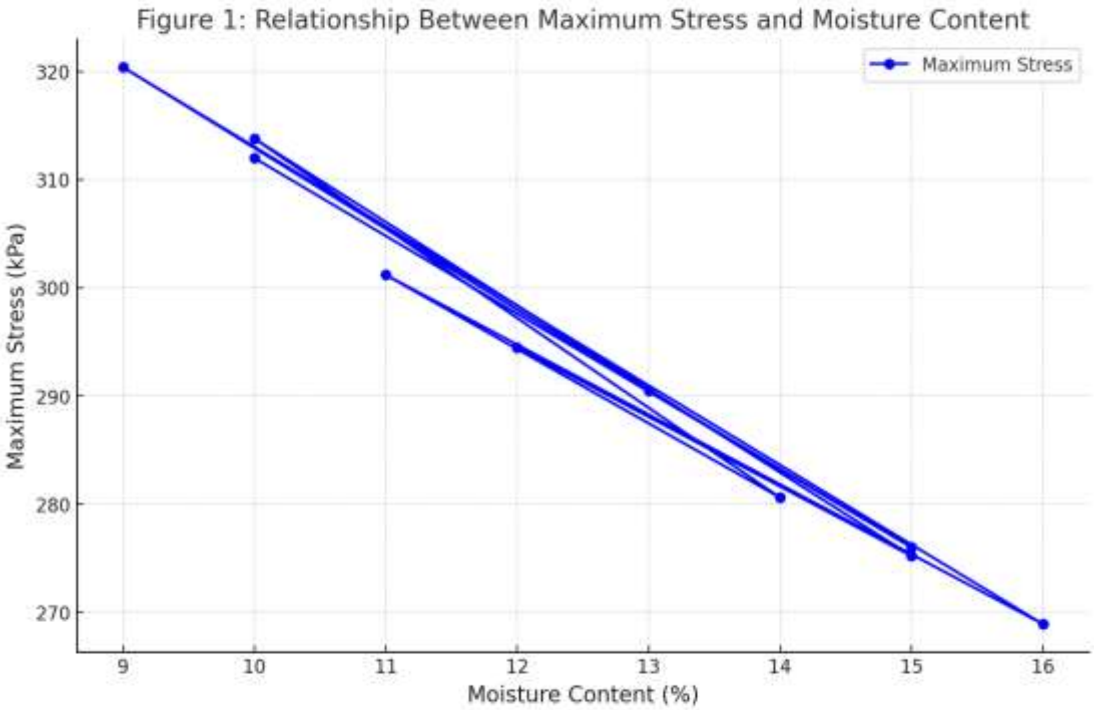

Figure 1: Relationship between maximum stress and moisture content

Figure 1 expresses the relationship between Maximum Stress and Moisture Content based on data extracted from Table 4 and when analyzing this figure, a clear trend can be observed showing the effect of moisture content on soil resistance and we begin by observing sample number 7 and which has the lowest moisture content of 9% and the highest dry density of 1.63 g/cm³, as this sample recorded the highest maximum stress of 320.4 kPa and this result shows that lower moisture content with higher dry density increases soil strength, due to reducing interparticle voids and improving the internal cohesion of the soil. On the other hand and sample No. 6 and which had the highest moisture content of 16% and the lowest dry density of 1.57 g/cm³ and showed the lowest maximum stress of 268.9 kPa and this decrease in maximum stress reflects the deterioration of soil strength due to increased moisture content that reduces the cohesive forces between soil particles, leading to a weakening of its resistance to external stresses and for sample No. 3 and which has a moisture content of 10% and a dry density of 1.62 g/cm³, a maximum stress of 313.8 kPa was recorded. Although the moisture content of this sample is slightly higher compared to sample No. 7, the higher dry density contributed to significantly improve its fatigue strength. Sample No. 2 and which had a moisture content of 15% and a dry density of 1.58 g/cm³ and showed a maximum stress of 275.2 kPa and this performance reflects the obvious negative effect of increased moisture content, as this reduces the internal frictional forces of the soil and increases the probability of collapse under loads.

When analyzing the relationship between maximum stress and moisture content across all samples, a clear pattern emerges of a decrease in soil compressive strength with increasing moisture content and this decrease is attributed to the effect of water on soil structure and whereby higher moisture content softens particles and reduces soil resistance to shear and axial stresses. In contrast and samples with lower moisture content showed a higher ability to withstand stresses due to improved internal cohesion and increased intermolecular friction and this pattern highlights the importance of controlling moisture content when designing pile foundations in swelling soils, as its increase leads to a deterioration in the mechanical performance of the soil.

Direct Shear Test Results

Table 6 indicates and the angle of internal friction and cohesion decrease with increasing moisture content. Sample No. 7 and which had a dry density of 1.63 g/cm³ and a moisture content of 9% and showed the highest shear strength and with an internal friction angle of 27° and a cohesion of 17 kPa. In contrast and sample No. 6 showed the lowest shear strength with an internal friction angle of 22° and cohesion of 12 kPa.

Table 6: Direct shear test results

Sample No.	Dry Density (g/cm³)	Moisture Content (%)	Vertical Load (kPa)	Shear Strength at Failure (kPa)	Internal Friction Angle (°)	Cohesion (kPa)
1	1.60	12	100	80	25	15
2	1.58	15	150	110	24	14
3	1.62	10	200	140	26	16
4	1.59	14	100	75	23	13
5	1.61	11	150	115	25	15
6	1.57	16	200	130	22	12
7	1.63	9	100	85	27	17
8	1.60	13	150	120	26	16
9	1.58	15	200	135	24	14
10	1.62	10	100	90	28	18

The results of sample No. 3 show that the soil under the highest vertical load (200 kPa) and low moisture content (10%) had a maximum shear capacity of 140 kPa. On the other hand and sample No. 4 showed the lowest strength with a value of 75 kPa under lower vertical load and higher moisture content and the internal friction angle represents

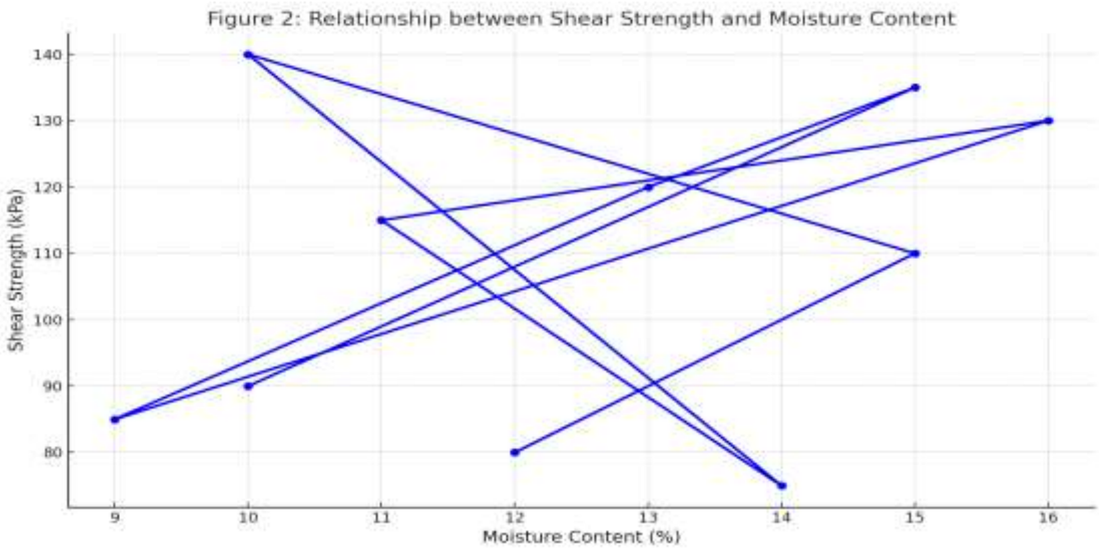

Figure 2: Relationship between shear strength and moisture content

the effect of frictional forces between particles, as sample No. 7 showed the highest angle of 27° and which reflects a more cohesive and stable soil.

Figure 2 shows the relationship between the shear strength at failure and the moisture content of the swelling soil based on the data in Table 6. Shear resistance represents the ability of the soil to withstand the horizontal forces acting on it and which depends on the angle of internal friction and cohesion and from the figure, the effect of increasing moisture content on decreasing shear resistance is clearly visible. When humidity decreases, the frictional forces between soil particles and the cohesion resulting from intermolecular bonds increase, leading to increased shear resistance. In contrast, at high moisture content, intergranular cohesion decreases and the internal friction angle decreases, resulting in a reduced ability of the soil to resist the applied forces. Sample No. 7, at a relatively low moisture content (9%) and high dry density (1.63 g/cm³), achieved the highest internal friction angle of 27° and cohesion of 17 kPa and this is attributed to the increased intergranular bonding under low humidity and the shear strength of this sample reached 85 kPa under a vertical load of 100 kPa and which reflects the high strength of the soil in resisting shear forces in this case. Sample No. 6 shows that at a relatively high moisture content (16%) and low dry density (1.57 g/cm³), the internal friction angle was only 22° and the cohesion was 12 kPa, representing the lowest value in all samples and the shear strength of this sample reached 130 kPa under a vertical load of 200 kPa and which is lower than other samples under the same load and these results indicate the effect of increasing moisture in reducing soil strength. As for Sample No. 3, this sample has a low moisture content (10%) and a relatively high dry density (1.62 g/cm³) also showed a shear strength of 140 kPa under a vertical load of 200 kPa and the internal friction angle for this sample was 26° also the cohesion was 16 kPa and these values indicate good ability to withstand shear forces and by comparing different samples and we find that increasing moisture content led to a decrease in the internal friction angle and cohesion also thus a decrease in the overall shear strength of the soil and for example and sample No. 7 (lowest moisture content): recorded the highest shear strength and internal friction angle and while sample No. 6 (highest moisture content): recorded the lowest shear strength and internal friction angle also sample No. 3 proved that lower humidity and increased dry density enhance soil resistance and thus and figure 2 shows the effect of moisture as a major factor in determining the properties of swelling soil. Soils with low moisture content exhibit higher shear strength due to increased internal friction and cohesion between particles. In contrast, high moisture content leads to reduced bonding between particles, making the soil less able to withstand shear forces and the analysis highlights the importance of controlling moisture content when designing foundations in swelling soils to ensure the stability of engineering structures

Triaxial Shear Test Results

Triaxial shear test results show the effect of ambient stress on the axial stress at failure. Sample No. 7 and with a dry density of 1.63 g/cm³ and a moisture content of 9% and showed the highest axial fatigue strength at failure with a value of 320 kPa. In contrast and sample No. 6 and with a moisture content of 16% and showed the lowest strength with a value of 310 kPa under high ambient pressure (150 kPa) and the data shows the effect of ambient pressure on enhancing soil resistance, but moisture content remains the most influential factor. Sample No. 10 showed the highest internal friction angle at 28° and which reflects the effect of low density and limited moisture content on soil stability.

Table 7: Triaxial shear test results

Sample No.	Dry Density (g/cm³)	Moisture Content (%)	Ambient Pressure (kPa)	Axial Stress at Failure (kPa)	Internal Friction Angle (°)	Cohesion (kPa)
1	1.60	12	50	200	25	20
2	1.58	15	100	250	24	18
3	1.62	10	150	300	26	22
4	1.59	14	50	190	23	19
5	1.61	11	100	260	25	21
6	1.57	16	150	310	22	17
7	1.63	9	50	320	27	23
8	1.60	13	100	290	26	22
9	1.58	15	150	330	24	20
10	1.62	10	50	315	28	24

Figure 3: Relationship between ambient pressure and axial stress at failure

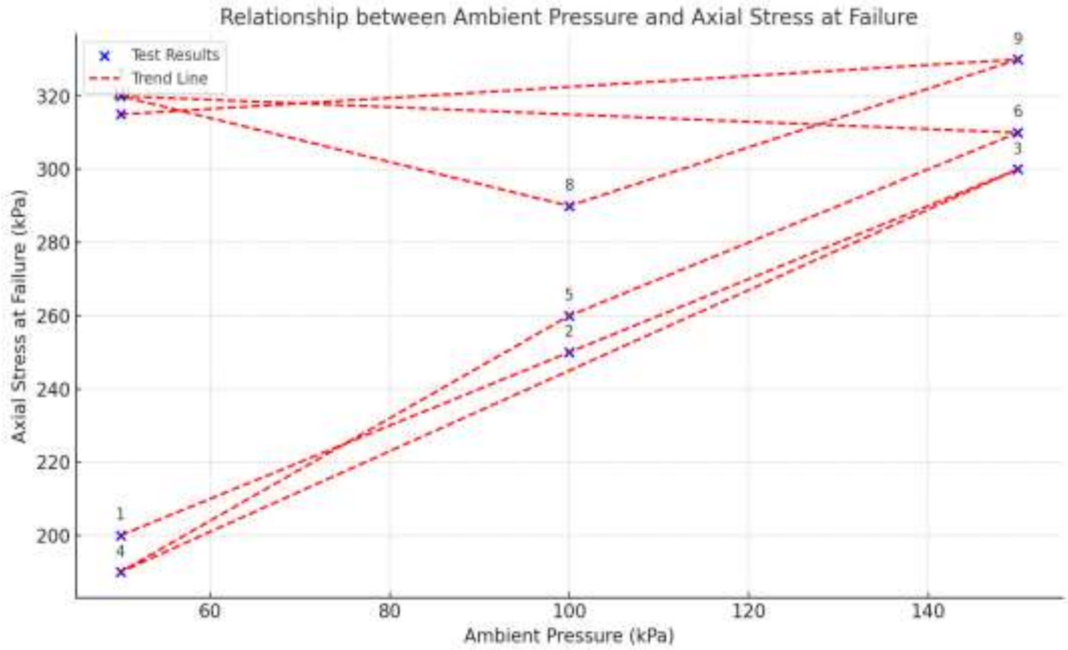

Figure 3 shows the relationship between ambient pressure and axial stress at failure for different samples in the triaxial shear test and from the analysis of the figure, it is evident that ambient pressure has a clear effect on the soil's resistance to axial stress, but it is not the only factor determining the soil's ability to withstand stress.One of the most noticeable conclusions is that increasing ambient pressure leads to higher resistance to axial stress at failure. As the ambient pressure increases, the soil's ability to resist axial stress increases and this suggests that ambient pressure enhances soil cohesion and which helps increase its strength and load-bearing capacity.However, moisture content remains the most influential factor on the mechanical performance of the soil. Soils with higher moisture content exhibited lower resistance to axial stress at failure compared to soils with lower moisture content and for example and sample No. 6 and which has a high moisture content of 16% and showed the lowest axial stress at failure (310 kPa), despite being exposed to a high ambient pressure (150 kPa) and this indicates that excess moisture reduces the internal cohesion of the soil, making it less capable of withstanding stres. On the other hand and sample No. 7 and which has a low moisture content (9%) and showed the highest axial stress at failure (320 kPa) despite the ambient pressure being relatively low (50 kPa) and this demonstrates that lower moisture content enhances soil strength and stability and even under lower ambient pressure and in conclusion and figure 3 demonstrates that while ambient pressure positively affects soil resistance, moisture content remains the critical factor in determining the soil's ability to withstand axial stress. High moisture content reduces soil cohesion, leading to lower resistance and while soils with lower moisture content exhibit higher resistance to axial stress.

Conclusions

The analysis of the unconfined compression, direct shear also triaxial shear tests revealed that moisture content and dry density significantly influence the mechanical properties of swelling soils. Lower moisture content leads to higher soil strength, increased cohesion also a greater ability to withstand stress and the results from the unconfined compression and shear tests confirm that soils with higher dry density and lower moisture content are more resistant to axial and shear stresses and furthermore, the ambient pressure in the triaxial shear test was shown to enhance soil resistance, although moisture content was found to be the most influential factor affecting soil stability and therefore, moisture content must be carefully controlled in foundation design to ensure soil stability and prevent structural failure in swelling soils.

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