# STUDY OF SHEAR STRENGTH CHARACTERISTICS OF CHEMICALLY TREATED SANDY SOIL USING DIRECT SHEAR TEST

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Partial Fulfillment of the Requirements for the Award of the Degree of

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# DECLARATION

I hereby declare that the work presented in this report entitled "STUDY OF SHEAR STRENGTH CHARACTERISTICS OF CHEMICALLY TREATED SANDY SOIL USING DIRECT SHEAR TEST" in partial fulfillment of the requirement for the award of the degree of Master of Technology in Civil Engineering with specialization in Geotechnical engineering submitted to the Department of Civil Engineering, Assam Engineering College, Jalukbari, Guwahati-13 under Assam Science and Technology University, is an authentic record of my work carried out in the said college for twelve months under the supervision and guidance of Dr. Sasanka Borah, Assistant Professor, Department of Civil Engineering, Assam Engineering College, Jalukbari, Guwahati-13, Assam.

Do hereby declare that this project report is solemnly done by me and is my effort and that no part of it has been plagiarized without citation.



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## ABSTRACT

Sandy soil is beneficial in geotechnical engineering due to its good drainage properties, high bearing capacity, and ease of compaction, making it suitable for constructing stable foundations and structures. However, it is important to note that sandy soils also have certain disadvantages, such as susceptibility to erosion and liquefaction under certain conditions (e.g., during earthquakes or when saturated with water). Thus it becomes important for engineers to assess the specific characteristics of sandy soil at a construction site to determine its suitability and take appropriate measures to mitigate any potential risks.

In our study, an attempt has been made to study the shear strength properties of the sandy soil of River Kulsi, along with their particle size variation, and to enhance the shear strength properties using a chemical modifier Zycobond and cement. A Direct Shear Test apparatus is used to study the shear strength parameters of the soil samples. Tests were conducted for both the virgin and chemically treated soil samples. Soil samples were prepared by adding a chemical soil modifier, zycobond at doses from 0.5 to 1.5 kg/cm3 with an increment of 0.25 at OMC and cement doses of 1%,2%,3%,4%, and 5%. The soil samples are cured for a period of 24 hrs. A constant density of 1.65g/cc is maintained while performing the direct shear test with a constant strain rate of 1.25mm/min.

The comparative analysis performed from the test results indicates that the shear strength parameters of the soil treated with chemical modifier showed an increase in shear strength, and shear strength parameters of treated soil showed optimum values at a dose of 1.25 kg/cm3 and 3 % cement it was also evident from the test results that the addition of Zycobond and cement to sand increases the shear strength by 23.2% and friction angle increased by 28%. Additionally, the results of the DST performed on the soil classified as Fine, medium, and coarse indicated that with the increase in particle size, the friction angle slightly increased.

The study concluded that the combination of cement and Zycobond significantly improved soil shear strength properties, making it more suitable for enhancing the shear properties of sandy soil for geotechnical purposes

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# LIST OF SYMBOLS AND ABBREVIATIONS

| SYMBOL/ABBREVIATION | DESCRIPTION |
|---|---|
| φ (in degree) | Angle of Internal Friction |
| c ($kg/cm^2$) | Cohesion |
| $C_U$ | Coefficient of uniformity |
| Cc | Coefficient of curvature |
| CS | Coarse Sand |
| CBR | California Bearing Ratio |
| DST | Direct Shear Test |
| FM | Fineness Modulus |
| FS | Fine Sand |
| MS | Medium Sand |
| MDD | Maximum Dry Density |
| OS | Original Sand |
| PPC | Portland Pozzolona Cement |
| OMC | Optimum Moisture Content |
| UCS | Unconfined Compression Test |
| ZB | Zycobond |

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# CHAPTER 1

# INTRODUCTION

Sandy soil is beneficial in geotechnical engineering due to its good drainage properties, high bearing capacity, and ease of compaction, making it suitable for constructing stable foundations and structures. However, it is important to note that Sandy soil is characterized by loose packing, non-plasticity, and low shear strength, susceptibility to erosion, and liquefaction under certain conditions (e.g., during earthquakes or when saturated with water) which can lead to engineering challenges. Thus it becomes important for engineers to assess the specific characteristics of sandy soil to determine its suitability and take appropriate measures to mitigate any potential risks. A soil modification strategy, enhancing shear strength and reducing permeability, holds promising future applications across diverse sectors such as pavement constructions, construction of landfills, zoned embankments, and reinforced soil structures. Modified soil with increased shear strength is helpful, providing engineers with an adaptable solution to satisfy project needs, decrease hauling costs, and maintain stability in various building scenarios

## 1.1 Shear Strength of soil

Shear strength is crucial in geotechnical engineering, representing soil's resistance to shearing stresses and inclination for shear deformation. Derived from particle interlocking, grain friction, and particle adhesion, it varies with soil type. In granular soils like sands, particle interlocking and friction dominate, while cohesive soils like clays involve friction and adhesion.

### 1.1.1. Shearing characteristics of sand

The shear strength of sand has two components: internal friction between grains which is a combination of rolling and sliding friction and another part known as ‘interlocking’. Interlocking, which means locking of one particle by the adjacent ones, resisting movements, contributes a large portion of the shearing strength in dense sands, while it does not occur in loose sands. The angle of internal friction, influenced by factors like density, particle shape, gradation, and normal pressure, measures resistance to sliding. The angle of repose resembles the loose state's friction angle. Cohesion in clean sands due to capillary tension is negligible and

unreliable for shear strength, but even small amounts of silt and clay can provide considerable cohesion. Sand typically allows for drained shear tests due to its high permeability, enabling quick drainage. However, extreme events like earthquakes or blasting can temporarily generate pore pressures, leading to "liquefaction," a sudden loss of shear strength and stability. The stress-strain behavior of sands varies with initial density, where denser sands exhibit higher strength, with interlocking contributing to additional strength in dense sands. Volume change characteristics show densification in loose sands and dilation in dense sands during shear due to particle rearrangement. Undrained shear in sands, though uncommon due to high permeability, may lead to positive pore pressures in loose specimens and negative pore pressures in dense ones.

### 1.1.2. Shear strength of sand

The shear strength of cohesionless soils, like sands, mainly relies on the angle of internal friction influenced by factors such as normal stress and moisture content. Direct shear or triaxial compression tests reveal behavior under specific stresses, with effective normal stress being crucial for mobilizing shear strength. Graphs plotting shear stress against effective normal pressure show Coulomb strength envelopes as straight lines through the origin at the angle of internal friction. For dry cohesionless soils, the failure envelope passes through the origin. However, in moist conditions, an intercept on the shear stress axis appears, termed "apparent cohesion," attributed to moisture film surface tension. This extra strength isn't reliable as it can dissipate with changes in moisture content, hence often disregarded in practice. The angle of internal friction chosen for practical use should be related to expected soil strains, with peak or ultimate values applied depending on the anticipated deformation magnitude.

## 1.2. Mohr–Coulomb Failure Criterion Coulomb

Mohr–Coulomb Failure Criterion, Coulomb, 1776 considered that failure of soil is a curved line. $\tau f = f(\sigma)$. Mohr (1900) presented a theory for rupture in materials that contended that a material fails because of a critical combination of normal stress and shearing stress. Thus, the failure can be expressed in the following form:

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

Where:

$c$ = cohesion

$\phi$ = angle of internal friction

$\sigma$ = normal stress on the failure plane

$\tau f$ = shear strength

The preceding equation is called the Mohr-Coulomb failure criterion. In saturated soil,

$$\sigma = \sigma' + u$$

The Mohr-Coulomb failure criterion, in terms of effective stress, will be:

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

Where $c'$ = cohesion and $\phi'$ = friction angle, based on effective stress.

The value of (c) for sand and inorganic silt = 0. For normally consolidated clays (c) can be = 0. Over consolidated Clays have values of (c) that are greater than 0. The angle of friction,$\phi'$ is sometimes referred to as the drained angle of friction.

The significance of the failure envelope can be explained using Figure 1.1. If the normal and shear stresses on a plane in a soil mass are such that they plot as point A, shear failure will not occur along the plane. If the effective normal stress and the shear stress on the plane plot as point B (which falls on the failure envelope), shear failure will occur along that plane. A state of stress on a plane represented by point C cannot exist because it plots above the failure envelope, and shear failure in the soil would have occurred already.

For cohesionless soils (c) = 0, the failure criterion will be:

$$\tau f = \sigma' \tan\phi'$$

For saturated soil under undrained conditions, the failure criterion will be:

$$\tau f = c'$$

The determination of soil shear strength involves plotting failure envelopes and evaluating shear strength parameters through various laboratory and field tests. The commonly used

laboratory tests include the Direct Shear Test, Triaxial Compression Test, and Unconfined Compression Test. In our study, we shall determine the shear strength of soil using the Direct Shear Test.

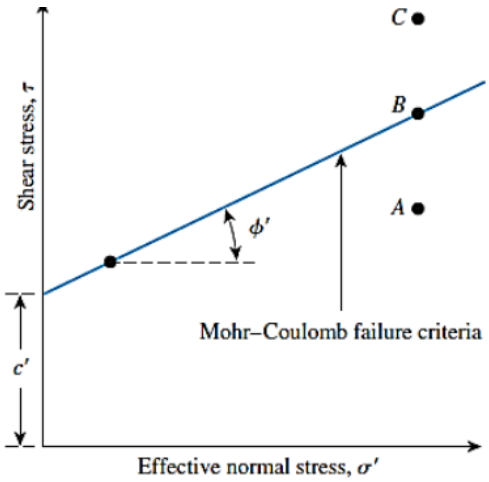


**Figure1.1** Mohr-Coulomb Failure Criterion

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The direct shear test has survived over the past 50 years in geotechnical engineering applications because of its simplicity and repeatability. The Direct Shear Test employs a shear box apparatus, applying normal and shear stresses to a soil specimen until failure occurs. Two methods control the test: stress-controlled, where shear stress is applied incrementally, and strain-controlled, where shear displacement is applied at a constant rate. The strain-controlled method is widely used, measuring shear force with a proving ring and displacement with dial gauges. The test offers insights into stress conditions, Mohr's circles, and failure envelopes.. The direct Shear Test is one of the oldest shear tests that is in use and is quite simple to perform.

In this study, our focus is to identify measures to enhance the shear strength of sandy soil which could be sustainable and economical, and to study its effectiveness in treating soils with soil modifiers The investigation aims to provide insights into how a chemical additive together with cement influences the direct shear behavior of soil, shedding light on their effectiveness as soil reinforcement agents. As the demand for sustainable and efficient soil stabilization techniques

grows, understanding the performance of these specific modifiers becomes essential for informed decision-making in geotechnical engineering applications**.**

## 1.3 SUMMARY:

Sandy soil is advantageous due to its excellent drainage properties and high bearing capacity. However, it presents challenges such as low shear strength and susceptibility to erosion and liquefaction. Shear strength is a critical parameter in geotechnical engineering, derived from particle interlocking, grain friction, and particle adhesion. For sandy soils, internal friction and interlocking are particularly important. The Mohr-Coulomb failure criterion explains soil failure based on a combination of normal and shear stresses, and it is used to determine the shear strength of soils. There are various tests for determining the shear strength of soil, The Direct Shear Test being one of them is the oldest yet simplest method used to measure the shear strength of soil, The present focus of the study is to identify measures to enhance shear strength of sandy soil and to study its effectiveness keeping in mind its sustainability and economic nature.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 INTRODUCTION:

Several researchers have worked in developing different methods of soil stabilization or methods of increasing the strength of soil, enhancing the properties to use them for various construction or other civil engineering purposes sustainably and economically. In this chapter, we have reviewed a few of the research works done by various research scholars highlighting the use of different soil modifiers and additives that have been used to enhance the properties of soil, their effectiveness, and also to examine briefly the effect of particle size on the shear strength of the soil.

## 2.2 REVIEW OF LITERATURE:

Habiba Afrin (2017) in "A Review on Different Types of Soil Stabilization Techniques" asserts that Soil stabilization is a method of improving soil properties by blending and mixing other materials. It is the process of improving the shear strength parameters of soil and thus increasing the bearing capacity of soil. Unbound materials can be stabilized using cementitious materials (cement, lime, fly ash, bitumen, or a combination of these) through soil stabilization. The soil that has stabilized materials is stronger, less permeable, and less compressible than the natural soil. In the case of cement stabilization, the void ratio of soil is decreased when it is stabilized with cement, which fills the spaces between the soil particles. After that, cement reacts with water when it is put into the soil, hardening it. Thus, the soil's unit weight is increased. Cement hardening results in an increase in bearing capacity and shear strength.

In another literature study by Choobbasti et al. (2015) it was seen that the tests performed to study the effect of cement and nano-silica on the mechanical properties of sandy soils have shown results that indicate that the addition of cement and nano-silica improves the engineering properties of sands. Specifically, the maximum dry unit weight of sand increases with higher

cement content. Optimal percentages of nano silica significantly enhance the mechanical properties of cemented sand.

Tawfiq Aamir Jawad and Asaad Mohammed Baqir (2009 conducted a study for the Improvement of shear strength and maximum dry density of cohesionless soil for better foundation stability. Bentonite (2.5%, 5%, 7.5%, 10%) was added to sandy poorly graded soil, and direct shear tests were performed, test results using 7.5% Bentonite effectively improved the shear strength and density of sandy poorly graded soil compared to other percentages.

Nandan A. Patel and C. B. Mishra (2014) in their paper discussed the enhancement of inorganic clayey soil's engineering properties for road construction by adding 2% Portland Pozzolana Cement (PPC). It highlights the importance of soil stabilization in civil engineering to improve strength and durability using PPC. The addition of PPC to soil significantly alters its index properties, reducing the liquid limit and plasticity index, which indicates a decrease in soil's plastic behavior. This modification leads to an increase in maximum dry density and a reduction in compressibility test results show a substantial increase in the soil's load-bearing capacity after treatment with PPC, suggesting an improved strength of the subgrade, which is crucial for pavement longevity. The study underscores the economic advantages of using 2% PPC in pavement design, promoting sustainable development in road construction.

Nandan A. Patel, C. B. Mishra et al. (2015) in their paper "Influence Of Chemical Additive In Modification Of Subgrade Soil For Pavements" discussed the use of chemical additives like Terrasil, Zycobond, and PPC to improve the engineering properties of subgrade soil for pavements, highlighting the need for cost-effective and sustainable road infrastructure. It referred to past studies on soil stabilization methods that are practical and economical, mentioning the use of Terrasil chemical for enhancing soil strength and the impact of cement additives on inorganic clayey soil properties. The study involves laboratory tests to evaluate the physical and engineering properties of soil, both untreated and treated with chemical stabilizers, focusing on consistency limits, CBR value, and permeability. The addition of stabilizers like Terrasil, Zycobond, and PPC significantly improved the soil's engineering properties, including reduced plasticity, increased CBR values, and decreased permeability, contributing to the durability and load-bearing capacity

of pavements. From an economic standpoint, improving soil qualities with the use of Terrasil (0.041%) and Zycobond (0.020%) is feasible

Roopika Srivastava et al. (2016) explored the use of Terrasil and Zycobond as nano-chemical stabilizers for soil. These materials were designed to improve the engineering properties of black cotton soil. The stabilization process involved mixing the soil with specific proportions of Terrasil and Zycobond. A comprehensive set of laboratory tests were conducted to evaluate the behavior of stabilized black cotton soil with 3 dosages of Terrasil+ Zycobond as chemical additive viz, (0.5+0.25),(0.75+0.375),(1.5+0.75) kg/$m^3$ and another for (Terrasil + Cement) of dosages (0.5+3%),(0.75+3%) and (1.5+3%) respectively. The tests included measuring the Unconfined Compressive Strength (UCS), California Bearing Ratio (CBR), and other relevant soil properties. Of which the results of Terrasil +Zycobond( 0.75+0.375)kg/m3 show the best performance. The study found that the performance of the soil significantly improved with the addition of nano-chemicals and cement. It also identified optimal dosages for the stabilizers that yielded the best results in terms of soil strength and impermeability

Olaniyan O.S & Ajileye V.O(2018) in their study explored the use of Terrasil and Zycobond nano chemicals to stabilize weak lateritic soils, commonly used in road construction. Tests such as Particle Size Analysis, Atterberg Limits, and California Bearing Ratio (CBR) were conducted, showing that nano chemicals enhance soil properties. Nano chemicals (Terrasil and Zycobond) as additives were implemented in doses of 5, 10, 15, and 20% respectively. It was found that 15% was the optimal percentage of nano chemicals for the highest compressive strength.

M. Senthen Amuthan and A. Boominathan, (2018) investigated the behavior of mixtures containing particulate rubber (PR), sand, and fly ash (PRFM) as potential materials for geotechnical applications. The aim was to assess the influence of replacing sand with fly ash on the engineering properties of these mixtures, particularly focusing on their maximum dry unit weight, shear strength, compressibility, and shear stiffness. Phenomenologically it was also evident from the test results that the addition of fly ash to sand increases the shear strength up to an optimum content of 30% (% by weight) followed by a reduction in the ultimate shear strength.

T Biswas and D Sarkar (2021) in their research work discussed soil stabilization techniques using nano-chemicals like Terrasil and Zycobond, along with fly ash. It highlighted the importance of improving soil properties to support pavement structures, especially in areas with heavy rainfall. Laboratory tests on natural and stabilized soil revealed that adding fly ash increased the Maximum Dry Density (MDD) while decreasing the Optimum Moisture Content (OMC). The soil samples were treated with 0.07% terrasil and 0.02% Zycobond along with (3%, 5%, 7%, 10%) fly ash at 7,28 days curing period. The California Bearing Ratio (CBR) and Unconfined Compressive Strength (UCS) tests indicated significant improvements in soil strength with the addition of nano-chemicals after a curing period of 28 days for 3% fly ash.UCS of untreated soil (816.59 (kN/m2 ), whereas UCS value for soil treated,i.e Soil+ 3%F.A+ 0.07% Te + 0.02% ZB showed a UCS value 2153.59 kN/$m^2$.The addition of nano-chemicals and fly ash also reduced soil permeability, suggesting enhanced durability. The study concluded that using fly ash as a filler material and nano-materials like Terrasil and Zycobond significantly improved soil properties, making it more suitable for construction purposes.

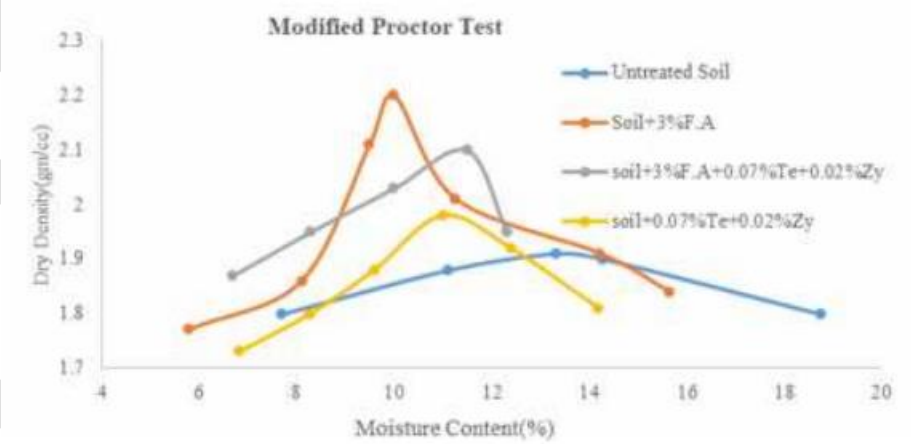


**Figure3.1** Moisture Content vs Dry Density Curve **,**Biswas.T et al.(2021)

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Kumar et al. (2022) explored the effectiveness of Zycobond and Rice Husk Ash(RHA) by conducting tests on expansive soil to enhance the strength of soil, The proportion of Rice husk ash (RHA) as a replacement was varied from 0% to 20% with an increment of 5% and further Zycobond was added with varying percentages from 0% to 2.0% with an increment of 0.5%. Test results showed that the treatment with RHA and Zycobond substantially enhances the strength and stability of expansive soils, making it a viable solution for soil stabilization in geotechnical applications. The results were analyzed and found that the optimum percentages of RHA were 15% and Zycobond 1.5% respectively.

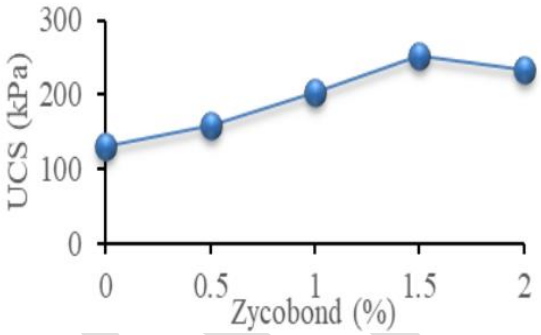



**Figure 3.2** Variation of UCS values on soil with varying percentages of Zycobond by Kumar et al.(2022)

MS Gayathri & SK Pal (2021) made a comparative study of the Compaction Characteristics of Non-conventional Conventional Stabilizers. The primary goals of the research were to establish the compaction and shear strength properties of various soil combinations created by combining nano-chemical solutions, as well as to determine the optimal dosages of nano-chemical agents that correspond to increased MDD and shear strength values. Results of the experimental program carried out on clayey-silt soil treated with various dosages of Terrasil, Zycobond, and cement when compared and evaluated showed that the UCS strength increased with increased stabilizer dosage and cure time. The ideal dosage of Terrasil and Zycobond was cited as 0.8 kg/m3 by weight of soil, and the maximum strength at 7% cement content.

Singh et.al (2022) investigated the properties of lateritic soil using various stabilizers. The study focused on a road designed to handle heavy vehicular traffic of 75 to 85 tons and withstand heavy rainfall ranging from 3000mm to 4000mm annually. Water percolation in the area has previously

led to the roads' reduced longevity. Consequently, a rigid pavement was chosen, utilizing advanced soil stabilization techniques. Terrasil combined with cement and Zycobond were used as stabilizers. The addition of nanoparticles has been found to enhance the soil's geotechnical properties. This paper examines the physical and chemical properties of the soil, along with its CBR and UCS, by varying the compositions of the additive materials: Terrasil (0.075%), Cement (1%), and Zycobond (0.075%). The results demonstrate a significant increase in soil strength following the use of these additives.

Li Pei-yong & Gao Chao (2016): This paper investigates the relationship between water content and shear strength of unsaturated sands. Sand specimens with varying water content were tested for shear strength using direct shear tests, results show that under the constant dry density, the cohesion of unsaturated sands increases with the water content increasing until reaching a peak value. Then, it is reduced with the increasing water content. On the other hand, the internal friction angle decreases to a lesser extent than the cohesion with the increase in water content. Maximum shear strength occurs at a specific water content called the "most effective water content". It shows that the trend increases first and then decreases. And at the particular water content, which is the most effective water content, the maximum value of "false Cohesion" can be reached.

P. Vangla and G.M Latha (2015) studied the effect of the size of the particles on the shear and interfacial shear strength of sand, using three sands of different particle sizes Coarse Sand, Medium Sand, Fine Sand with similar morphological characteristics, and the results observed from the symmetric direct shear tests that the particle size does not affect the peak friction angle when the tests were carried out at same void ratio. However, ultimate friction angles were affected by the particle size.

R. Alias, A. Kasa et al. (2014) conducted tests to see if and how particle size affects the shear strength of granular materials using DST. The large direct shear tests(LDST) and the small direct shear tests(SDST) were carried out using the same shearing rate of 0.09 mm/min and similar normal stresses of 100, 200, and 300 kPa. The results show that effective internal friction depends on particle size, larger size particles produced a higher effective internal friction angle and developed high shear strength. Thus peak and residual shear strength increases as particle size

increases Also it is found that at low normal stress, the specimen showed large vertical deformation in both SDST and LDST

Naiem (2008) said that the angle of internal friction in sand increases with particle size, whether the sand is fine, medium, or coarse. This angle also rises with dry density across all sand specimens. In loose states, characterized by low dry densities, a higher percentage of coarse sand leads to an increased angle of internal friction. Conversely, in medium or dense states, increasing the proportions of fine and medium sand enhances the angle of internal friction by improving contact shear surfaces. Additionally, for low dry densities or sand specimens consisting of a single type, the angle of internal friction increases with the average diameter. However, in high dry densities and mixed sand types, the angle of internal friction decreases when the average diameter exceeds 0.37.

Christopher. A et al. (2008) carried out Direct shear tests on 30 fill materials with gravel contents ranging from 0% to 30% in a small scale 64 mm square "SSDS" direct shear box and a direct shear box at large “LSDS” scale of 305 mm square. The objectives were to compare the shear behavior of a wide range of natural sandy fill materials tested in SSDS and LSDS boxes and to determine whether the same friction angle ( φ′) is obtained in SSDS and LSDS when the natural fill material contains gravel, also triaxial compression (TC) test was conducted to compare the results. Friction angles from both the tests SSDS and LSDS are essentially the same provided the gravel fraction is less than 30%, angles differed no more than 4 degrees, and in most cases differed by less than 2. Results observed from the test also mention that no statistically significant difference in the failure envelope was found from the SSDS, LSDS, TC, suggesting that φ for clean sand backfill with gravel content less than 30%,can be measured with similar accuracy from any of the three test methods.

Malidarreh, N. R., Shooshpasha (2017): They investigated the mechanical behavior of artificially cement-treated Babolsar sand reinforced with sack, polyethylene terephthalate (PET) and polypropylene (PP) fibers, examined the effects of fiber content, type, and normal or confining pressure on the soil’s mechanical properties. The study conducted direct shear and triaxial tests on

cemented sand samples with varying fiber contents and types. It explored the influence of fibers on peak strength, stiffness, brittleness index, and volumetric strain. The addition of fibers enhanced the peak strength and ductility of cemented sand, with PP fibers showing the most significant improvement. The study also found that fibers reduced the brittleness index and increased the compressive volumetric strain. The research concluded that fiber reinforcement, particularly with PP fibers, can significantly improve the mechanical behavior of cement-treated sand, making it a viable option for geotechnical applications

V. Padmavathi et al.(2019) highlighted the efficacy of nanomaterials like Terrasil, Zycobond, and Cement as admixtures in enhancing the strength properties of a c-φ soil (SC) with 31 percent fines and a plasticity index value of about 15%. The addition of Terrasil to the base soil yielded water tightness to the product and considerable improvement in the strength properties were also observed when Zycobond and Terrasil are used independently as additives and also in combination with cement, test results showed that c and φ deceased considerably on saturated soil but when treated with Zycobond there was both OMC and SMC almost the same parameters were obtained indicating that there is no effect of saturation on the shear parameters and they not much different from base soil properties. Thereby indicating that when Zycobond is used as an admixture, it leads to improvement in the strength properties of the soil. Despite this improvement, the soil remains stable without being significantly affected by moisture content. This finding highlights the potential benefits of using Zycobond in soil stabilization.

G. Surya Teja et al. (2022**)** discussed the use of Stone Dust (SD) and Zycobond (ZB) to improve expansive soils, highlighting the environmental benefits of repurposing waste materials in construction. They evaluate the effectiveness of using eco-friendly waste materials like SD and chemical stabilizers like ZB to mitigate the problematic behavior of expansive soil, as supported by laboratory tests .ZB has been used in doses from 0% to 2% with a 0.5% increase, results however showed that the properties of expansive soil improved when 25% Stone dust is substituted combined with 1.5% Zycobond.

Hao, S., Yu, Y., Song, J. et al. (2023) In their recent study, they investigated the direct shear strength properties of sandy soil mixed with polyurethane pre-polymer and sisal fiber. Sand

samples were prepared with varying dry densities, sisal fiber content, and polyurethane pre-polymer concentration. Direct shear tests were conducted to evaluate the shear strength of the sand mixtures. The dry density of the sand mixture positively influenced shear strength within the test range. Higher dry density led to improved shear strength. Increasing the concentration of polyurethane pre-polymer enhanced shear strength. The stable network structure formed by polyurethane contributed to this improvement. At a polymer content of 3%, cohesion reached approximately 148 kPa.The shear strength of sand initially increased with sisal fiber content.However, beyond an optimal point (around 0.4% sisal fiber content), further fiber addition led to decreased shear strength.

Rakshita GS and and G.Suresh (2022) addressed the engineering challenges posed by black cotton soil, which exhibits significant swelling and shrinkage with moisture change. They performed a study to investigate the impact of Terrasil and Zycobond on black cotton soil strength properties. Different dosages (ranging from 0.06% to 0.12% by dry weight) were used, along with an optimal 30% content of Waste Foundry Sand. The soil's behavior was evaluated through various laboratory tests. The study found that 0.1% Terrasil and Zycobond by dry weight, along with 30% Waste Foundry Sand yielded the best results in terms of maximum dry density, CBR, and UCC while reducing the Freeswell index.

**2.3 SUMMARY:**

This chapter presents a comprehensive review of numerous studies and research papers on soil stabilization techniques and their effectiveness. It covers various methods and materials such as cement, lime, fly ash, and bitumen, which are used to enhance soil properties, increase strength, and reduce permeability and compressibility. Research indicates that adding cement and nano-silica to sandy soils improves dry unit weight and mechanical properties, while bentonite and PPC boost shear strength and density. Chemicals like Terrasil, Zycobond, and nano-chemicals significantly enhance soil properties, including strength, CBR values, and impermeability. Additionally, studies have shown that particle size can influence shear strength.

After critically reviewing the literature, several research gaps were identified. While many studies have examined the effects of chemical additives on different soil types, such as expansive soil,

clayey soil, and lateritic soils primarily through UCS and CBR tests, there has been limited research to study their impact on sandy soils, particularly in terms of shear strength. Based on the findings from the literature review, it can be inferred that while Zycobond acts as a soil modifier in the case of other types of soil, its effects on sandy soils require further investigation.

# CHAPTER: 3
# OBJECTIVES AND SCOPE

## 3.1 INTRODUCTION:

Based on the literature review relevant to present work and as presented in the last chapter, the objectives and the scope of the present study are as discussed in this chapter. The objective and scope of any research endeavor are pivotal in defining its purpose, setting the framework for investigation, and delineating the boundaries within which the study operates. This chapter serves as a foundational element that clarifies the goals, aims, and limitations of the research, providing a roadmap for understanding its significance and relevance. This dissertation aims to investigate the enhancement of shear strength properties of sandy soil through the application of chemical additives. The primary objectives of this study include:

## 3.2 OBJECTIVES OF THE STUDY:

- To assess the effectiveness of chemical additives in improving the shear strength characteristics of sandy soil.
- To analyze the influence of different dosages of chemical additives on shear strength parameters such as cohesion and internal friction angle.
- To investigate the effect of particle size on the shear strength of soil.

## 3.3 SCOPE OF THE STUDY:

This dissertation aims to investigate the enhancement of shear strength properties of sandy soil through the application of chemical additives. The study will focus on evaluating the effectiveness of chemical additives in improving shear strength parameters such as cohesion and internal friction angle of sandy soils. Specifically, it seeks to analyze the influence of the chemical additive Zycobond and dosage of the chemical additive on the engineering properties of sandy soil under controlled laboratory conditions.

The objectives of this study include assessing how the chemical additive interacts with sandy soil particles to modify its shear strength behavior. Key research questions to be addressed include investigating the optimal dosages of chemical additives required to achieve maximum improvement in shear strength, understanding the mechanisms through which these additives enhance soil stability, and examining the variability of additive performance based on soil composition and environmental factors.

Methodologically, the study will involve conducting a series of laboratory tests using standard geotechnical techniques. Direct shear tests will be performed on untreated sandy soil samples and those treated with selected chemical additives. Testing protocols will be limited to specific curing periods and environmental conditions to simulate real-world scenarios. Data analysis will focus on quantifying changes in shear strength parameters and comparing the performance of the additives.

The deliverables of this dissertation will include a comprehensive analysis of the effects of chemical additives on sandy soil shear strength properties, recommendations for optimal additive selection and application in geotechnical engineering practices, and a dataset comprising test results, analyses, and conclusions drawn from the study. Assumptions underlying this research include the availability and uniformity of chemical additives for laboratory testing while acknowledging limitations related to the controlled nature of laboratory conditions and their potential divergence from field conditions.

Significantly, this study is expected to contribute to the understanding of chemical additives as a viable method for improving the engineering properties of sandy soils. The findings will provide valuable insights for engineers and researchers involved in soil stabilization and geotechnical projects in sandy soil regions, potentially influencing best practices in the field of geotechnical engineering. Ethical considerations guiding this research include adherence to safety protocols in handling chemical additives and ensuring environmental responsibility during laboratory testing procedures.

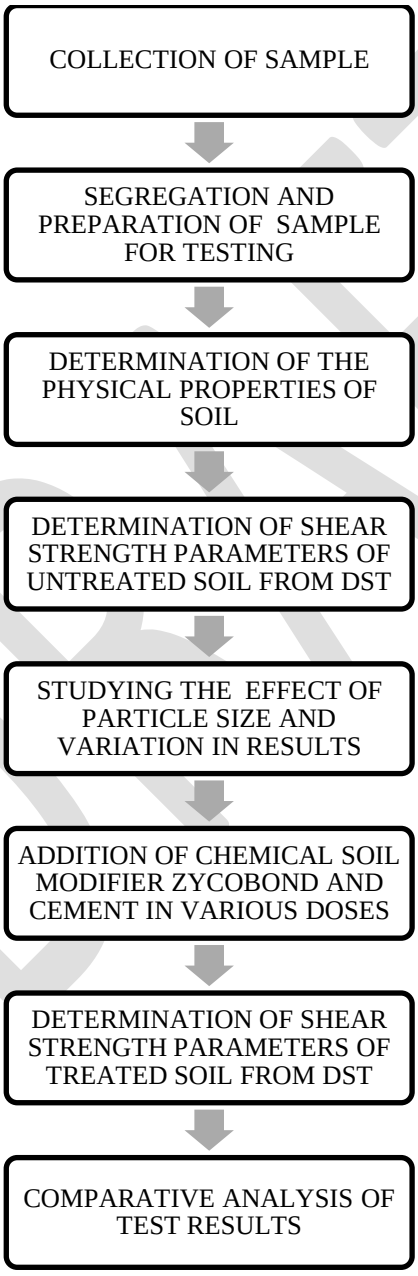
## 3.4 SUMMARY:

This chapter outlines the objectives and scope of the study, which aims to enhance the shear strength properties of sandy soil using chemical additives. It sets the framework for the investigation and defines the boundaries within which the study operates. The primary objectives are to study the effectiveness of chemical additives in improving the shear strength characteristics of sandy soil to analyze the influence of different dosages of chemical additives on shear strength parameters also to investigate the effect of particle size on the shear strength of the soil. Methodologically, it involves conducting direct shear tests on untreated and treated soil samples, analyzing data to quantify changes in shear strength, and comparing additive performance. The deliverables include a comprehensive analysis, recommendations for additive application, and a dataset of test results. The study acknowledges the limitations of laboratory conditions and emphasizes ethical considerations in handling chemicals and environmental responsibility.

# CHAPTER: 4

# METHODOLOGY

## 4.1 AN OUTLINE OF THE METHODOLOGY:



## 4.2 MATERIALS:

### 4.2.1 Sand:

The soil sample used for testing was collected from the Kulsi River in Kamrup District. According to the Unified Soil Classification System, this soil is classified as poorly graded sand (SP). For the study, the soil was separated into specific particle size fractions: coarse sand (CS) with particle sizes ranging from 4.75 to 2 mm, medium sand (MS) ranging from 2 to 0.425 mm, and fine sand (FS) ranging from 0.425 to 0.075 mm. These fractions are referred to as CS, MS, and FS respectively in this report. The original river sand collected from the Kulsi River is denoted as OS for convenience.

### 4.2.2 Cement:

The cement used is Portland Pozzolana Cement (PPC) of cement grade-53 [PPC, IS:1489 (part 1) 1991 – fly ash based. PPC (Portland Pozzolana Cement) Grade 53 is widely used in construction due to its numerous advantages. It combines Portland cement clinker with pozzolanic materials like fly ash, enhancing its workability, durability, and strength characteristics. One of the primary advantages of PPC Grade 53 cement is its higher compressive strength compared to ordinary Portland cement (OPC), making it suitable for structural applications where strength is crucial. Additionally, incorporating fly ash reduces heat generation during hydration, minimizing the risk of thermal cracking in large concrete structures. PPC Grade 53 cement also offers improved resistance to chloride and sulfate attacks, making it ideal for marine and coastal constructions. Its eco-friendly nature, by utilizing industrial byproducts like fly ash, contributes to sustainable building practices by reducing carbon emissions and promoting efficient use of resources.

### 4.2.3 Chemical Soil Modifier:

Chemicals based on nanotechnology that are involved in the synthesis and reactivity of nanoparticles and their compounds are known as nano-chemicals. The size of these materials is produced on a scale that is ten thousand times smaller than that of human hair. At this point, new methods of conducting chemical processes become feasible, and quantum effects may become prominent. The distinct nano chemical Zycobond is employed as a soil stabilizer agent in this study

#### 4.2.3.1 Zycobond :

Zycobond abbreviated as (ZB) is a liquid acrylic Co-polymer emulsion that is delivered as a ready-to-use bonding solution. It is used as a bonding primer and porosity filler material manufactured by Zydex Industries and available in the local markets. Figure 4.5(b)shows the sample of the chemical additive used.It is composed of an acrylic co-polymer that is soluble in water, stable to heat, and resistant to ultraviolet radiation. This versatile substance chemically binds soil particles into a flexible crosslinked network, improving load-bearing capacity and enhancing flexibility in soil bases. It imparts resistance to soil erosion and dust controls. It is an 80 - 90 nm flexible acrylic co-polymer with a very high surface area for bonding. The higher number of contact points ensures flexible bonding at a nano level, leading to improved fatigue resistance in stabilized soils. It maintains friction values between silt, sand, and clay particles, allowing for strength and deformation resistance management

**Table 4.1** Chemical Composition of Zycobond (M. P. Kumar et al.)

| S. No | Component | Concentration (%) |
|---|---|---|
| 1 | Quaternary Ammonium compounds | 1-5 |
| 2 | Methanol | 0.1-0.2 |
| 3 | Acetic acid | 0.2-1 |
| 4 | Acrylic Co polymer | 34-36 |
| 5 | Water | 62-65 |

**Table 4.2** Physical properties of Zycobond (M. P. Kumar et al.)

| S.No | Property | Values |
|---|---|---|
| 1 | Color | Milky White |
| 2 | Odour | No |
| 3 | Flashpoint | above 100°C |
| 4 | Soluble in Water | Dispersible |
| 5 | pH value | 5-6 |

## 4.3 WORKING METHODOLOGY

### 4.3.1 Collection of the soil sample:

Soil sample is collected from the Kulsi River, a tributary of the Brahmaputra River, in Kamrup District. The sandy soil collected from the site is then used for testing purposes.

### 4.3.2 Preparation of the samples for testing:

Soil samples obtained from the site are brought and washed thoroughly under the tap water in the 75µ IS sieve, letting out all the silt and clay particles if present washed out under the running water. The soil (sand) sample is left to dry in the oven at a standard temperature of 105º-110°C for 24 hours. The oven-dried sample is then allowed to cool to room temperature and then sieved through the Indian Standards sieves: 4.75mm,2mm,425µ,75µ. The mass of soil retained on the 2mm IS sieve is kept aside and classified as Coarse sand (CS), the soil retained on the 425 IS sieve is separated and classified as Medium Sand (MS), The soil retained on the 75 IS sieve is classified as Fine Sand (FS). The un-sieved soil passing through a 4.75mm IS sieve is marked as Original sand (OS). These soil samples are then used to study the shear strength using a Direct shear testing apparatus.

**Figure 4.1** Soil sample washed in75µ IS sieve under tap water.

**Figure 4.2** Washed sand sample

**Figure 4.3** Oven-dried sand sample

**Figure 4.4** Test Sand Samples MS, FS, CS

For the second part of the study, we have used the OS sample only. The OS sample was introduced with the chemical soil modifier Zycobond in addition to Cement in minimal quantity. Zycobond solutions were prepared by mixing it with water,shown in Figure 4.5 (a) at 5 doses of 0.5 kg/$m^3$,0.75 kg/$m^3$,1 kg/$m^3$,1.25 kg/$m^3$ and 1.5 kg/$m^3$. For using cement as an additive, PPC cement was used which was added to the soil sample at doses of 1%,2%,3%,4%, and 5% for the purpose of testing. A total of 25 numbers of soil samples were prepared for testing. Soil samples were prepared by taking soil of 500 grams to which cement was added at 5 different cement doses of 1%,2%,3%,4%, and 5% to which ZB solution was added at OMC.(Figure 4.6) For each cement

dose+soil,5 samples were prepared with ZB doses of 0.5 kg/$m^3$,0.75 kg/$m^3$,1 kg/$m^3$,1.25 kg/$m^3$and 1.5 kg/$m^3$.All soil samples prepared for tests were cured under a curing period of 24 hours.

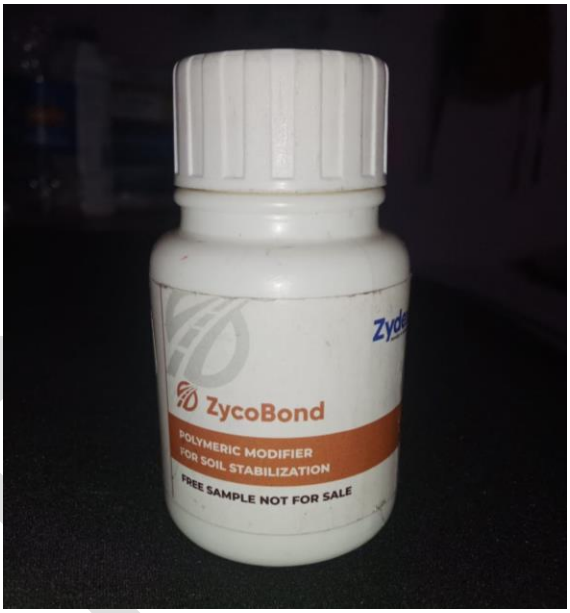



**Figure 4.5** (a) Zycobond solutions prepared (b) Chemical soil modifier Zycobond

### 4.3.3 Direct Shear Test (DST):

The DST machine used for the tests is a manually operated device from AIMIL shown in Figure 4.9 For the test to be conducted, the position of the lever is set to position A, and the turret lever at 1, giving it a deformation rate of 1.25 mm/min. The test setup and the parts of the machine are shown in Figure 4.9 . The Direct Shear Box and its parts are shown in Figure 4.8 and Figure 4.7

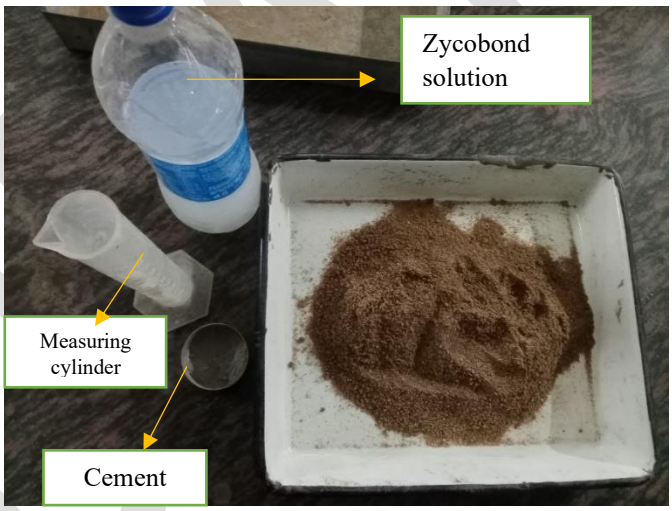
Following Data values to consider for the test:

- Proving ring constant=0.33 kg/div
- Dial gauge constant=0.01mm/div
- Deformation Rate=1.25 mm/min
- Shear box size= 6*6*2.5 $cm^3$
- Volume(V) of shear box=90 $cm^3$
- Area of shear box=36 $cm^2$
- Weight of empty DST box=2.728 kg

- Weight of DST with soil=2.876 kg
- Density of Sample =1.64 gm/cm$^3$

#### 4.3.3.1 Direct Shear Test Procedure:

The empty weight of the direct shear box together with the grid and base plates are noted down as ($w_1$) . The DSB is arranged in sequence, placing the base plate at the bottom, followed by the porous stone over which the perforated grid plate is placed at an angle of 90º to the direction of shear. The soil is placed inside the Direct shear box in three equal layers, each layer tamped with 25 numbers of blows, maintaining uniform compaction effort. Over this soil, the grid plate is placed with the perforated grids placed similarly at 90 to shear direction, and then porous stone over which the loading pad is placed. The weight of the box assembly is noted down ($w_2$).




(a)

(b)

**Figure 4.6**.(a) & (b) Soil sample prepared with Zycobond solution + cement

Now, $W_2$-$W_1$=W gives us the mass of the soil inside the shear box. Thus to maintain a constant density throughout the tests, the mass is kept the same for all the tests performed. Density is calculated by W/Volume of the box

**Figure 4.7** Direct Shear Box Parts

**Figure 4.8** Direct Shear box with soil


**Figure 4.9** Test setup-DST machine.(AIMIL-Manually operated)

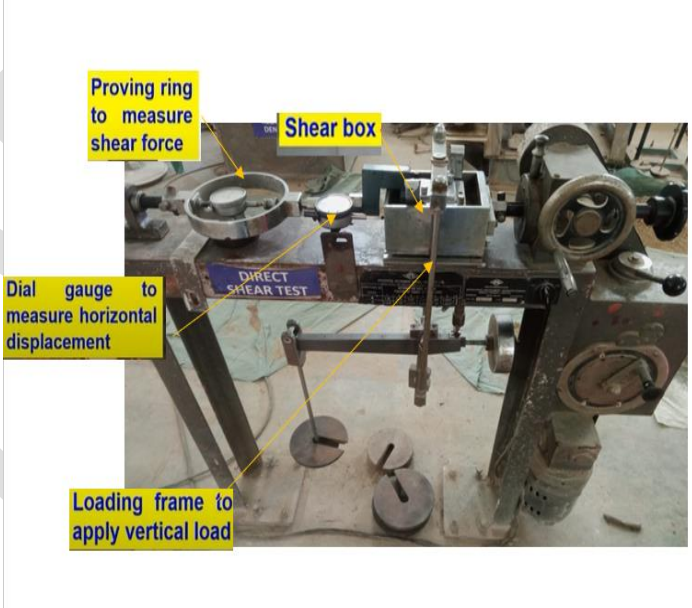



**Figure 4.10** Parts of the Test Setup Machine

## 4.4 SUMMARY:

The chapter discussed the methodology and materials used in the study. For the study Soil samples were collected from the Kulsi River in Kamrup District. The samples were washed, dried, and

sieved into coarse, medium, and fine sand fractions to study the effect of particle size on shear strength. For the next part of the study the original unsieved soil, i.e. the Kulsi river sand is considered for a chemical treatment to study the shear strength properties. The study used Portland Pozzolana Cement (PPC) Grade 53 and a chemical soil modifier called Zycobond, an acrylic co-polymer emulsion. The shear strength of untreated and treated soil samples was determined using a Direct Shear Test (DST). Various doses of cement and Zycobond were added to the soil samples for testing. The results of the shear strength tests for treated and untreated soils were compared to evaluate the effectiveness of the soil stabilization methods.

# CHAPTER 5
# TEST RESULTS

This chapter reports on the different tests performed in the laboratory and the results of these tests have been presented in the form of tables and graphs

## 5.1 Determination of the physical properties of the soils:

1. Determination of specific gravity was performed as per IS 2720 (Part 3) 1980.
2. Determination of gradation of the soil samples by wet sieve analysis was performed following IS 2720 (Part 4) -1985

**Table 5.1** Percentage of sand content concerning size

| Sample | %Coarse Sand | %Med Sand | %Fine Sand |
|---|---|---|---|
| Kulsi River Sand | 3 | 72 | 25 |

**Table 5.2** Particle Size distribution results of the soil samples.

| SAMPLE | % SAND | % FINES (CLAY +SILT) |
|---|---|---|
| Kulsi River Sand | 99.26 | 0.74 |

The soil collected from site was sieved and classified to see the percentage fine ,medium and coarse sand particles present. Table 5.1 shows the different percentages of sand present in the Kulsi River Sand. Gradation of soil samples performed following IS 2720 (Part 4) 1985,showed that the soil contains 0.74% fines and 99.26% sand content.The gradation curve for the soil sample (OS) is shown in Figure 5.1 and Figure 5.2 shows the gradation curve for FS,MS ,CS and OS altogether. From the gradation data and specific gravity tests performed with pycnometer bottles, the physical properties were determined .The different values obtained for all the 4 types of soil are tabulated in Table 5.3

**Table5.3** Physical properties of soil

| Property Grain Size Parameter | Coarse Sand (CS) | Medium Sand(MS) | Fine Sand(FS) | Original Sand(OS) |
|---|---|---|---|---|
| **FM** | 4.925 | 2.88 | 2.37 | 2.48 |
| **$D_{10}$ (mm)** | 2.42 | 0.4 | 0.157 | 0.27 |
| **$D_{30}$ (mm)** | 2.94 | 0.62 | 0.22 | 0.41 |
| **$D_{60}$ (mm)** | 3.72 | 0.93 | 0.33 | 0.63 |
| **Coefficient of uniformity ($C_U$)** | 1.53 | 2.28 | 2.12 | 2.32 |
| **Coefficient of curvature ($Cc$)** | 0.96 | 1.01 | 0.92 | 1 |
| **Specific Gravity** | 2.55 | 2.62 | 2.77 | 2.59 |

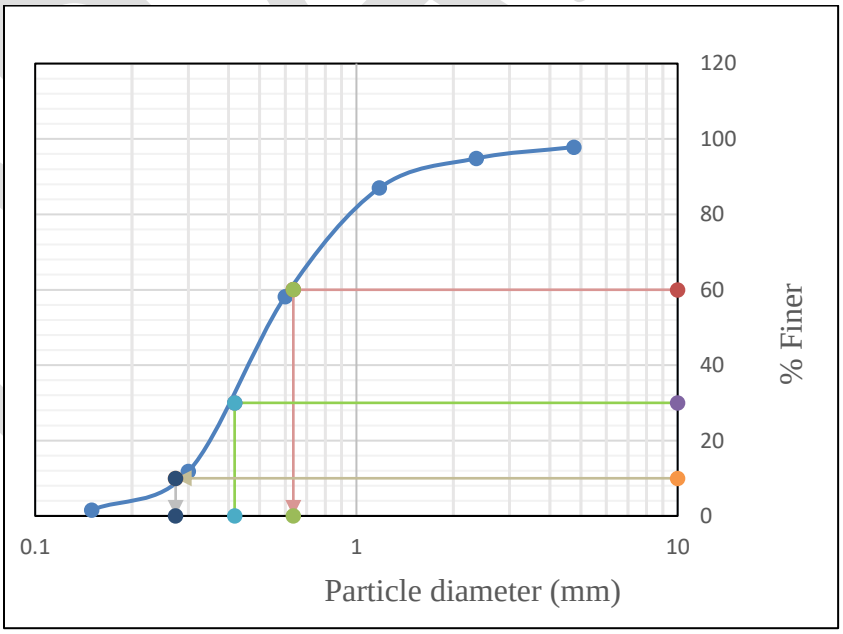



**Figure 5.1** Gradation Curve for Original Soil (OS) sample

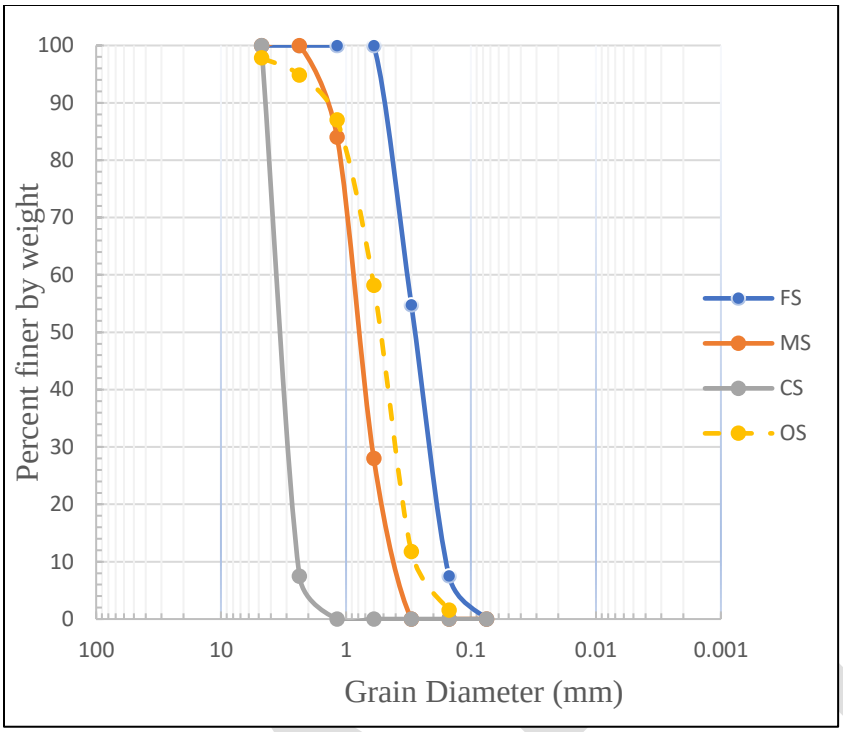



**Figure 5.2** Gradation Curve for OS, FS, MS, CS.

### 5.2 Determination of compaction properties of soil:

The standard Proctor's compaction test was conducted in the laboratory to determine the optimum moisture content corresponding to the maximum dry density in accordance with IS: 2720 (Part 7) 1980. The result of the soil sample is presented in Table 5.4 and the Standard Proctor curve obtained from the test is shown in Figure.5.3

**Table 5.4** Optimum moisture content and maximum dry unit weight by Standard Proctor compaction test

| Soil Sample | Maximum Dry Density ($g/cm^2$) | Optimum Moisture Content (OMC) (%) |
|---|---|---|
| Kulsi Sand | 1.63 | 9 |

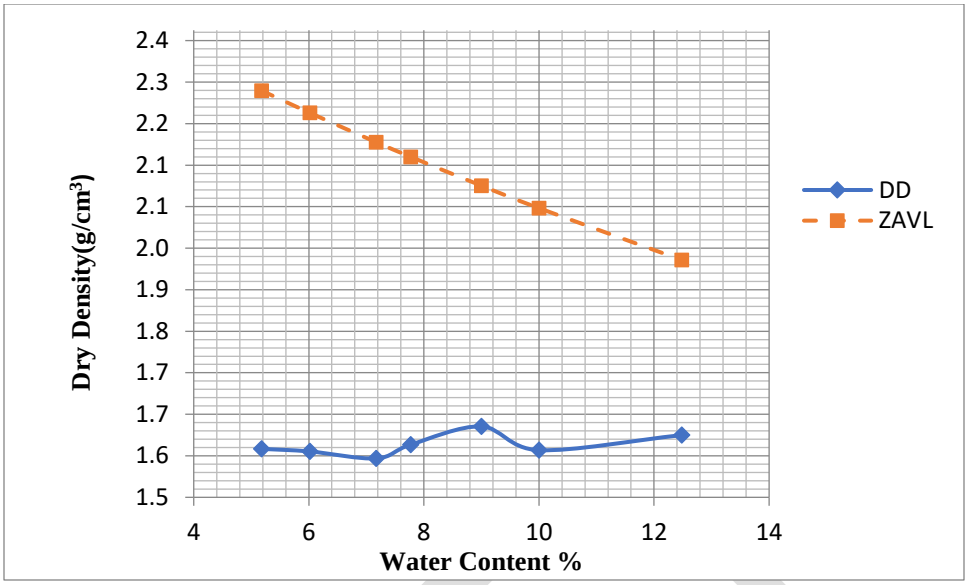



**Figure 5.3** Standard Proctor Curve for OS sample

### 5.3 Determination of the Shear strength parameters of soils from the Graph :

To determine the shear strength parameters of soil, the Direct Shear Test is conducted in the laboratory on four different soil groups (FS, MS, CS, and OS) under three different normal stresses (0.5 kg/cm², 1 kg/cm², and 1.5 kg/cm²) according to IS 2720-13 (1986). The maximum shear stress is obtained from the plot of shear stress versus horizontal displacement. This maximum shear stress is then plotted against the normal stresses to create the failure envelope, using a linear regression approach. The slope of this envelope provides the shear strength parameters: the angle of internal friction (φ) and cohesion (c )

Test results showed that the stress-strain curves for all the soil samples do not show an apparent peak associated with the failure point, thus as per guidelines in Indian Standard Code IS 2720-13 (1986): Methods of test for soils, Part 13: Direct shear test, the failure point is considered at 20% longitudinal displacement, thus the maximum displacement is marked at 1.2 cm or approximately at 20% longitudinal displacement and the Shear stress corresponding to at 20% longitudinal displacement is marked as the maximum shear stress at which the failure occurs.

Figure 5.4 shows the variation of Horizontal Displacement vs. Shear stress at constant normal stresses 0.5 kg/cm², 1 kg/cm², and 1.5 kg/cm²) for FS. Similar graphs are obtained for MS,CS

and OS samples, which are shown in Figures 5.5,5.6 and 5.7 respectively. Figure 5.8 shows the Shear stress vs. Horizontal Displacement for OS at OMC. The Maximum Shear Stress values obtained corresponding to the Normal Stresses for FS, MS, CS, and OS are enlisted in tables 5.5,5.6,5.7,5.8 and 5.9 and the failure envelopes obtained for all four soil samples FS, MS,CS, and OS are shown in Figure 5.9,5.10,5.11,5.12. Figure 5.13 shows the failure envelope OS sample obtained at OMC. For reference the readings of the DST results are enlisted in Appendix A, (Table 1 to Table 15.)

### 5.3.1 Graphs for the Test Results of DST:

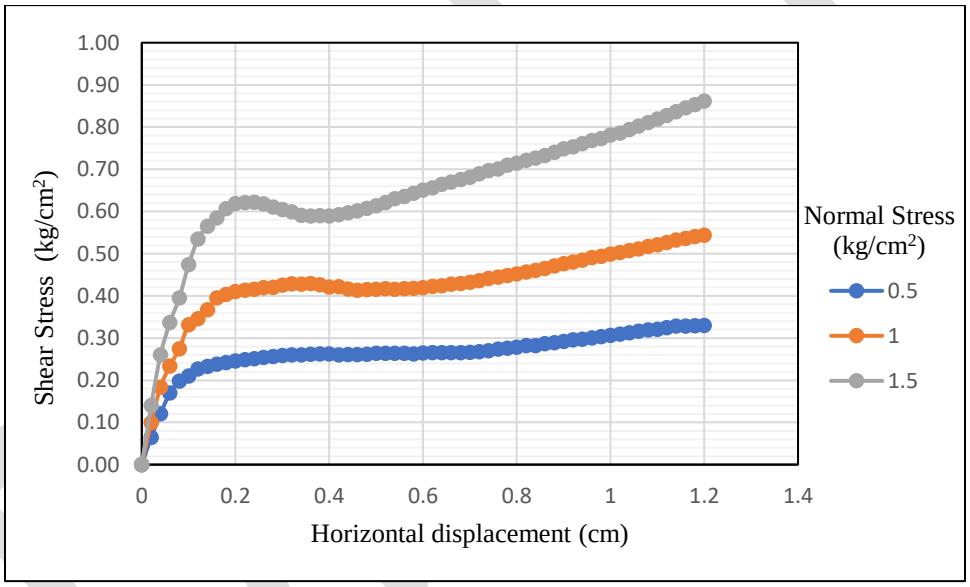



**Figure 5.4** Shear stress(kg/cm$^2$) vs Horizontal displacement (cm) of Fine Sand (FS)

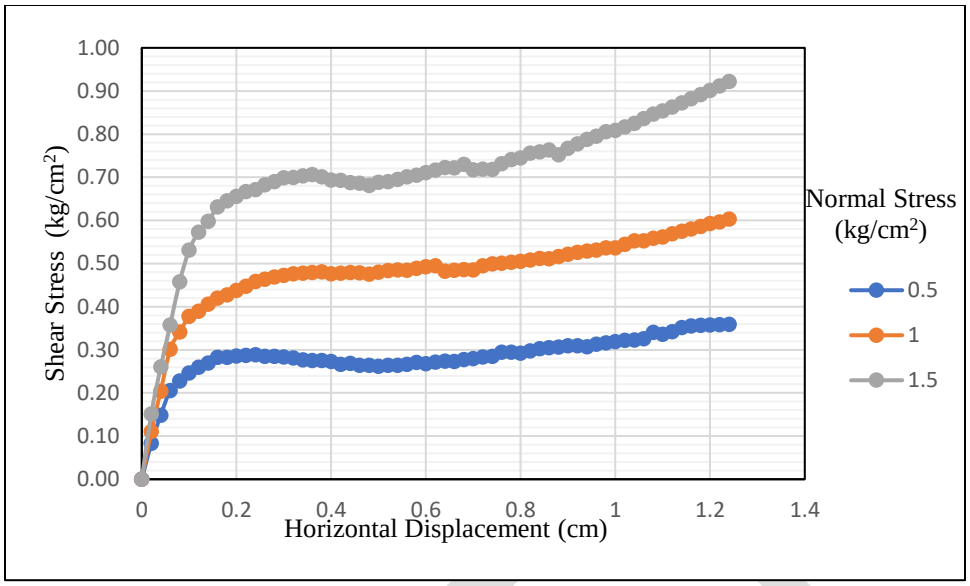



**Figure 5.5** Shear stress (kg/cm$^2$) vs Horizontal displacement (cm) of Medium Sand (MS)

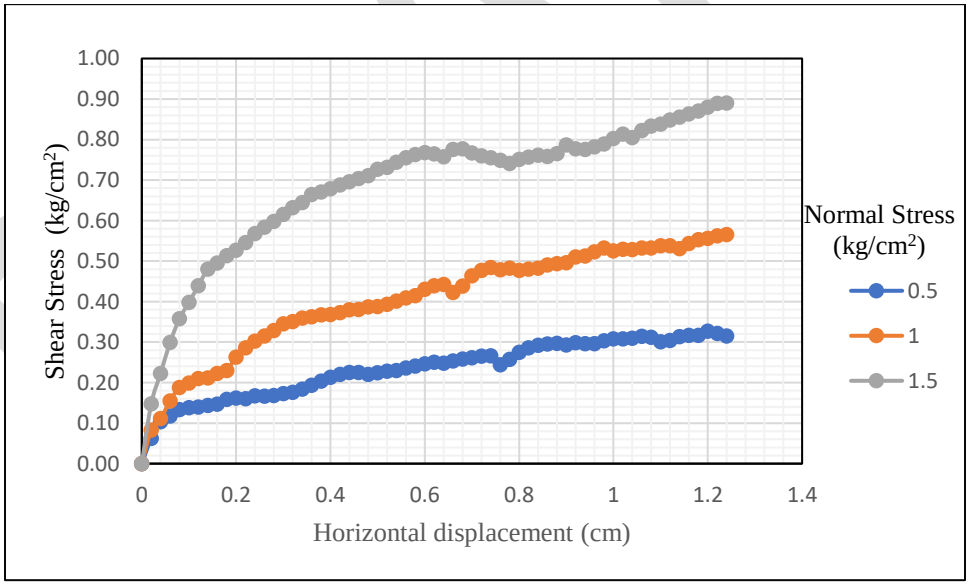



**Figure 5.6** Shear stress(kg/cm$^2$) vs Horizontal displacement (cm) of Coarse Sand (CS)

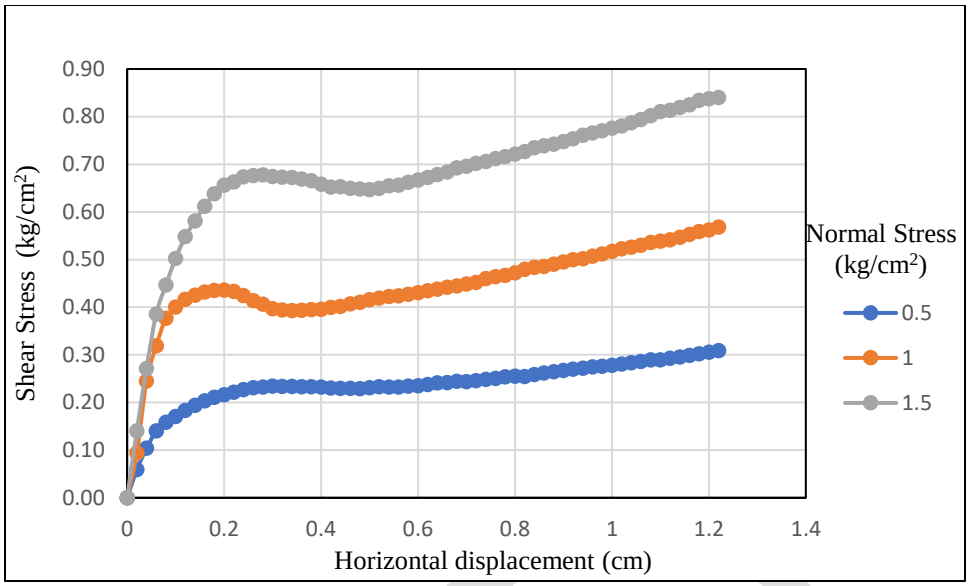



**Figure 5.7** Shear stress(kg/cm$^2$) vs Horizontal displacement (cm) of Original Sand(OS) at Dry State

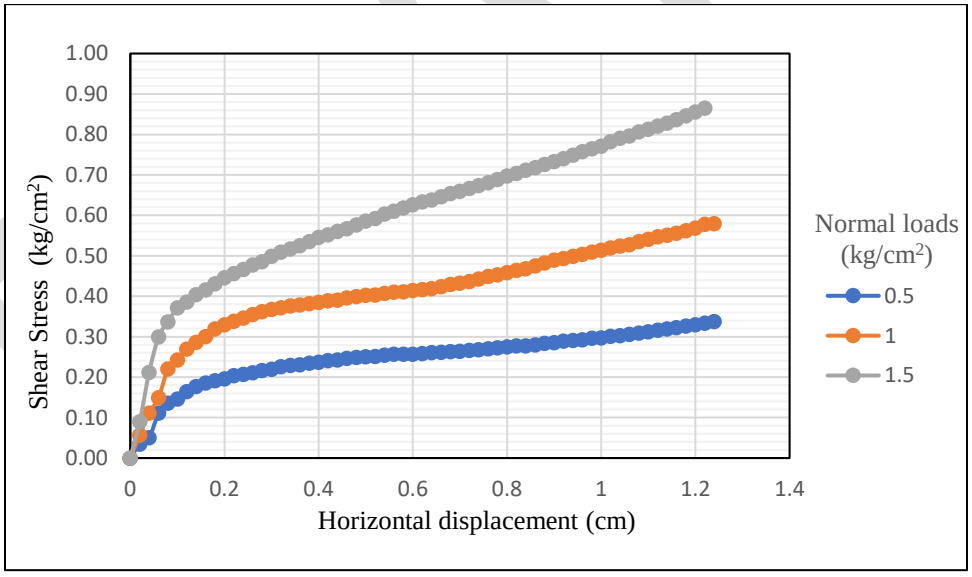



**Figure 5.8** Shear stress(kg/cm$^2$) vs Horizontal displacement (cm) of Original Sand (OS) at OMC

**Table 5.5** Shear stress values of Test 1,2,3 at Normal stresses of 0.5,1,1.5 kg/cm$^2$ for Fine Sand (FS)

| Test no. | Normal Stress (kg/cm$^2$) | Max Shear Stress (kg/cm$^2$) |
|---|---|---|
| 1 | 0.5 | 0.33 |
| 2 | 1 | 0.54 |
| 3 | 1.5 | 0.86 |

**Table 5.6** Shear stress values of Test 1,2,3 at Normal stresses of 0.5,1,1.5 kg/cm$^2$ for Medium Sand (MS)

| Test no. | Normal Stress (kg/cm$^2$) | Max Shear Stress (kg/cm$^2$) |
|---|---|---|
| 1 | 0.5 | 0.36 |
| 2 | 1 | 0.6 |
| 3 | 1.5 | 0.92 |

**Table 5.7** Shear stress values of Test 1,2,3 at Normal stresses of 0.5,1,1.5 kg/cm$^2$ for Coarse Sand (CS)

| Test no. | Normal Stress (kg/cm$^2$) | Max Shear Stress (kg/cm$^2$) |
|---|---|---|
| 1 | 0.5 | 0.38 |
| 2 | 1 | 0.66 |
| 3 | 1.5 | 0.93 |

**Table 5.8** Shear stress values of Test 1,2,3 at Normal stresses of 0.5,1,1.5 kg/cm$^2$ for Original Sand (OS) at OMC

| Test no. | Normal Stress (kg/cm$^2$) | Max Shear Stress (kg/cm$^2$) |
|---|---|---|
| 1 | 0.5 | 0.30 |
| 2 | 1 | 0.54 |
| 3 | 1.5 | 0.86 |

**Table 5.9** Shear stress values of Test 1,2,3 at Normal stresses of 0.5,1,1.5 kg/cm$^2$ for Original Sand (OS) at Dry State

| Test no. | Normal Stress (kg/cm$^2$) | Max Shear Stress (kg/cm$^2$) |
|---|---|---|
| 1 | 0.5 | 0.32 |
| 2 | 1 | 0.57 |
| 3 | 1.5 | 0.84 |

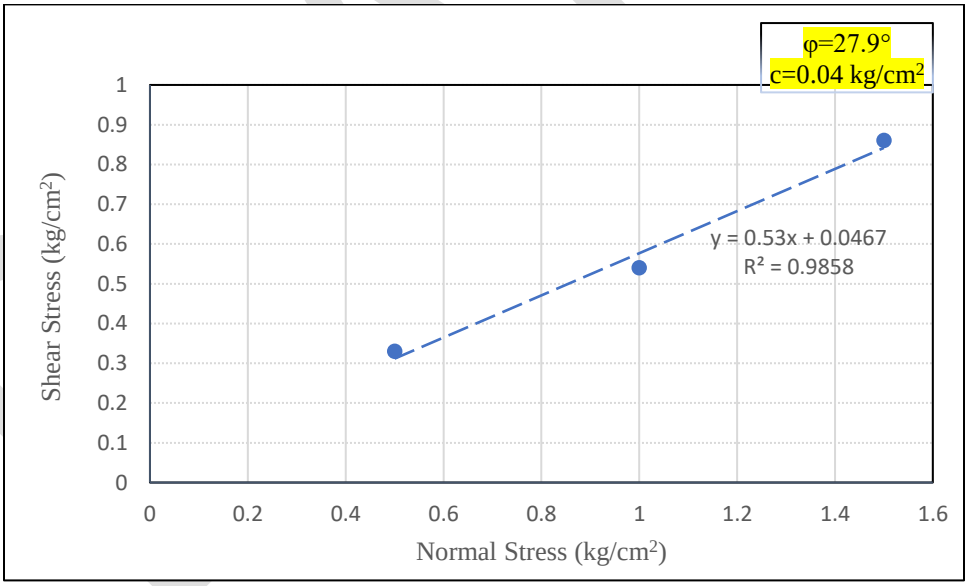



**Figure 5.9** Shear Stress vs.Normal Stress Plot for FS

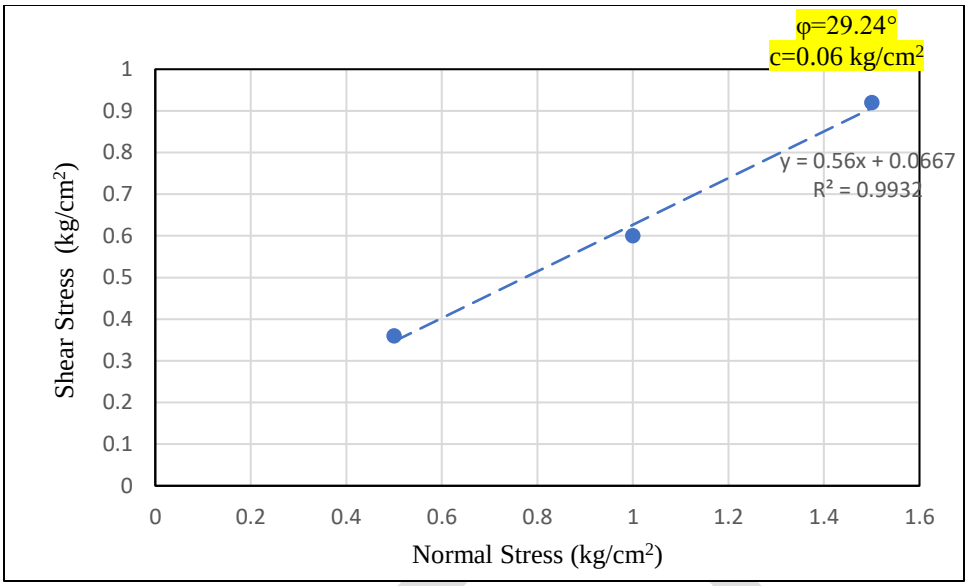



**Figure 5.10** Shear Stress vs.Normal Stress Plot for MS

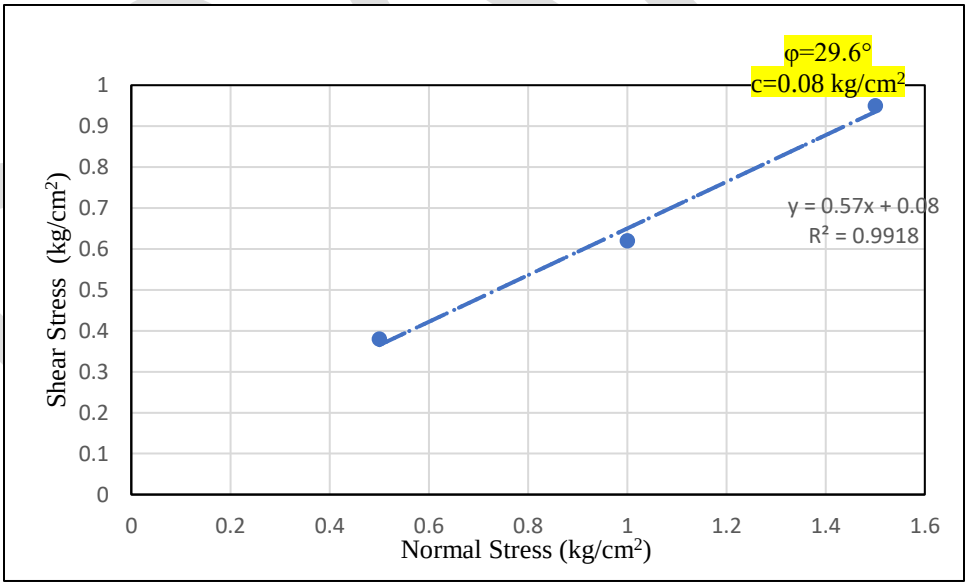



**Figure 5.11** Shear Stress vs.Normal Stress Plot for CS

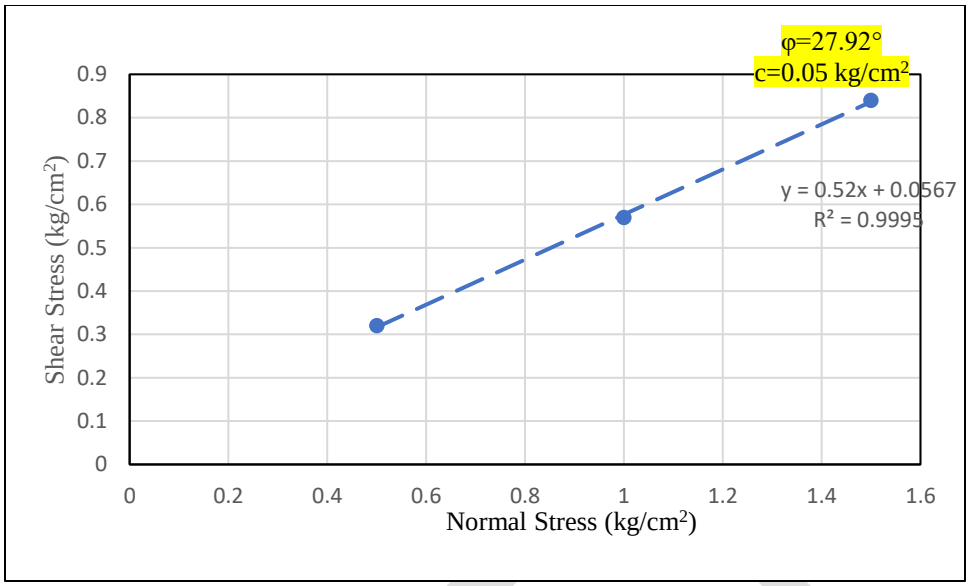



**Figure 5.12** Shear Stress vs. Normal Stress Plot for OS at Dry State

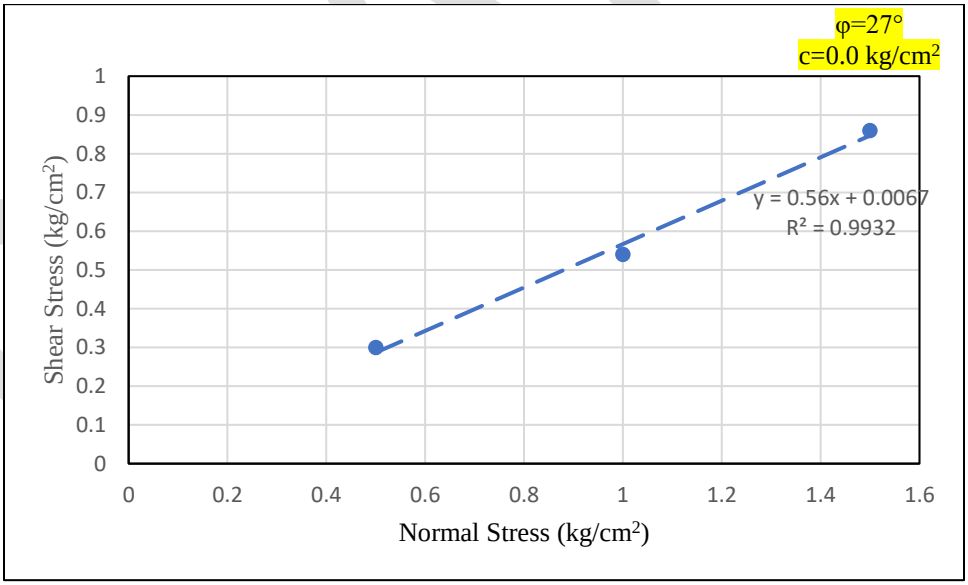



**Figure 5.13** Shear Stress vs.Normal Stress Plot for OS at OMC

**Table 5.10** .Shear Strength parameters for FS,MS,CS,OS

| SAND TYPE | SHEAR STRENGTH PARAMETERS | |
|---|---|---|
| | Angle of Internal Friction (φ) in degrees | Cohesion ( c ) in kg/cm$^2$ |
| FINE SAND | 27.9 | 0.04 |
| MEDIUM SAND | 29.2 | 0.06 |
| COARSE SAND | 29.6 | 0.08 |
| ORIGINAL SAND at OMC | 27 | 0.006 |
| ORIGINAL SAND at Dry State | 27.92 | 0.05 |

Table 5.10 shows the Shear Strength parameters for FS,MS,CS and OS at dry and OMC from the failure envelopes obtained from from the DST results.

For the next phase of our study, we prepared a total of 25 soil samples as mentioned in the previous chapter. The Direct Shear Test was conducted on Sample No. 1, which consists of soil mixed with 1% cement and 0.5 kg/m³ ZB, under a normal stress of 0.5 kg/cm². The test results are recorded in Appendix B, Table B1. The tests were also performed under normal stresses of 1.0 kg/cm² and 1.5 kg/cm², with the results documented in Appendix B, Tables B2 and B3, respectively. Similar tests were conducted for Sample No. 2, which includes soil with 1% cement and 0.75 kg/m³ ZB. The results for these tests are found in Appendix B, Tables B4, B5, and B6. For Samples No. 3, 4, and 5, which consist of soil with 1% cement and varying amounts of ZB (1.0 kg/m³, 1.25 kg/m³, and 1.5 kg/m³, respectively), the test results are detailed in Appendix B, Tables B7 to B15

Figure 5.16 shows the variation of Shear Stress vs Horizontal displacement for soil samples with 0.5 ZB and 1% cement obtained from direct shear tests at normal stress of 0.5 kg/cm$^2$, 1.0kg/cm$^2$, 1.5 kg/cm$^2$. Similar trends were observed for other Sample No.2, Sample No.3, Sample No.4, and Sample No.5, in Figure 5.17, Figure 5.18, Figure 5.19, and Figure 5.20.

As shown in Figures all the stress-strain curves do not show an apparent peak associated with failure point, thus as per guidelines in the Indian Standard Code IS 2720-13 (1986): *Methods of test for soils, Part 13: Direct shear test*, Bureau of Indian Standards, New Delhi, India, the failure point is considered at 20% longitudinal displacement, thus the maximum displacement is marked at 1.2 cm or approximately at 20 % longitudinal displacement as the failure point. and the corresponding Maximum stresses obtained for samples 3,4 and 5 are listed in Table.5.13, Table.5.14, and 5.15 respectively.

Determining the maximum shear stress at the corresponding Normal stress. a plot of Maximum Shear Stress vs Normal Stress is plotted,(Figure 5.21-Figure 5.25) the slope obtained from the graph gives us the value of internal friction angle,φ(in degrees), and cohesion (c )obtained from the graph is found to be almost 0,.The values of c (kg/cm$^2$) and φ(in degrees) for 1% cement+soil at various proportions of ZB :0.5 ,0.75,1,1.25,1.5 kg/m$^3$ are tabulated in Table 5.16

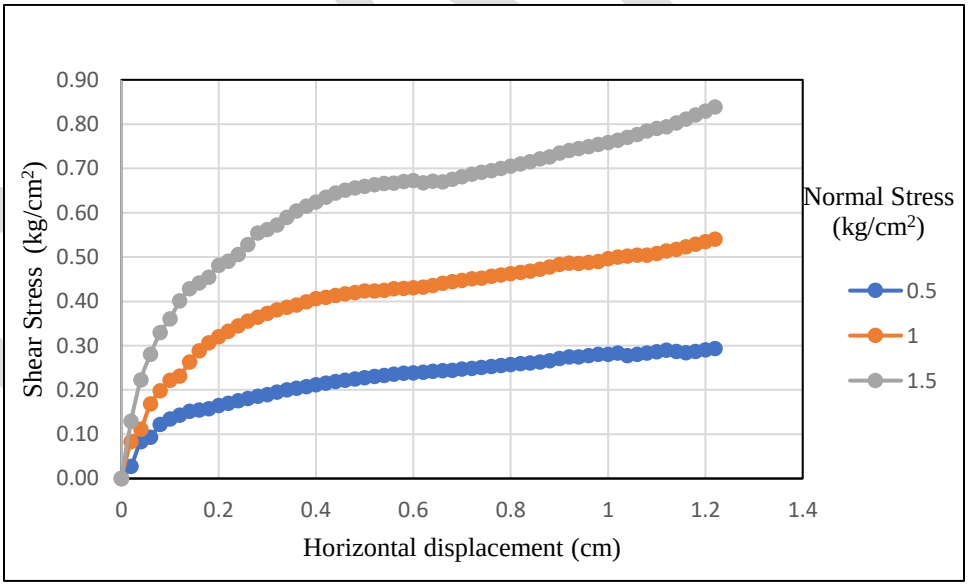



**Figure 5.14** Shear stress(kg/cm$^2$) vs Horizontal displacement (cm) graph for SOIL+ 1% CEMENT+ 0.5 kg/m$^3$ ZB

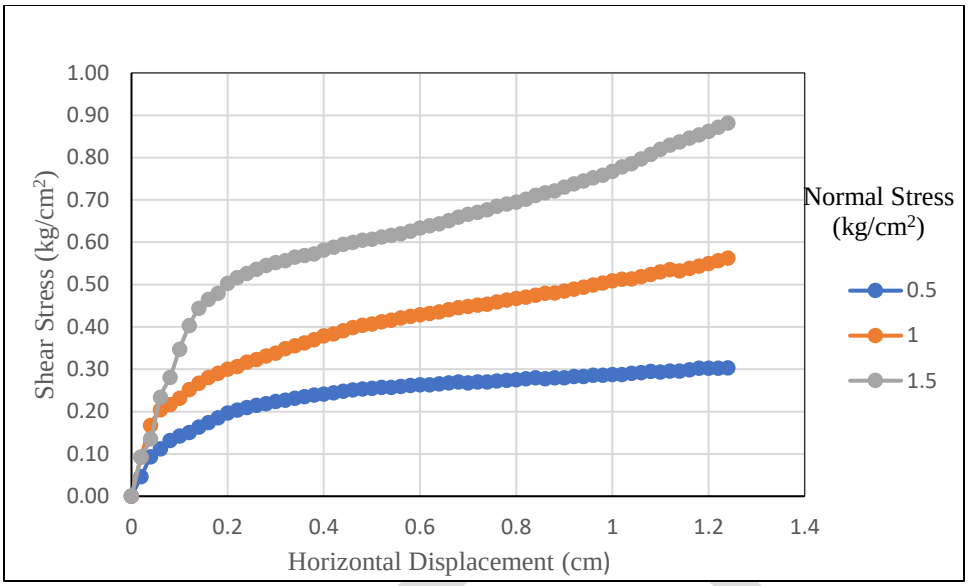



**Figure 5.15** Shear stress(kg/cm$^2$) vs Horizontal displacement (cm) graph for SOIL+ 1% CEMENT+ 0.75 kg/m$^3$ ZB

and the corresponding Maximum stresses obtained for samples 3,4 and 5 are listed in Table.5.13, Table.5.14, and 5.15 respectively.

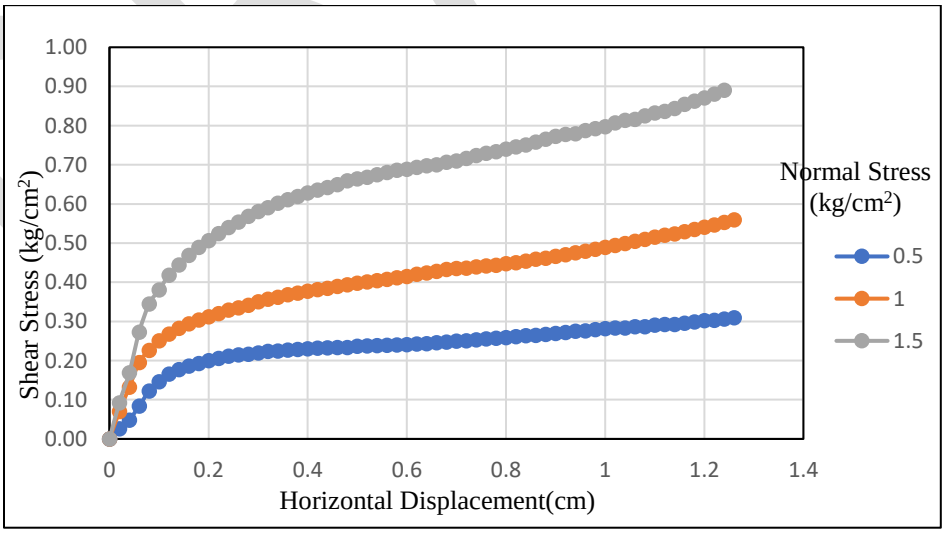



**Figure 5.16** Shear stress(kg/cm$^2$) vs Horizontal displacement (cm) graph for SOIL+ 1% CEMENT+ 1.0 kg/m$^3$ ZB

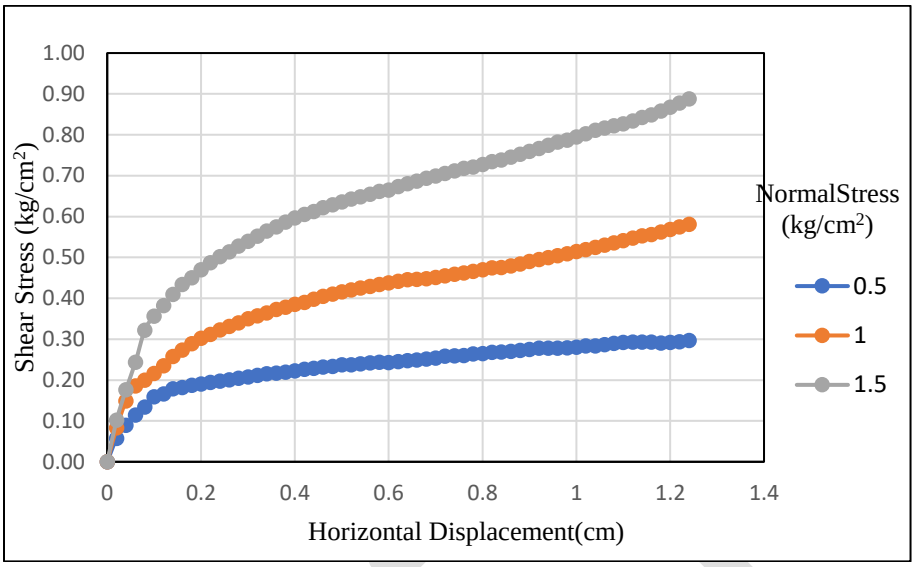



**Figure 5.17** Shear stress(kg/cm$^2$) vs Horizontal displacement (cm) graph for SOIL+ 1% CEMENT+ 1.25 kg/m$^3$ ZB

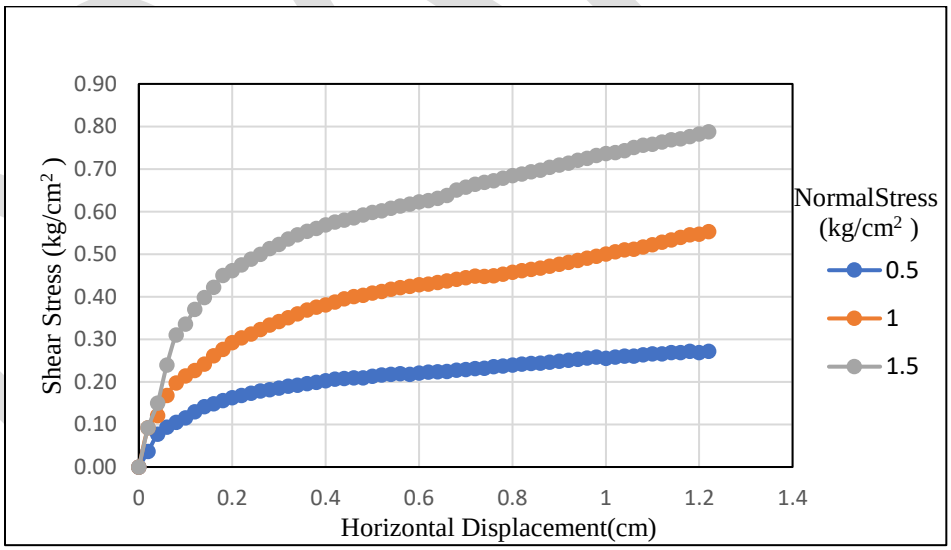



**Figure 5.18** Shear stress(kg/cm$^2$) vs Horizontal displacement (cm) graph for SOIL+ 1% CEMENT+ 1.5 kg/m$^3$ ZB

**Table 5.**11 Shear stress values at Normal stresses of 0.5,1,1.5 kg/cm$^2$ for SOIL+ 1% CEMENT+ 0.5 kg/m$^3$ ZB

| Test no. | Normal Stress (kg/cm$^2$) | Max Shear Stress (kg/cm$^2$) |
|---|---|---|
| 1 | 0.5 | 0.29 |
| 2 | 1 | 0.54 |
| 3 | 1.5 | 0.84 |

**Table 5.12** Shear stress values at Normal stresses of 0.5,1,1.5 kg/cm$^2$ for SOIL+1% CEMENT+ 0.75 kg/m$^3$ ZB

| Test no. | Normal Stress (kg/cm$^2$) | Max Shear Stress (kg/cm$^2$) |
|---|---|---|
| 1 | 0.5 | 0.30 |
| 2 | 1 | 0.56 |
| 3 | 1.5 | 0.88 |

**Table 5.13** Shear stress values at Normal stresses of 0.5,1,1.5 kg/cm$^2$ for SOIL+ 1% CEMENT+ 1.0 kg/m$^3$ ZB

| Test no. | Normal Stress (kg/cm$^2$) | Max Shear Stress (kg/cm$^2$) |
|---|---|---|
| 1 | 0.5 | 0.31 |
| 2 | 1 | 0.58 |
| 3 | 1.5 | 0.89 |

**Table 5.14.** Shear stress values at Normal stresses of 0.5,1,1.5 kg/cm$^2$ for SOIL+ 1% CEMENT+ 1.25 kg/m$^3$ ZB

| Test no. | Normal Stress (kg/cm$^2$) | Max Shear Stress (kg/cm$^2$) |
|---|---|---|
| 1 | 0.5 | 0.3 |
| 2 | 1 | 0.58 |
| 3 | 1.5 | 0.89 |

**Table 5.**15 Shear stress values at Normal stresses of 0.5,1,1.5 kg/cm$^2$ for SOIL+ 1% CEMENT+ 1.5 kg/m$^3$ ZB

| Test no. | Normal Stress (kg/cm$^2$) | Max Shear Stress (kg/cm$^2$) |
|---|---|---|
| 1 | 0.5 | 0.30 |
| 2 | 1 | 0.57 |
| 3 | 1.5 | 0.87 |

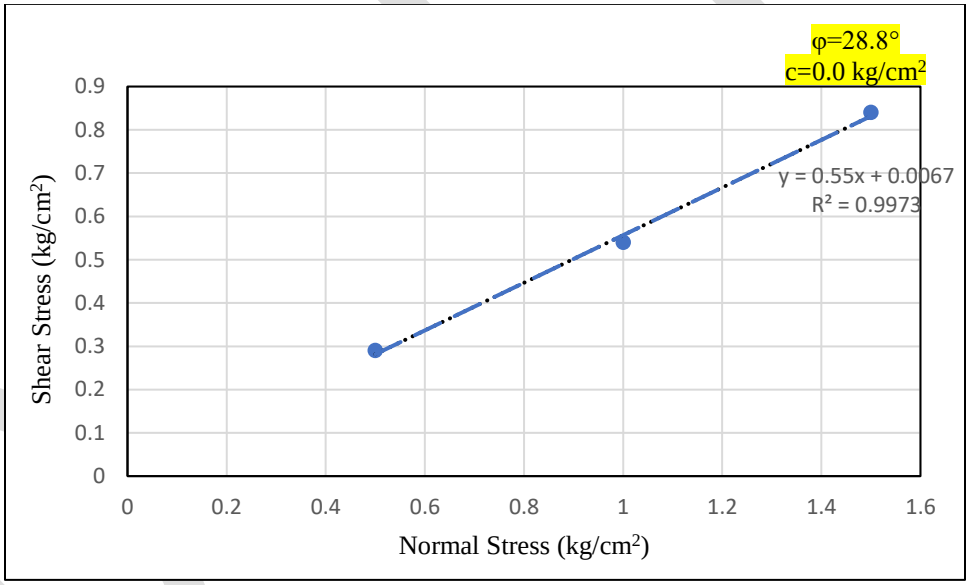



**Figure 5.19** Shear Stress vs.Normal stress Plot for SOIL+ 1% CEMENT+0.5 kg/m$^3$ ZB

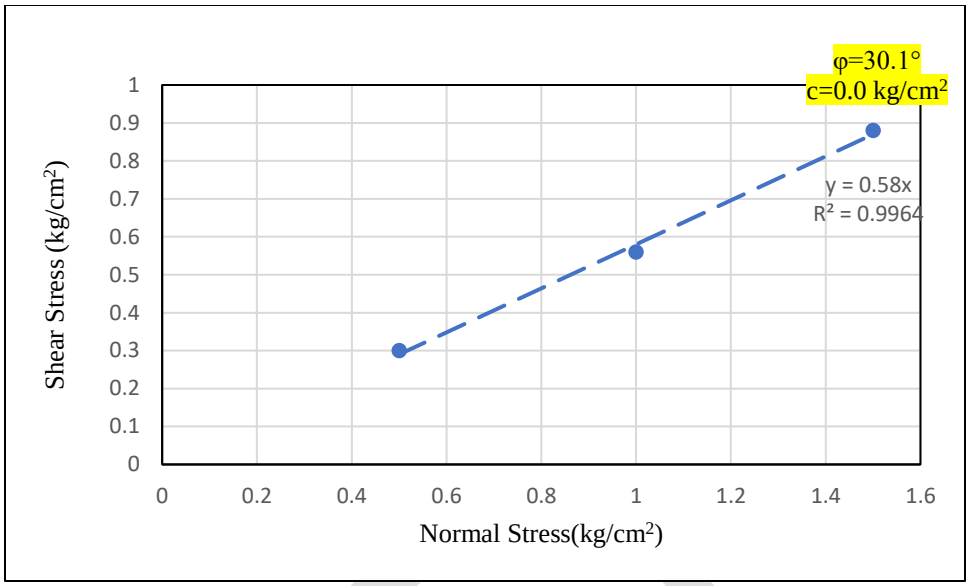



**Figure 5.20** Shear Stress vs.Normal stress Plot for SOIL+ 1% CEMENT+0.75 kg/m$^3$ ZB

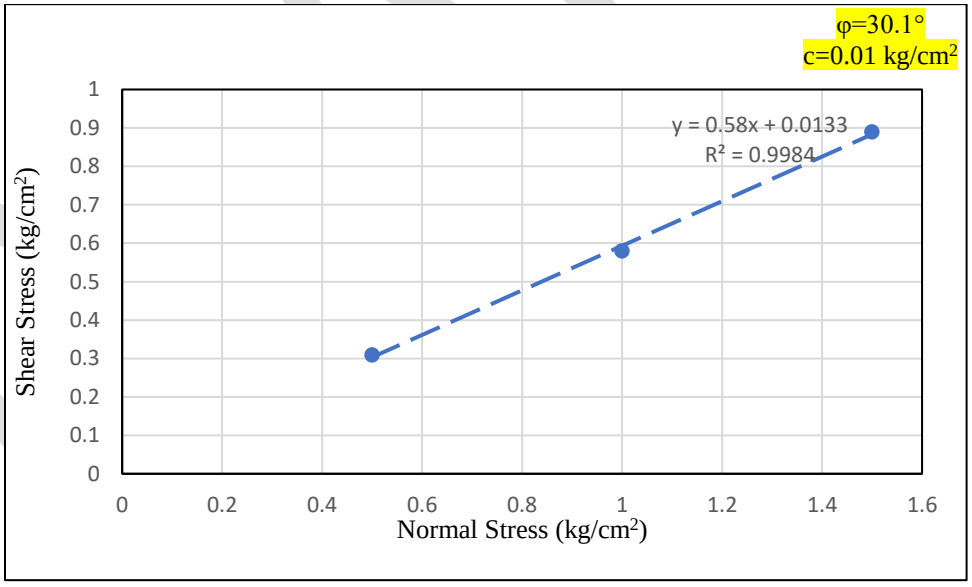



**Figure 5.21** Shear Stress vs.Normal stress Plot for SOIL+ 1% CEMENT+1.0 kg/m$^3$ ZB

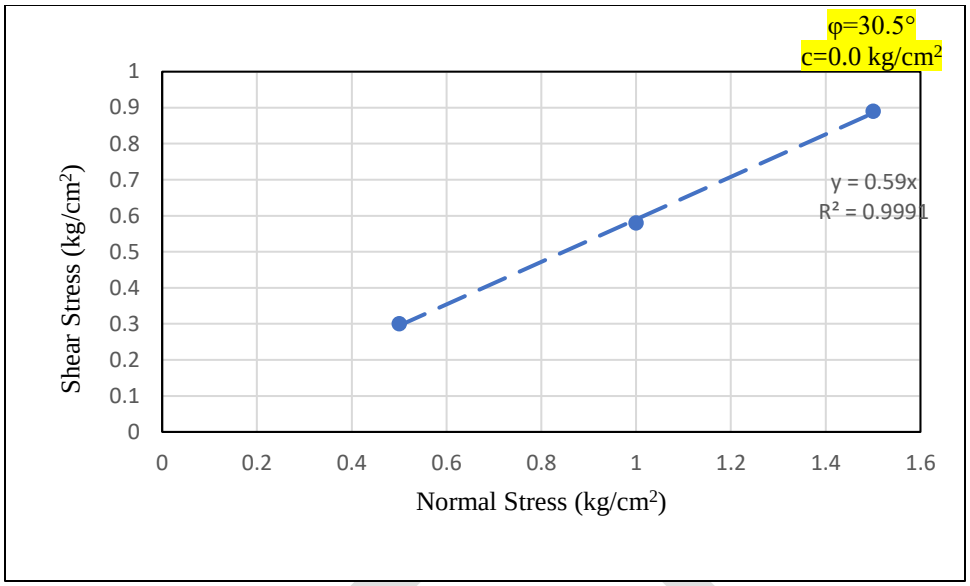



**Figure 5.22** Shear Stress vs.Normal stress Plot for SOIL+ 1% CEMENT+1.25 kg/m$^3$ ZB

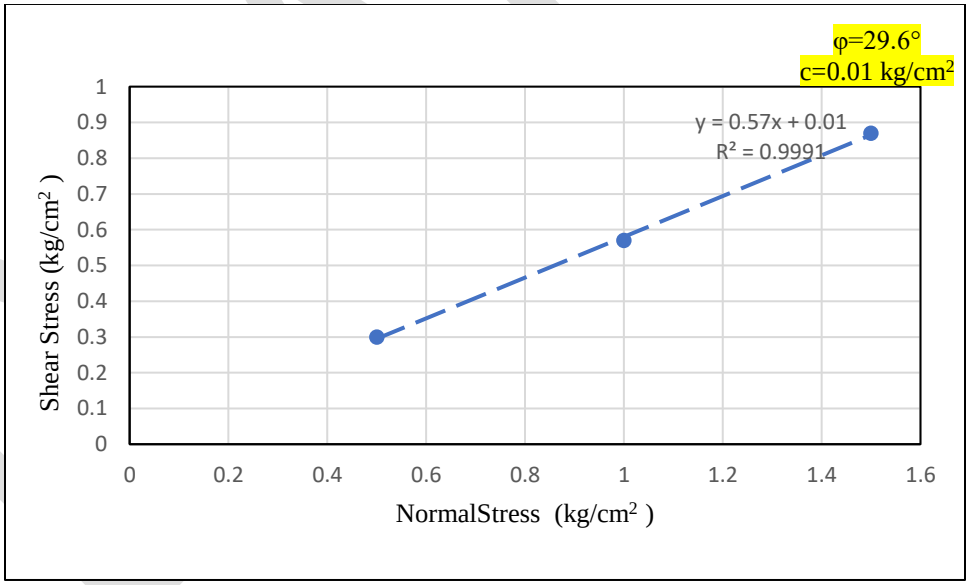



**Figure 5.23** Shear Stress vs.Normal stress Plot for SOIL+ 1% CEMENT+1.5 kg/m$^3$ ZB

**Table 5.16** Shear Strength parameters for soil+1% cement +ZB

| Admixture | Shear Strength Parameters | |
|---|---|---|
| | **The angle of Internal Friction ( Ø ) in degrees** | **Cohesion ( c ) in kg/cm$^2$** |
| **0.50 kg/m$^3$ ZB + 1% Cement** | 28.8 | 0 |
| **0.75 kg/m$^3$ ZB + 1% Cement** | 30.1 | 0 |
| **1.00 kg/m$^3$ ZB + 1% Cement** | 30.1 | 0.01 |
| **1.25 kg/m$^3$ ZB + 1% Cement** | 30.5 | 0 |
| **1.50 kg/m$^3$ ZB + 1% Cement** | 29.7 | 0.01 |

For the next set of tests, for Sample No.6- Sample No10, DST test were performed at Normal Stresses of 0.5 kg/cm$^2$ ,1 kg/cm$^2$ ,1.5 kg/cm$^2$ with 2% cement+ZB ( at doses of 0.5 kg/m$^3$ ,0.75 kg/m$^3$,1 kg/m$^3$,1.25 kg/m$^3$,1.5 kg/m$^3$.The readings of DST are tabulated in Appendix C, Table C1-Table C15. Test readings are plotted to obtain a graph of Horizontal Displacement vs Shear Stress as shown in the Figure.5.26, Figure.5.27, Figure 5.28 Figure.5.29, Figure.5.30.Tables 5.17-Table 5.21 gives the Maximum Stresses obtained for Normal Stresses for soil samples with 2% cement + ZB Doses. The Shear strength parameters c and φ are obtained from the graph of Maximum Shear stress vs Normal Stress as shown in Figure.5.31, Figure5.32, Figure 5.33, Figure5.34, Figure5.35The final values of Shear strength parameters c and φ obtained from tests are tabulated in Table.5.22

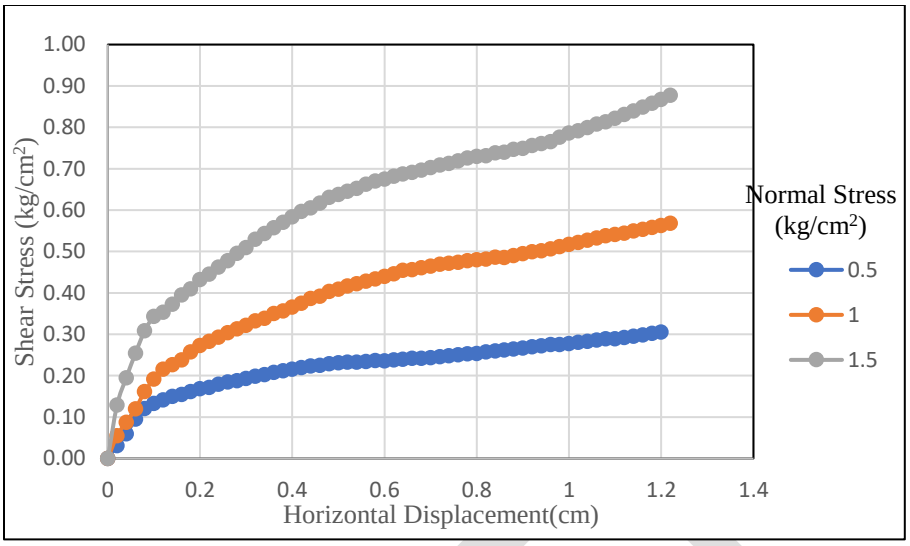



**Figure 5.24** Shear stress(kg/cm$^2$) vs Horizontal displacement (cm) graph for SOIL+ 2% CEMENT+ 0.5 kg/m$^3$ ZB

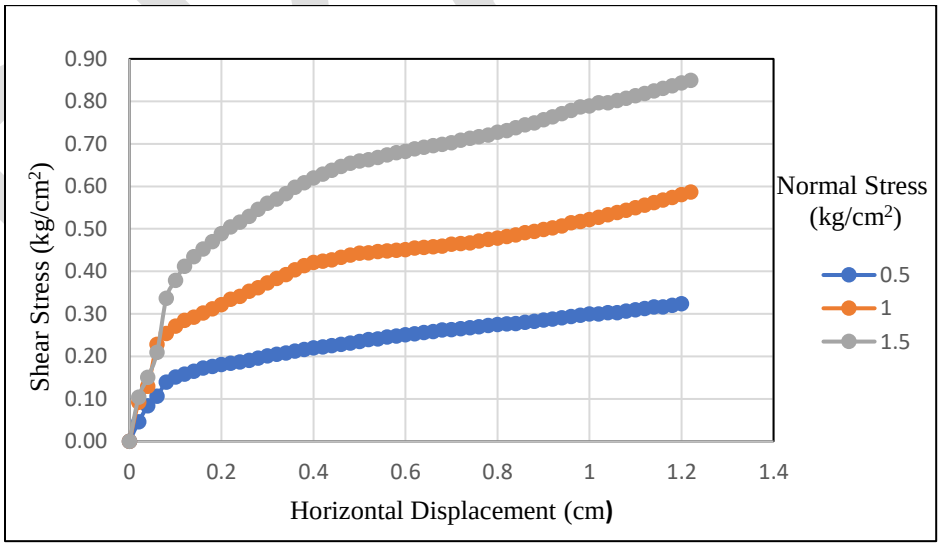



**Figure 5.25** Shear stress(kg/cm$^2$) vs Horizontal displacement (cm) graph for SOIL+ 2% CEMENT+ 0.75 kg/m$^3$ ZB

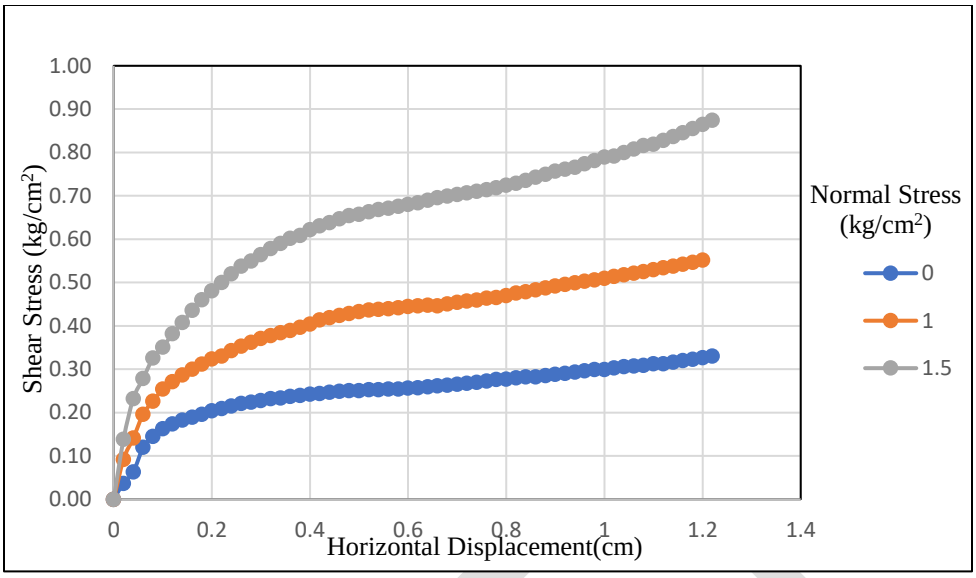



**Figure 5.26** Shear stress(kg/cm$^2$) vs Horizontal displacement (cm) graph for SOIL+ 2% CEMENT+ 1.0 kg/m$^3$ ZB

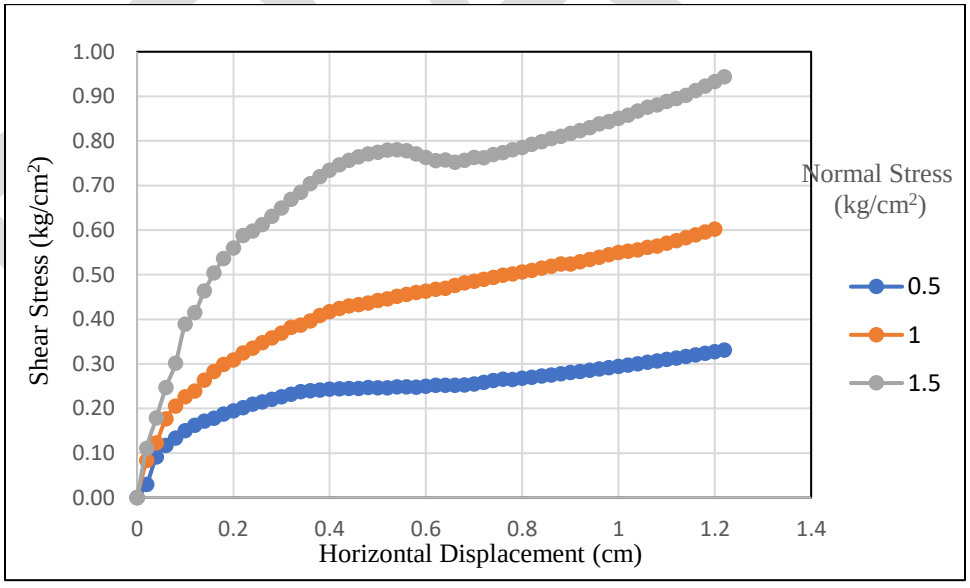



**Figure 5.27** Shear stress(kg/cm$^2$) vs Horizontal displacement (cm) graph for SOIL+ 2% CEMENT+ 1.25 kg/m$^3$ ZB

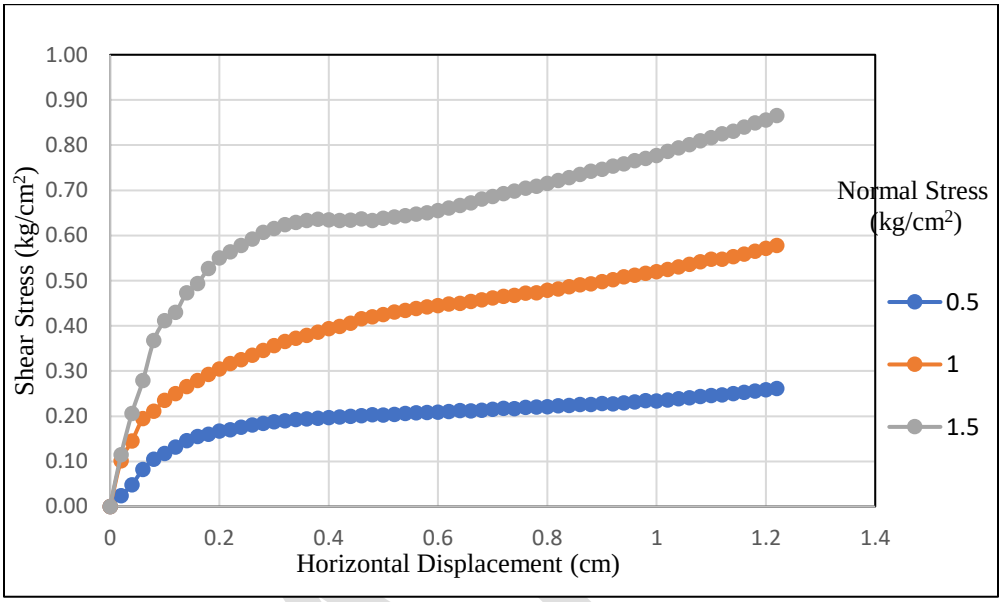



**Figure 5.28** Shear stress(kg/cm$^2$) vs Horizontal displacement (cm) graph for SOIL+ 2% CEMENT+ 1.5 kg/m$^3$ ZB

**Table 5.17** Shear stress values at Normal stresses of 0.5,1,1.5 kg/cm$^2$ for SOIL+ 2% CEMENT+ 0.5 kg/m$^3$ ZB

| Test no. | Normal Stress (kg/cm$^2$) | Max Shear Stress (kg/cm$^2$) |
|---|---|---|
| 1 | 0.5 | 0.28 |
| 2 | 1 | 0.57 |
| 3 | 1.5 | 0.88 |

**Table 5.**18 Shear stress values at Normal stresses of 0.5,1,1.5 kg/cm$^2$ for SOIL+ 2% CEMENT+ 0.75 kg/m$^3$ ZB

| Test no. | Normal Stress (kg/cm$^2$) | Max Shear Stress (kg/cm$^2$) |
|---|---|---|
| 1 | 0.5 | 0.29 |
| 2 | 1 | 0.58 |
| 3 | 1.5 | 0.85 |

**Table 5.19** Shear stress values at Normal stresses of 0.5,1,1.5 kg/cm$^2$ for SOIL+ 2% CEMENT+ 1.0 kg/m$^3$ ZB

| Test no. | Normal Stress (kg/cm$^2$) | Max Shear Stress (kg/cm$^2$) |
|---|---|---|
| 1 | 0.5 | 0.30 |
| 2 | 1 | 0.58 |
| 3 | 1.5 | 0.89 |

**Table 5.20** Shear stress values at Normal stresses of 0.5,1,1.5 kg/cm$^2$ for SOIL+ 2% CEMENT+ 1.25 kg/m$^3$ ZB

| Test no. | Normal Stress (kg/cm$^2$) | Max Shear Stress (kg/cm$^2$) |
|---|---|---|
| 1 | 0.5 | 0.32 |
| 2 | 1 | 0.60 |
| 3 | 1.5 | 0.94 |

**Table 5.21** Shear stress values at Normal stresses of 0.5,1,1.5 kg/cm$^2$ for SOIL+ 2% CEMENT+ 1.5 kg/m$^3$ ZB

| Test no. | Normal Stress (kg/cm$^2$) | Max Shear Stress (kg/cm$^2$) |
|---|---|---|
| 1 | 0.5 | 0.29 |
| 2 | 1 | 0.58 |
| 3 | 1.5 | 0.90 |

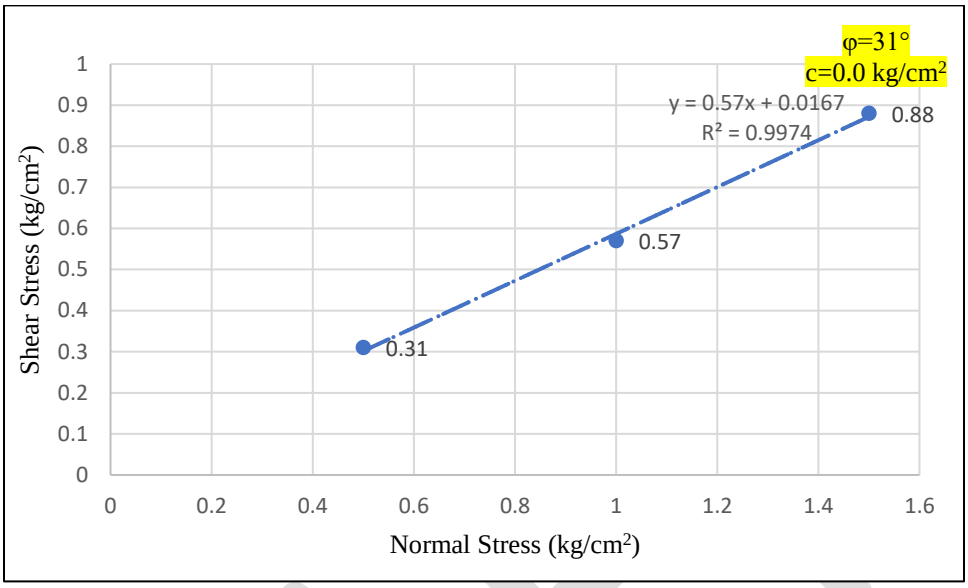



**Figure 5.29** Shear Stress vs.Normal stress Plot for SOIL+ 2% CEMENT+0.5 kg/m$^3$ ZB

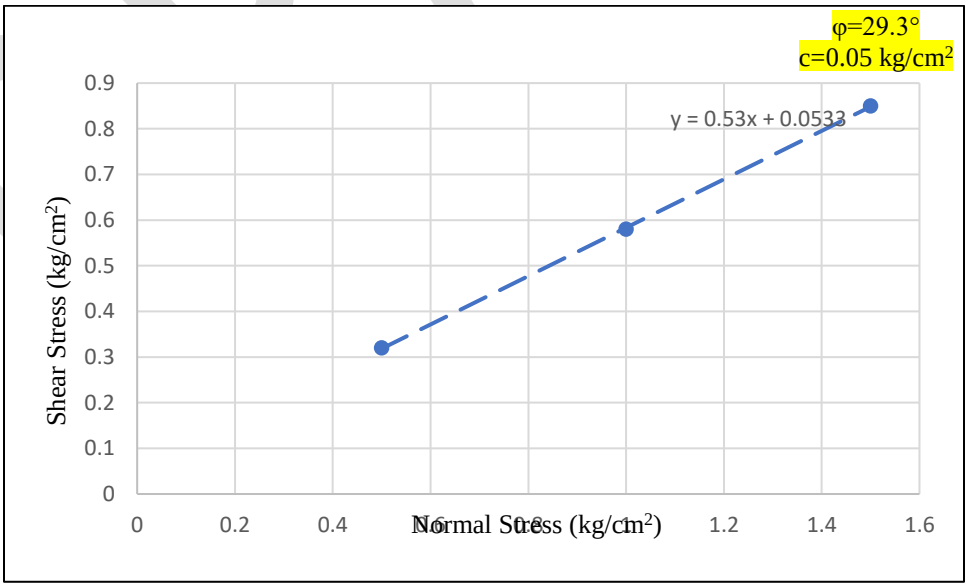



**Figure 5.30** Shear Stress vs.Normal stress Plot for SOIL+ 2% CEMENT+0.75 kg/m$^3$ ZB

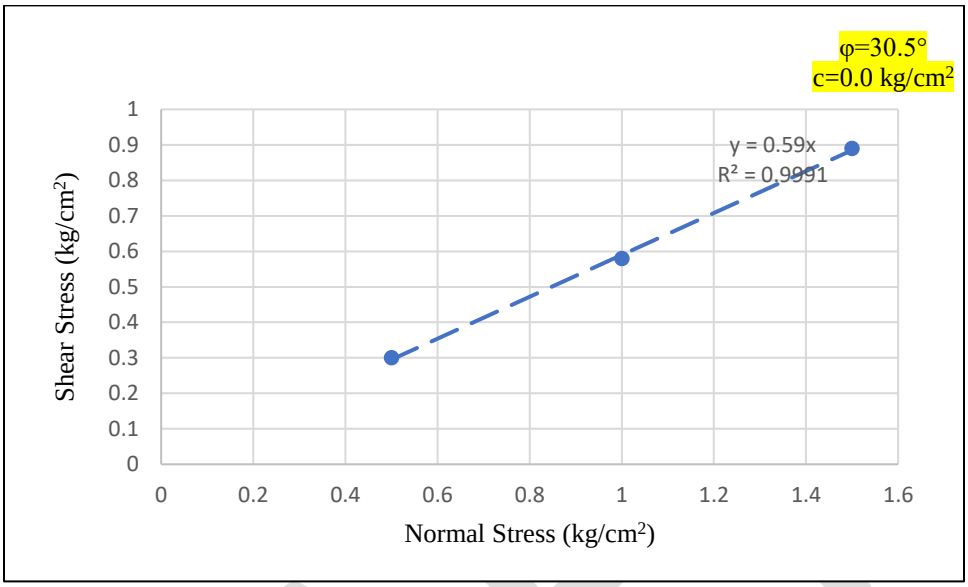



**Figure 5.31** Shear Stress vs.Normal stress Plot for SOIL+ 2% CEMENT+1.0 kg/m$^3$ ZB

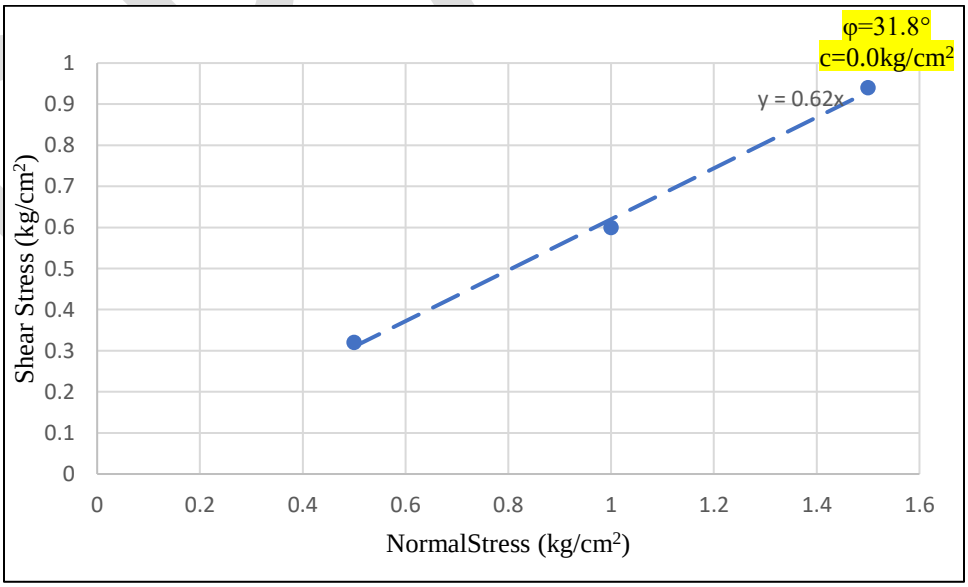



**Figure 5.32** Shear Stress vs.Normal stress Plot for SOIL+ 2% CEMENT+1.25 kg/m$^3$ ZB

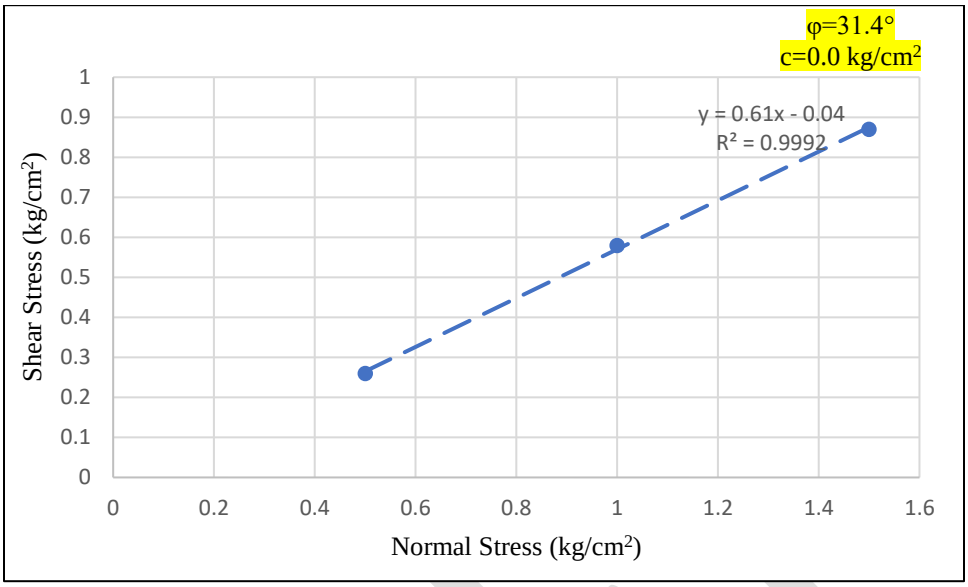



**Figure 5.33** Shear Stress vs.Normal stress Plot for SOIL+ 2% CEMENT+1.5 kg/m$^3$ ZB

**Table 5.22** Shear Strength parameters for soil+2% cement +ZB

| Admixture | Shear Strength Parameters | |
|---|---|---|
| | Angle of Internal Friction φ (in degrees) | Cohesion ( c ) |
| 0.50 kg/m$^3$ ZB + 2% Cement | 31.0 | 0.05 |
| 0.75 kg/m$^3$ ZB + 2% Cement | 29.2 | 0 |
| 1.00 kg/m$^3$ ZB + 2% Cement | 30.5 | 0 |
| 1.25 kg/m$^3$ ZB + 2% Cement | 31.8 | 0 |
| 1.50 kg/m$^3$ ZB + 2% Cement | 31.4 | 0 |

For the next set of tests, for Sample No.12- Sample No 16, DST tests were performed at Normal Stresses of 0.5 kg/cm$^2$ ,1 kg/cm$^2$ ,1.5 kg/cm$^2$ with 3% cement+ZB ( at doses of 0.5 kg/m$^3$

,0.75 kg/$m^3$,1 kg/$m^3$,1.25 kg/$m^3$,1.5 kg/$m^3$.The readings of DST are tabulated in Appendix D,Table D1-Table D15.Test readings are plotted to obtain a graph of Horizontal Displacement vs Shear Stress as shown in Figure.5.36- Figure.5.40.Tables 5.23- Table 5.27 gives the Maximum Stresses obtained for Normal Stresses for soil samples with 3% cement + ZB Doses.The Shear strength parameters c and φ are obtained from graph of Maximum Shear stress vs Normal Stress as shown in Figure.5.41, Figure5.42, Figure 5.43, Figure5.44, Figure5.45.The final values of Shear strength parameters c and φ obtained from tests are tabulated in Table.5.28

**Table 5.23** Shear stress values at Normal stresses of 0.5,1,1.5 kg/$cm^2$ for SOIL+ 3% CEMENT+ 0.5 kg/$m^3$ ZB

| Test no. | Normal Stress (kg/$cm^2$) | Max Shear Stress (kg/$cm^2$) |
|---|---|---|
| 1 | 0.5 | 0.24 |
| 2 | 1 | 0.54 |
| 3 | 1.5 | 0.89 |

**Table 5.24** Shear stress values at Normal stresses of 0.5,1,1.5 kg/$cm^2$ for SOIL+ 3% CEMENT+ 0.75 kg/$m^3$ ZB

| Test no. | Normal Stress (kg/$cm^2$) | Max Shear Stress (kg/$cm^2$) |
|---|---|---|
| 1 | 0.5 | 0.32 |
| 2 | 1 | 0.60 |
| 3 | 1.5 | 0.92 |

**Table 5.25** Shear stress values at Normal stresses of 0.5,1,1.5 kg/$cm^2$ for SOIL+ 3% CEMENT+ 1.0 kg/$m^3$ ZB

| Test no. | Normal Stress (kg/$cm^2$) | Max Shear Stress (kg/$cm^2$) |
|---|---|---|
| 1 | 0.5 | 0.36 |
| 2 | 1 | 0.63 |
| 3 | 1.5 | 0.98 |

**Table 5.26** Shear stress values at Normal stresses of 0.5,1,1.5 kg/cm$^2$ for SOIL+ 3% CEMENT+ 1.25 kg/m$^3$ ZB

| Test no. | Normal Stress (kg/cm$^2$) | Max Shear Stress (kg/cm$^2$) |
|---|---|---|
| 1 | 0.5 | 0.37 |
| 2 | 1 | 0.66 |
| 3 | 1.5 | 1.06 |

**Table 5.27.** Shear stress values at Normal stresses of 0.5,1,1.5 kg/cm$^2$ for SOIL+ 3% CEMENT+ 1.5 kg/m$^3$ ZB

| Test no. | Normal Stress (kg/cm$^2$) | Max Shear Stress (kg/cm$^2$) |
|---|---|---|
| 1 | 0.5 | 0.35 |
| 2 | 1 | 0.64 |
| 3 | 1.5 | 1.02 |

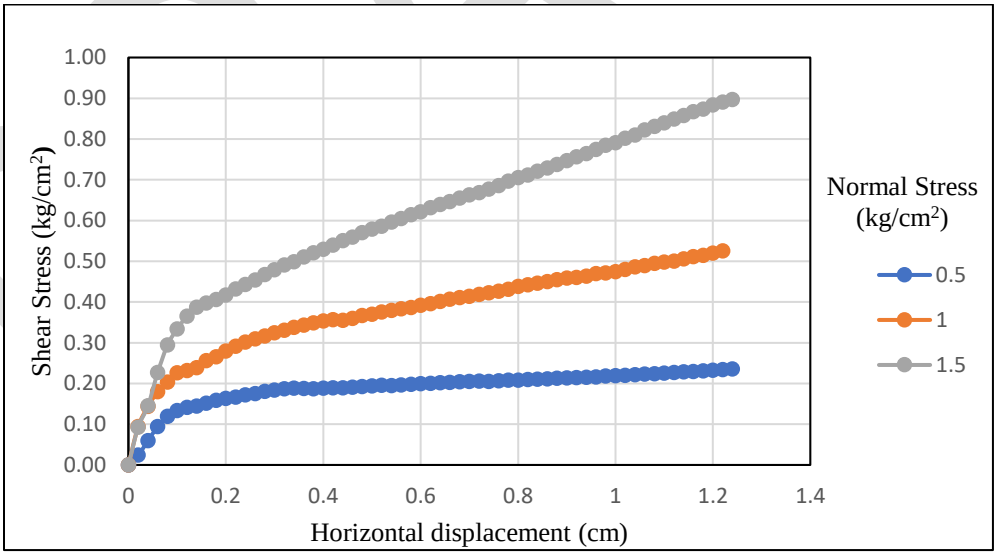



**Figure 5.34** Shear stress(kg/cm$^2$) vs Horizontal displacement (cm) graph for SOIL+ 3% CEMENT+0.5 kg/m$^3$ Z

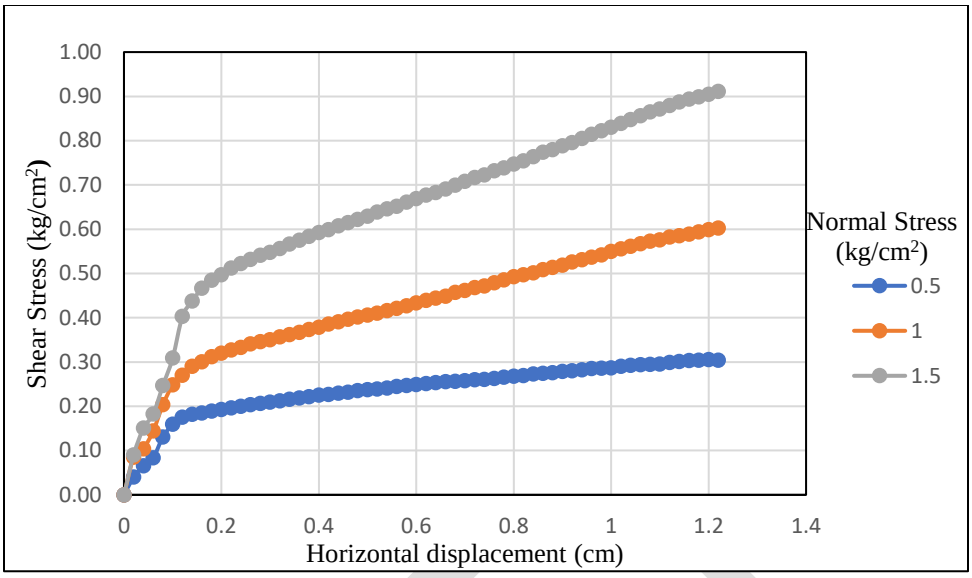



**Figure 5.35** Shear stress(kg/cm$^2$) vs Horizontal displacement (cm) graph for SOIL+ 3% CEMENT+0.75 kg/m$^3$ ZB

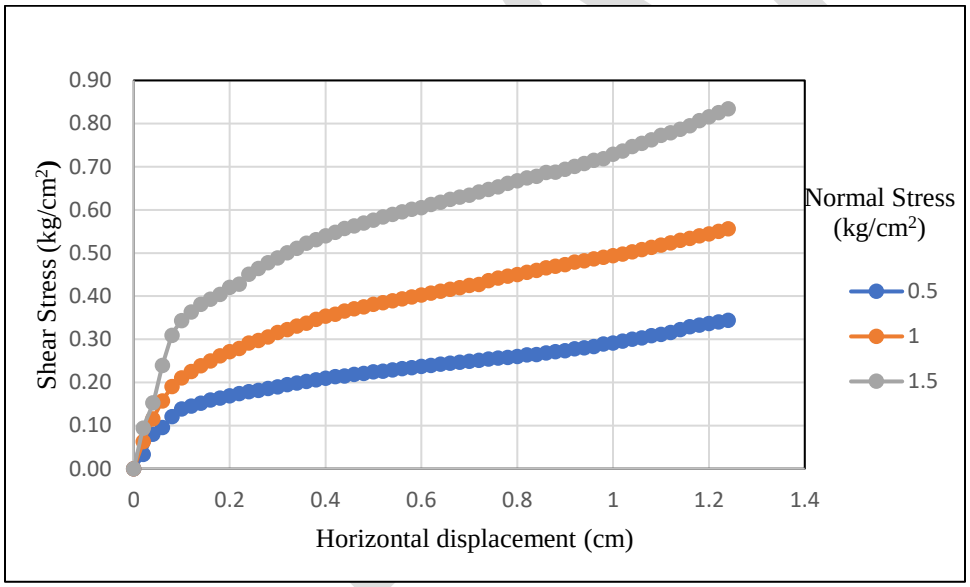



**Figure 5.36** Shear stress(kg/cm$^2$) vs Horizontal displacement (cm) graph for SOIL+ 3% CEMENT+1.0 kg/m$^3$ ZB

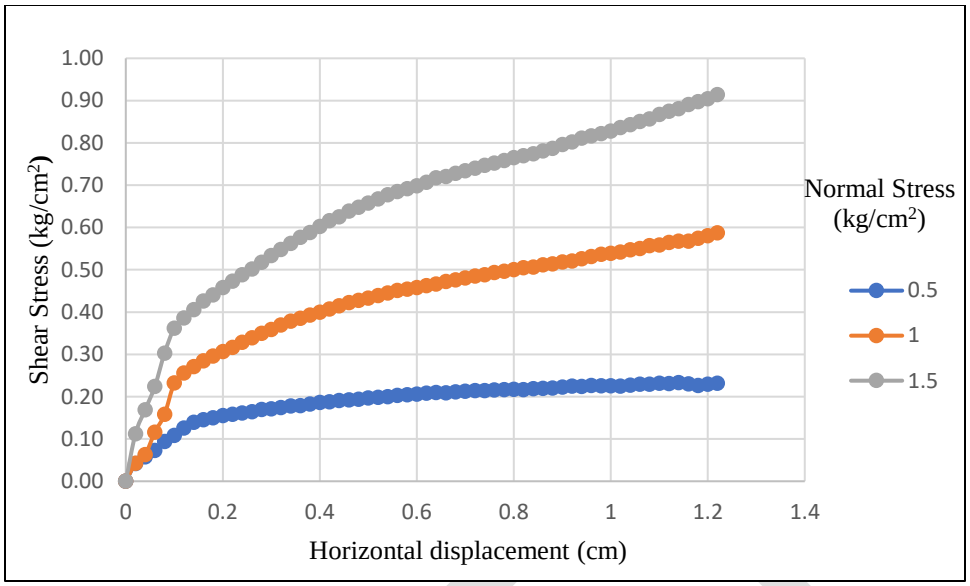



**Figure 5.37** Shear stress(kg/cm$^2$) vs Horizontal displacement (cm) graph for SOIL+ 3% CEMENT+1.25 kg/m$^3$ ZB

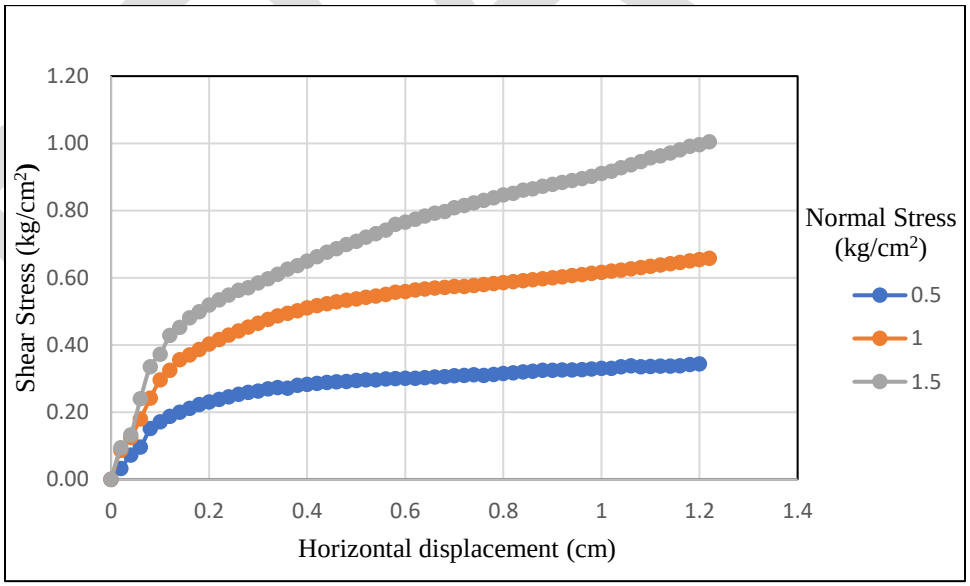



**Figure 5.38** Shear stress(kg/cm$^2$) vs Horizontal displacement (cm) graph for SOIL+ 3% CEMENT+1.5 kg/m$^3$

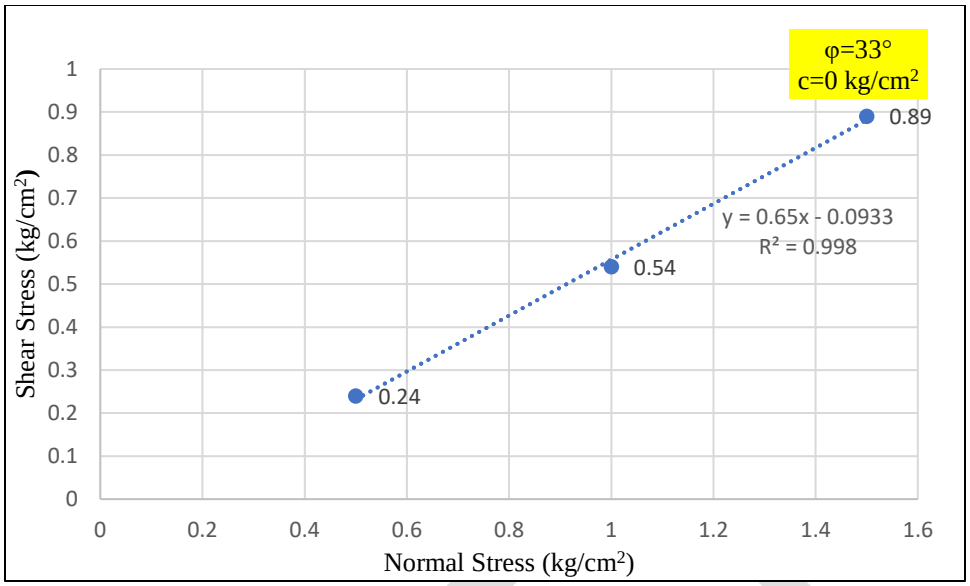



**Figure 5.39** Shear Stress vs.Normal stress Plot for SOIL+ 3% CEMENT+0.5 kg/m$^3$ ZB

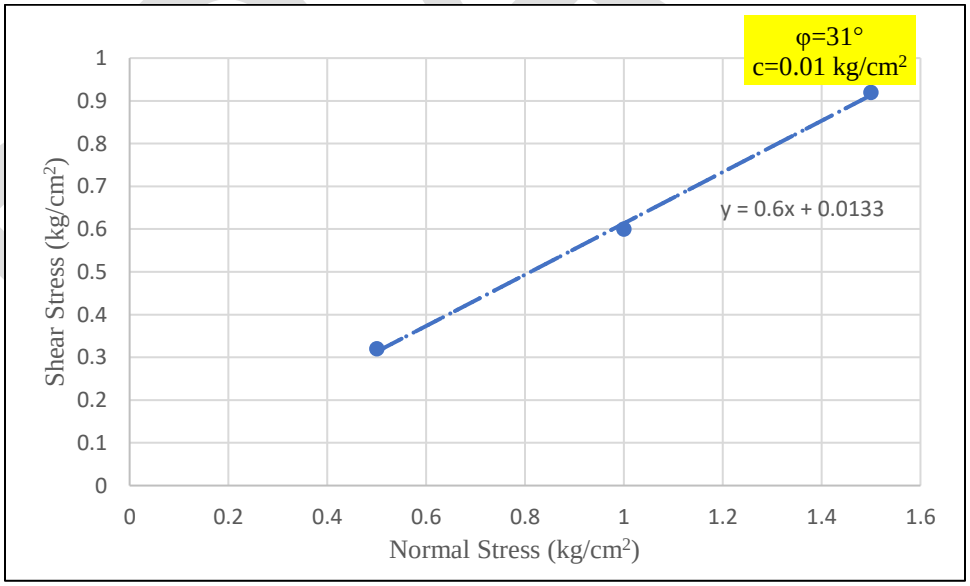



**Figure 5.40** Shear Stress vs.Normal stress Plot for for SOIL+ 3% CEMENT+0.75 kg/m$^3$ ZB

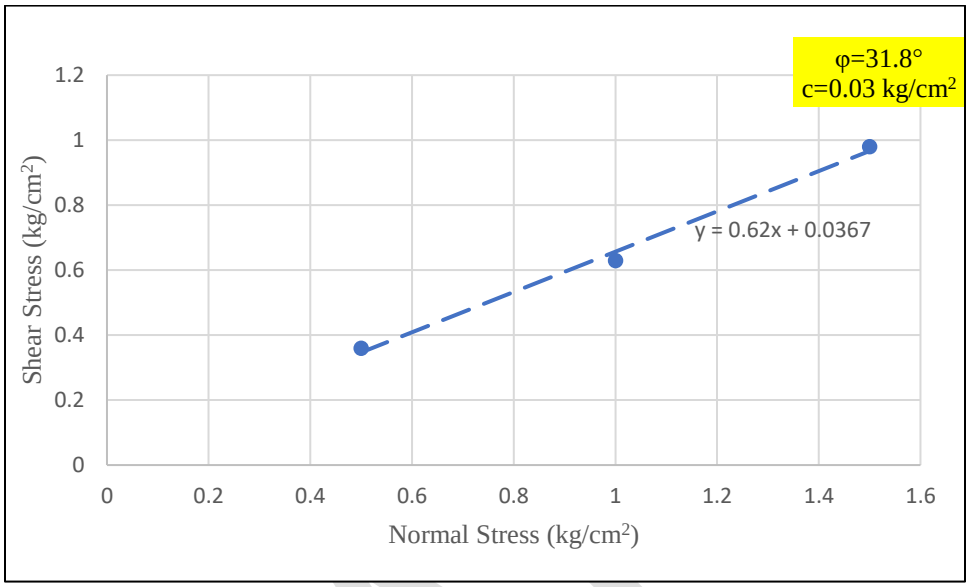



**Figure 5.41** Shear Stress vs.Normal stress Plot for for SOIL+ 3% CEMENT+1.0 kg/m$^3$ ZB

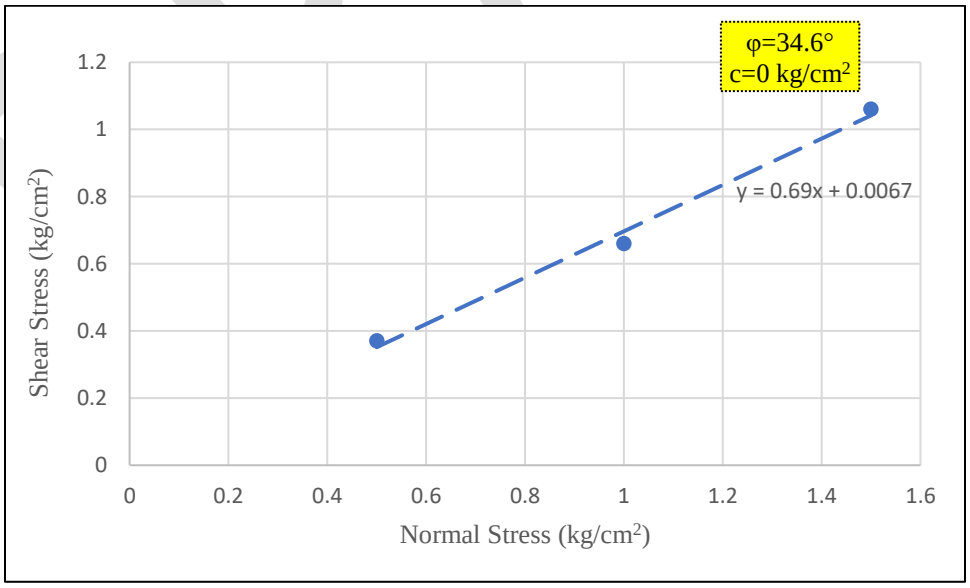



**Figure 5.42** Shear Stress vs.Normal stress Plot for for SOIL+ 3% CEMENT+1.25 kg/m$^3$ ZB

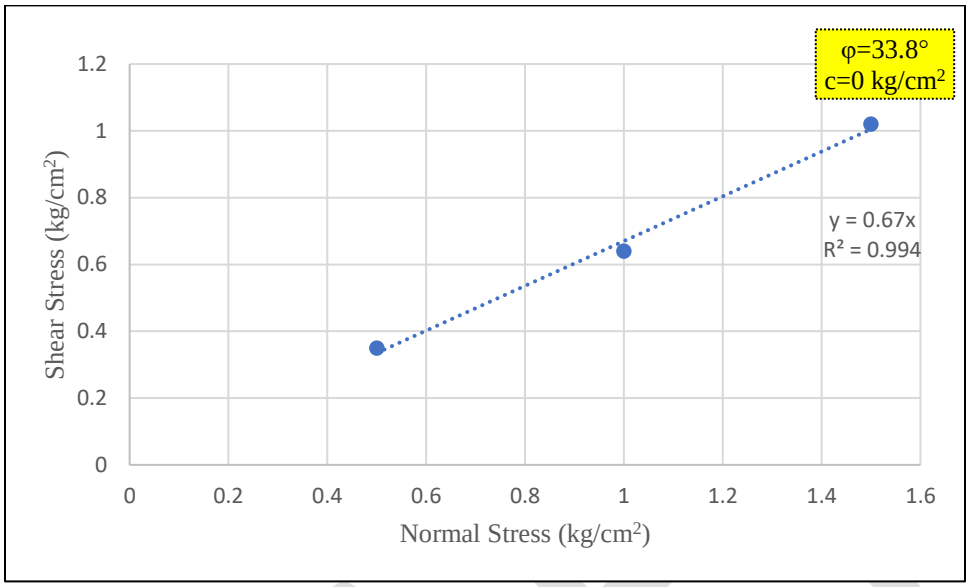



**Figure 5.43** Shear Stress vs.Normal stress Plot for for SOIL+ 3% CEMENT+1.5 kg/m$^3$ ZB

Table 5.28 Shear Strength parameters for soil+3% cement +ZB

| **Admixture** | **Shear Strength Parameters** | |
|---|---|---|
| | **Angle of Internal Friction(φ) (in degrees)** | **Cohesion ( c ) kg/cm$^2$** |
| **0.50 kg/m$^3$ ZB + 3% Cement** | 33.0 | 0 |
| **0.75 kg/m$^3$ ZB + 3% Cement** | 31.0 | 0.01 |
| **1.00 kg/m$^3$ ZB + 3% Cement** | 31.8 | 0.03 |
| **1.25 kg/m$^3$ ZB + 3% Cement** | 34.6 | 0 |
| **1.50 kg/m$^3$ ZB + 3% Cement** | 33.8 | 0 |

For Sample no.16-21,similar DST were performed at 4% cement + ZB doses ,For the sake of reference the test readings are tabulated in Appendix E,Table 1-Table15.

Figure 5.46-Figure 5.50 gives us the Shear stress vs Horizontal Displacement curves for the soil samples at 4% cement + ZB doses 0.5 kg/cm$^3$,0.75 kg/cm$^3$,1.0 kg/cm$^3$,1.25kg/cm$^3$ , 1.5kg/cm$^3$. Table 5.29-Table 33,shows the maximun shear stress obtained ar nomal stresses for the different soil samples. Figure.5.51-5.55 shows the plot from which the shear parameters are determined.The final values for c and φ are listed in Table.5.34

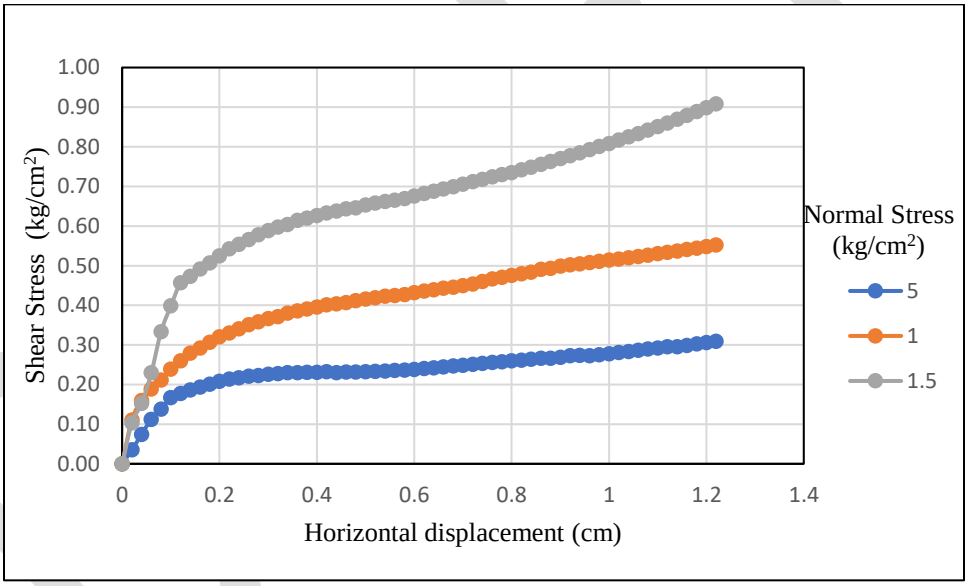



**Figure 5.44** Shear stress(kg/cm$^2$) vs Horizontal displacement (cm) graph for SOIL+ 4% CEMENT+0.5 kg/m$^3$ ZB

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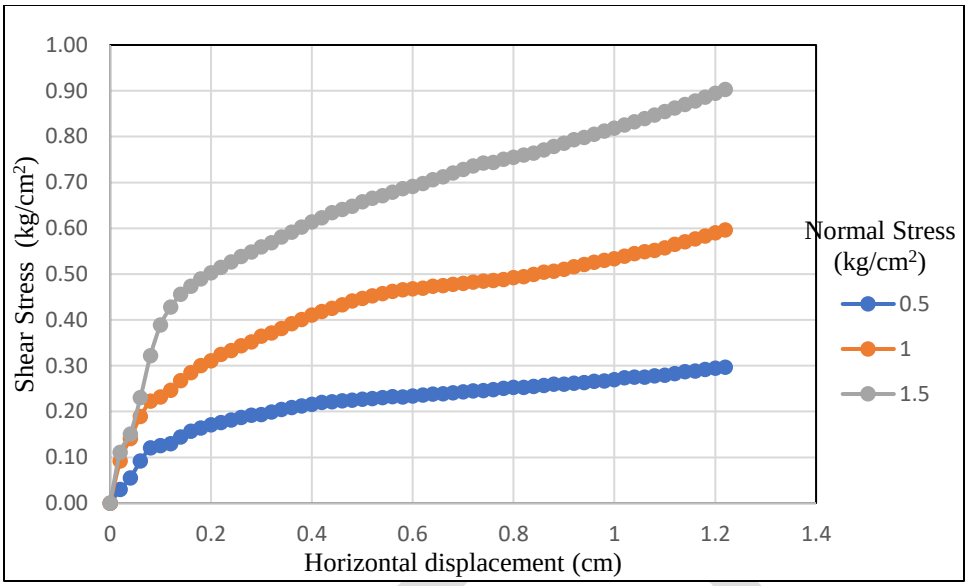


**Figure 5.45** Shear stress(kg/cm$^2$) vs Horizontal displacement (cm) graph for SOIL+ 4% CEMENT+0.75 kg/m$^3$ ZB

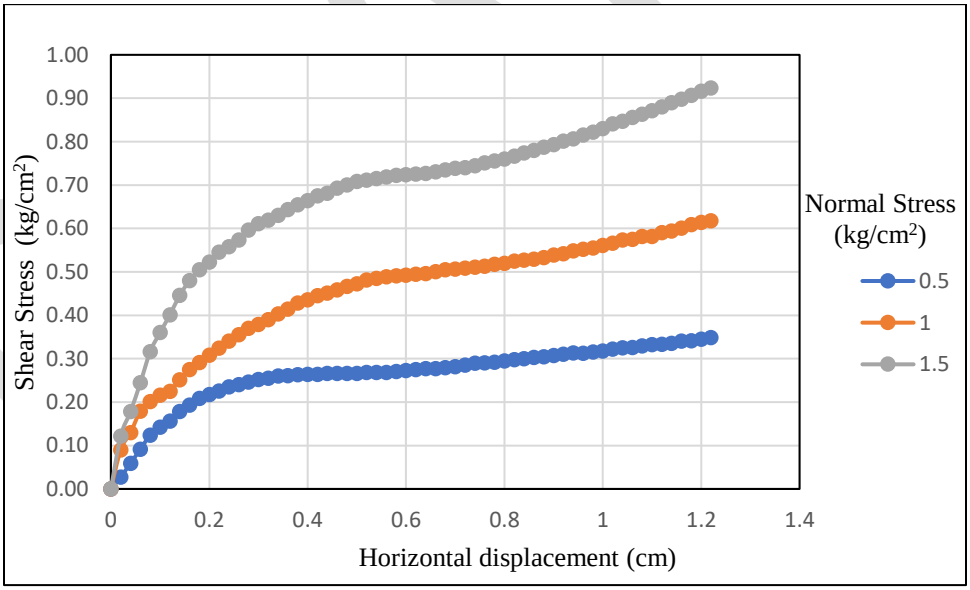


**Figure 5.46** Shear stress(kg/cm$^2$) vs Horizontal displacement (cm) graph for SOIL+ 4% CEMENT+1.0 kg/m$^3$ ZB

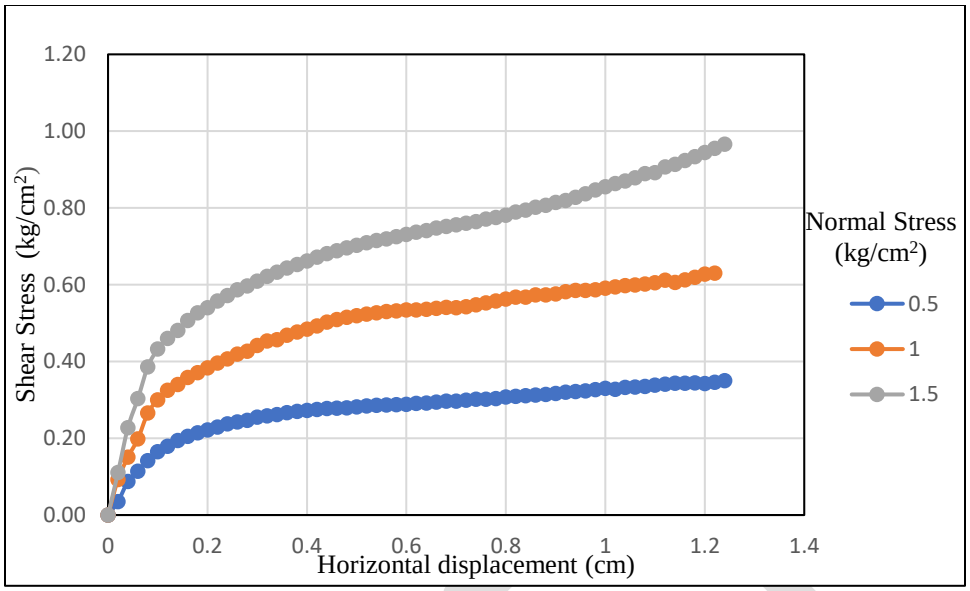


**Figure 5.47** Shear stress(kg/cm$^2$) vs Horizontal displacement (cm) graph for SOIL+ 4% CEMENT+1.25 kg/m$^3$ ZB

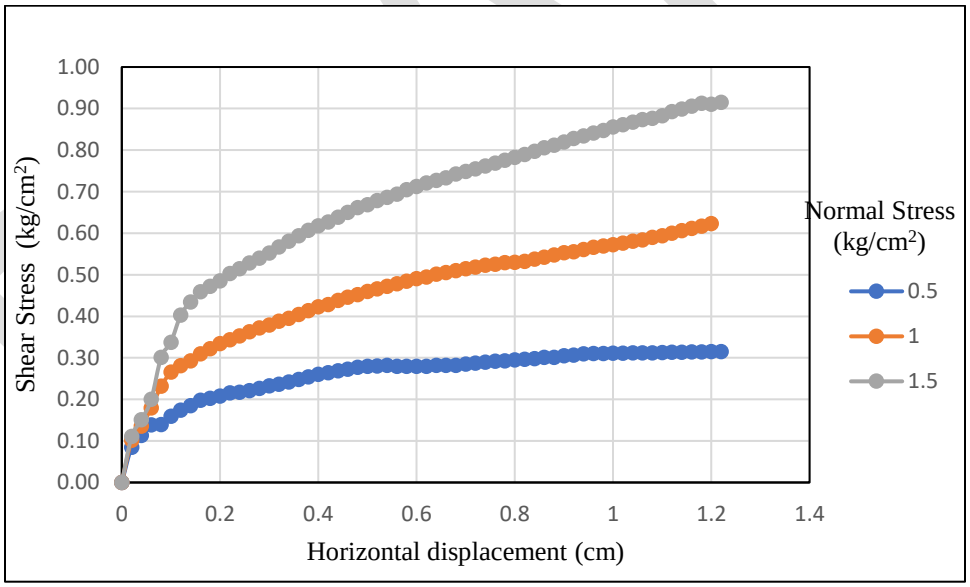


**Figure 5.48** Shear stress(kg/cm$^2$) vs Horizontal displacement (cm) graph for SOIL+ 4% CEMENT+1.5 kg/m$^3$ ZB

**Table 5.**29 Shear stress values at Normal stresses of 0.5,1,1.5 kg/cm$^2$ for SOIL+ 4% CEMENT+ 0.5 kg/m$^3$ ZB

| Test no. | Normal Stress (kg/cm$^2$) | Max Shear Stress (kg/cm$^2$) |
|---|---|---|
| 1 | 0.5 | 0.29 |
| 2 | 1 | 0.59 |
| 3 | 1.5 | 0.90 |

**Table 5.30** Shear stress values at Normal stresses of 0.5,1,1.5 kg/cm$^2$ for SOIL+ 4% CEMENT+ 0.75 kg/m$^3$ ZB

| Test no. | Normal Stress (kg/cm$^2$) | Max Shear Stress (kg/cm$^2$) |
|---|---|---|
| 1 | 0.5 | 0.3 |
| 2 | 1 | 0.53 |
| 3 | 1.5 | 0.83 |

**Table 5.**31 Shear stress values at Normal stresses of 0.5,1,1.5 kg/cm$^2$ for SOIL+ 4% CEMENT+ 1.0 kg/m$^3$ ZB

| Test no. | Normal Stress (kg/cm$^2$) | Max Shear Stress (kg/cm$^2$) |
|---|---|---|
| 1 | 0.5 | 0.35 |
| 2 | 1 | 0.62 |
| 3 | 1.5 | 0.92 |

**Table 5.32** Shear stress values at Normal stresses of 0.5,1,1.5 kg/cm$^2$ for SOIL+ 4% CEMENT+ 1.25 kg/m$^3$ ZB

| Test no. | Normal Stress (kg/cm$^2$) | Max Shear Stress (kg/cm$^2$) |
|---|---|---|
| 1 | 0.5 | 0.35 |
| 2 | 1 | 0.63 |
| 3 | 1.5 | 0.97 |

**Table 5.33** Shear stress values at Normal stresses of 0.5,1,1.5 kg/cm$^2$ for SOIL+ 4% CEMENT+ 1.5 kg/m$^3$ ZB

| Test no. | Normal Stress (kg/cm$^2$) | Max Shear Stress (kg/cm$^2$) |
|---|---|---|
| 1 | 0.5 | 0.32 |
| 2 | 1 | 0.62 |
| 3 | 1.5 | 0.92 |

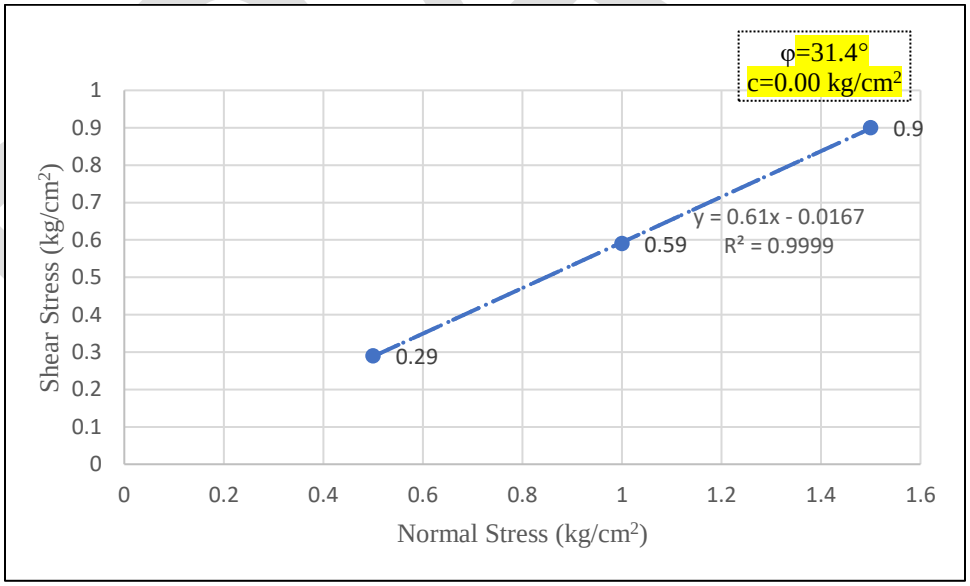


**Figure 5.49** Shear Stress vs.Normal stress Plot for SOIL+ 4% CEMENT+0.5 kg/m$^3$ ZB

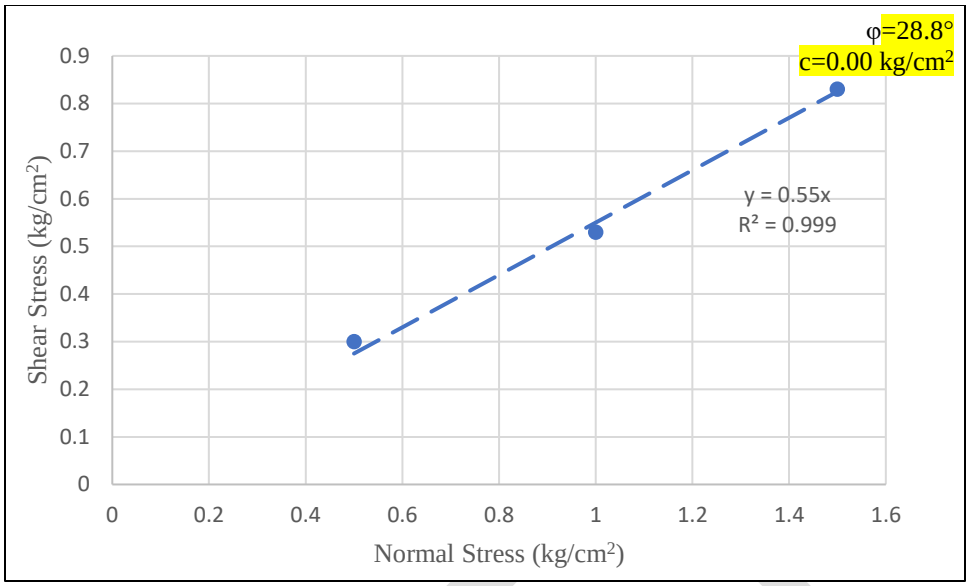


**Figure 5.50** Shear Stress vs.Normal stress Plot for SOIL+ 4% CEMENT+0.75 kg/m$^3$ ZB

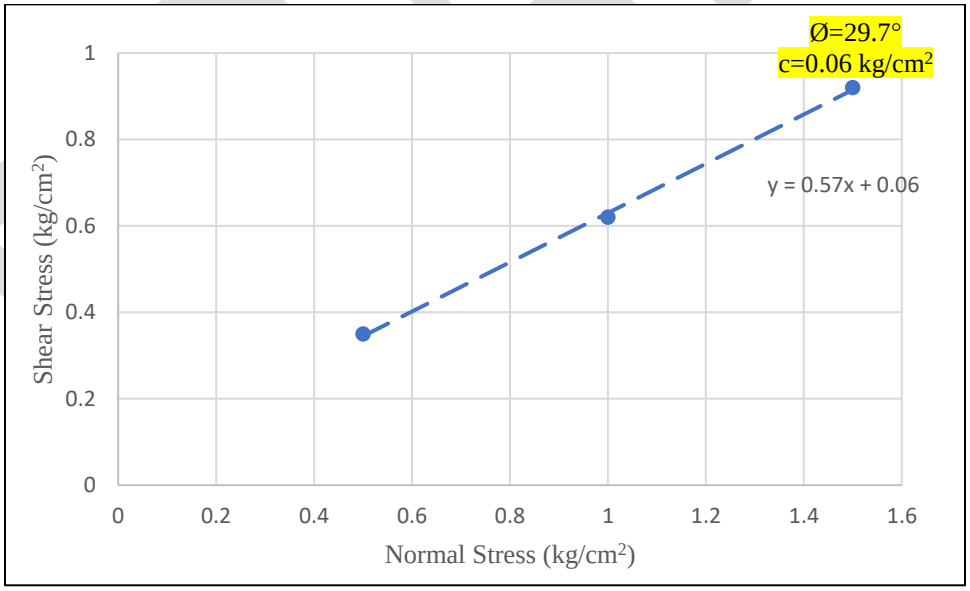


**Figure 5.51** Shear Stress vs.Normal stress Plot for SOIL+ 4% CEMENT+1.0 kg/m$^3$ ZB

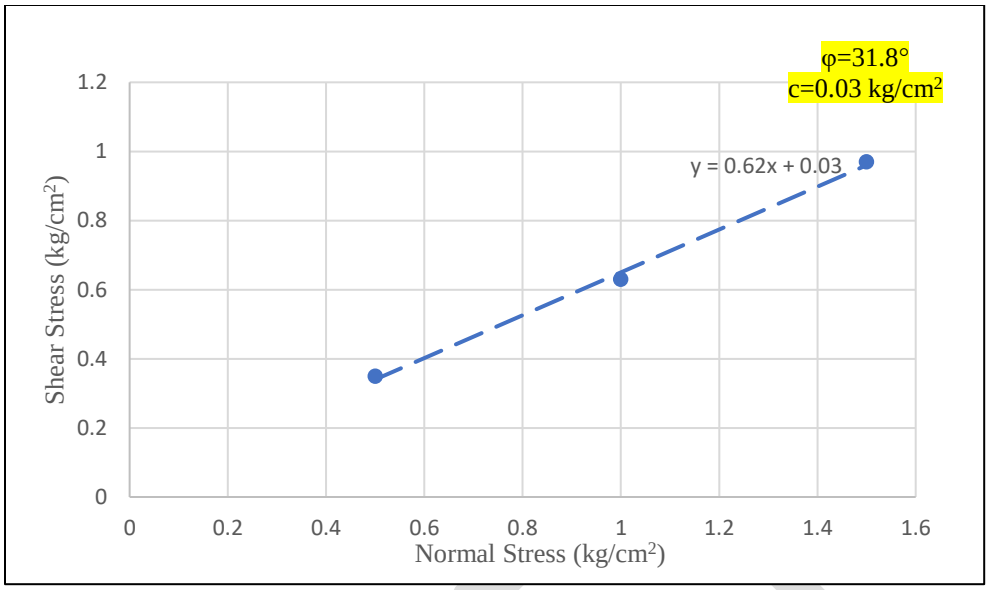


**Figure 5.52** Shear Stress vs.Normal stress Plot for SOIL+ 4% CEMENT+1.25 kg/m$^3$ ZB

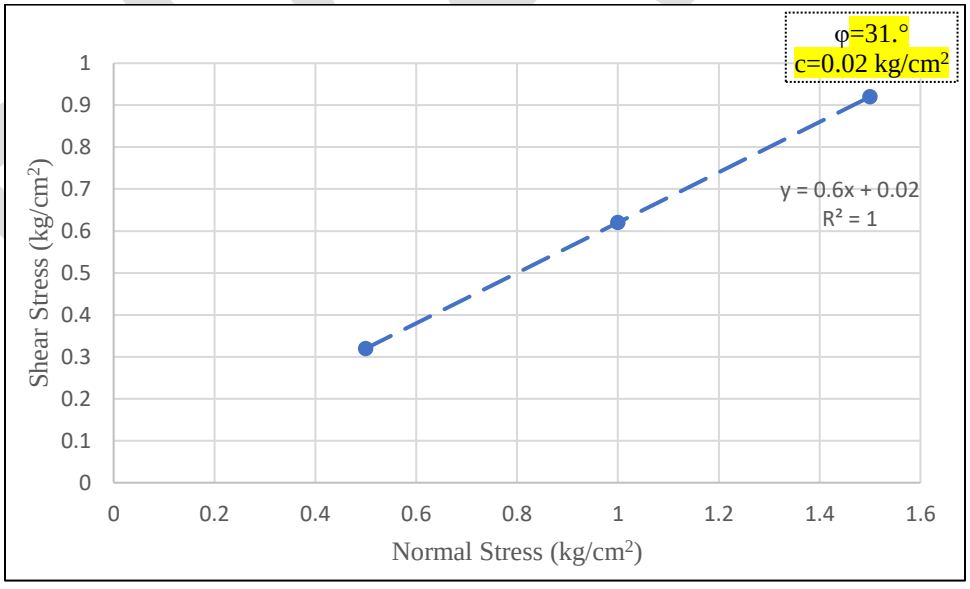


**Figure 5.53** Shear Stress vs.Normal stress Plot for SOIL+ 4% CEMENT+1.5 kg/m$^3$ ZB

Table 5.34 Shear Strength parameters for soil+4% cement +ZB Shear

| **Admixture** | **Shear Strength Parameters** | |
|---|---|---|
| | **Angle of Internal Friction (φ)** | **Cohesion ( c ) ($kg/cm^2$)** |
| **0.50 $kg/m^3$ ZB + 4% Cement** | 31.4 | 0 |
| **0.75 $kg/m^3$ ZB + 4% Cement** | 28.8 | 0 |
| **1.00 $kg/m^3$ ZB + 4% Cement** | 29.7 | 0.06 |
| **1.25 $kg/m^3$ ZB + 4% Cement** | 31.8 | 0.03 |
| **1.50 $kg/m^3$ ZB + 4% Cement** | 31.0 | 0.02 |

For the next set of tests, for Sample No.21- Sample No.25 .DST tests were performed at Normal Stresses of 0.5 $kg/cm^2$ ,1 $kg/cm^2$ ,1.5 $kg/cm^2$ with 5% cement+ZB ( at doses of 0.5 $kg/m^3$ ,0.75 $kg/m^3$,1 $kg/m^3$,1.25 $kg/m^3$,1.5 $kg/m^3$.The readings of DST are tabulated in Appendix F, Table F1-Table F15.

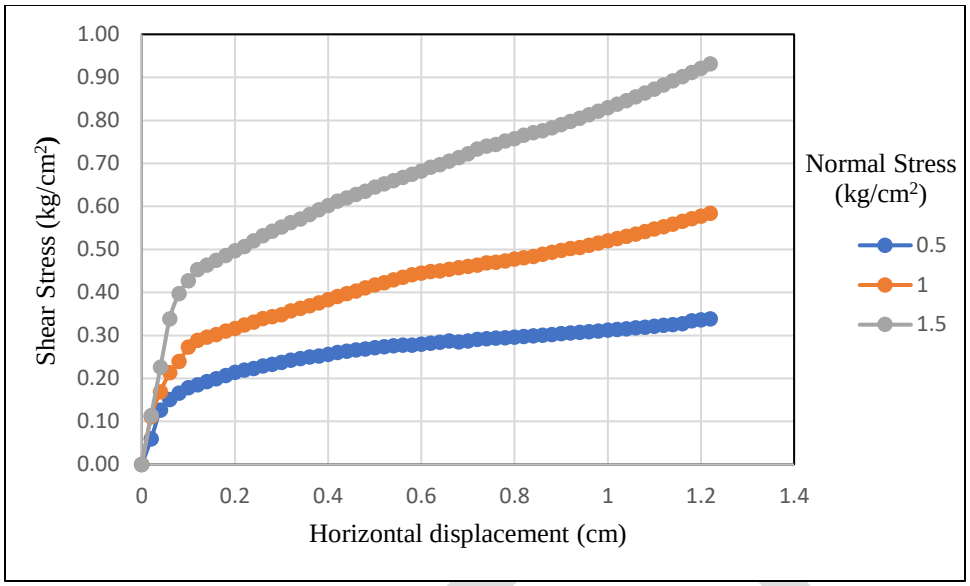


**Figure 5.54** Shear stress(kg/cm$^2$) vs Horizontal displacement (cm) graph for SOIL+ 5% CEMENT+0.5 kg/m$^3$ ZB

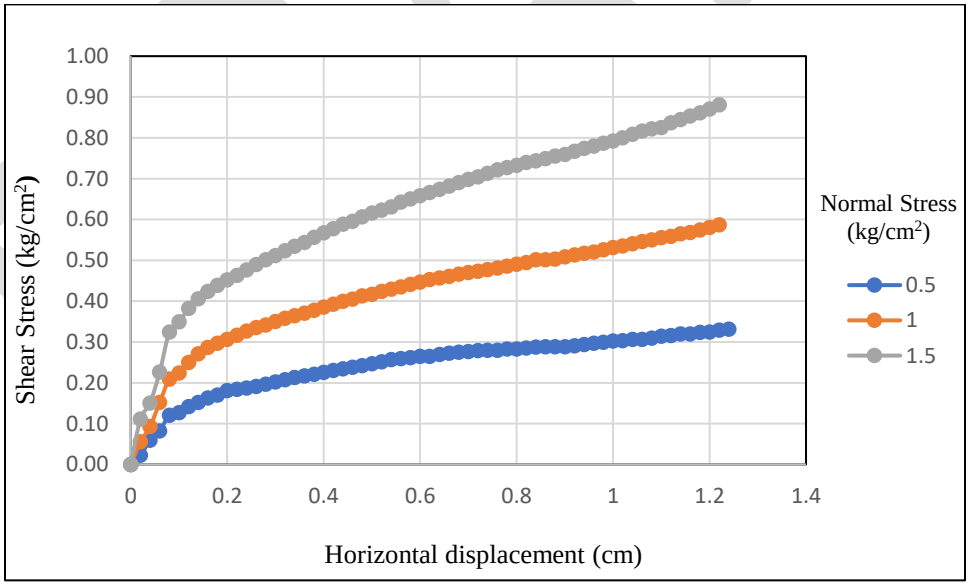


**Figure 5.55** Shear stress(kg/cm$^2$) vs Horizontal displacement (cm) graph for SOIL+ 5% CEMENT+0.75 kg/m$^3$ ZB

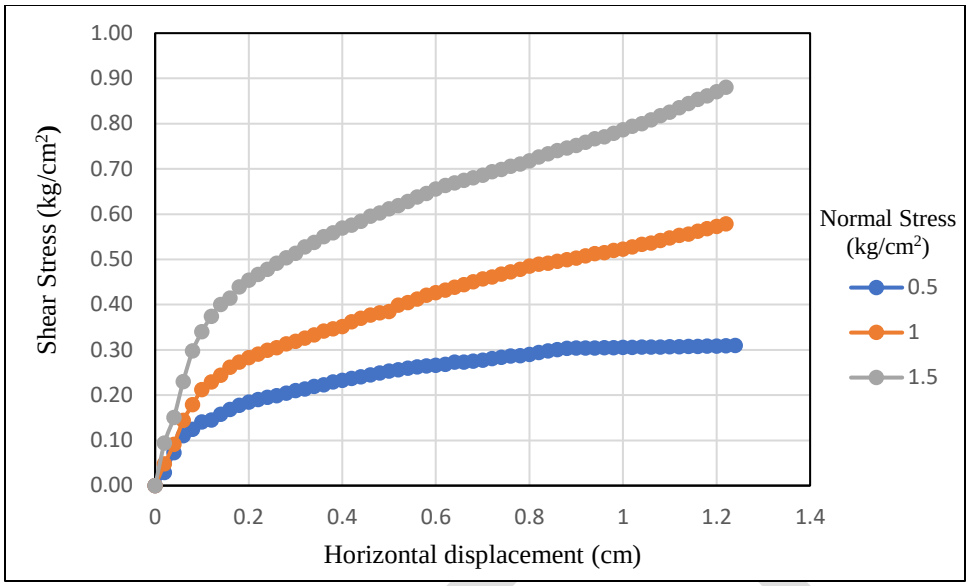


**Figure 5.56** Shear stress(kg/cm$^2$) vs Horizontal displacement (cm) graph for SOIL+ 5% CEMENT+1.0 kg/m$^3$ ZB

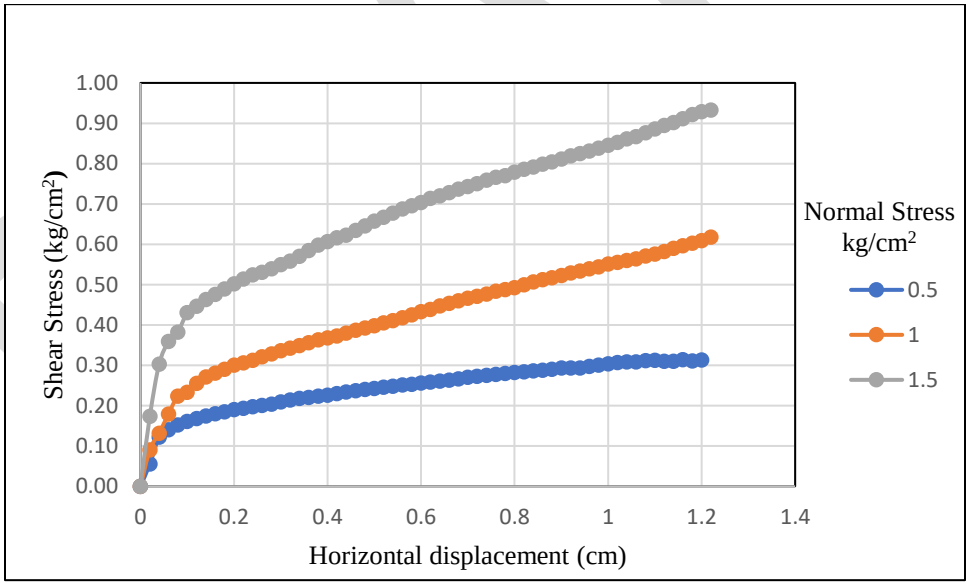


**Figure 5.57** Shear stress(kg/cm$^2$) vs Horizontal displacement (cm) graph for SOIL+ 5% CEMENT+1.25 kg/m$^3$ ZB

Test readings are plotted to obtain a graph of Horizontal Displacement vs Shear Stress as shown in Figure.5.56- Figure 5.60. Tables 5.35- Table 5.39 gives the Maximum Stresses obtained for

Normal Stresses for soil samples with 3% cement + ZB Doses. The Shear strength parameters c and φ are obtained from graph of Maximum Shear stress vs Normal Stress as shown in Figure.5.61, Figure5.62, Figure 5.63, Figure5.64, Figure5.65.The final values of Shear strength parameters c and φ obtained from tests are tabulated in Table.5.40

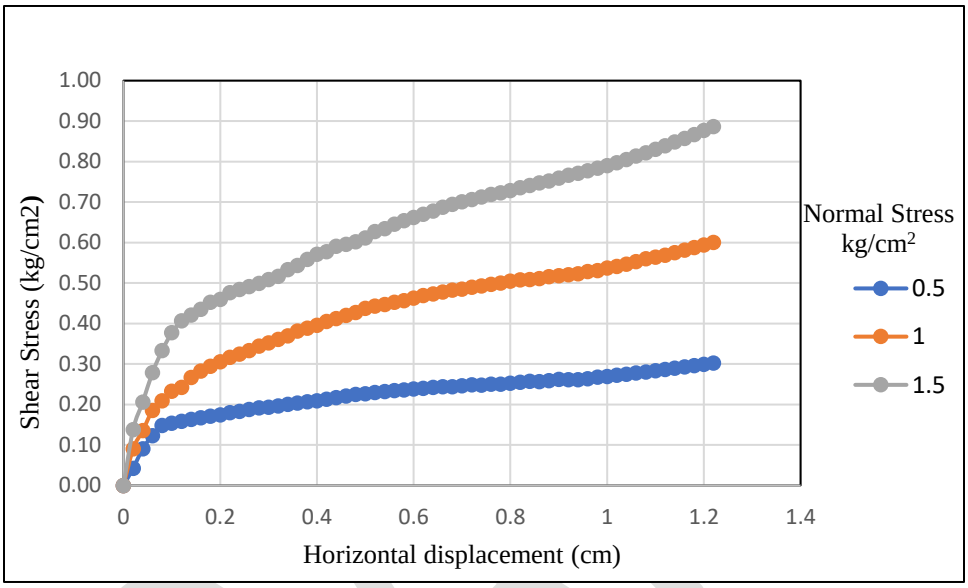


**Figure 5.58** Shear stress(kg/cm$^2$) vs Horizontal displacement (cm) graph for SOIL+ 5% CEMENT+1.5 kg/m$^3$ ZB

**Table 5.35** Shear stress values at Normal stresses of 0.5,1,1.5 kg/cm$^2$ for SOIL+ 5% CEMENT+ 0.5 kg/m$^3$ ZB

| Test no. | Normal Stress (kg/cm$^2$) | Max Shear Stress (kg/cm$^2$) |
|---|---|---|
| 1 | 0.5 | 0.31 |
| 2 | 1 | 0.58 |
| 3 | 1.5 | 0.93 |

**Table 5.36** Shear stress values at Normal stresses of 0.5,1,1.5 kg/cm$^2$ for SOIL+ 5% CEMENT+ 0.75 kg/m$^3$ ZB

| Test no. | Normal Stress (kg/cm$^2$) | Max Shear Stress (kg/cm$^2$) |
|---|---|---|
| 1 | 0.5 | 0.33 |
| 2 | 1 | 0.59 |
| 3 | 1.5 | 0.88 |

**Table 5.37** Shear stress values at Normal stresses of 0.5,1,1.5 kg/cm$^2$ for SOIL+ 5% CEMENT+ 1.0 kg/m$^3$ ZB

| Test no. | Normal Stress (kg/cm$^2$) | Max Shear Stress (kg/cm$^2$) |
|---|---|---|
| 1 | 0.5 | 0.34 |
| 2 | 1 | 0.58 |
| 3 | 1.5 | 0.88 |

**Table 5.**38 Shear stress values at Normal stresses of 0.5,1,1.5 kg/cm$^2$ for SOIL+ 5% CEMENT+ 1.25 kg/m$^3$ ZB

| Test no. | Normal Stress (kg/cm$^2$) | Max Shear Stress (kg/cm$^2$) |
|---|---|---|
| 1 | 0.5 | 0.35 |
| 2 | 1 | 0.64 |
| 3 | 1.5 | 1.00 |

**Table 5.39** Shear stress values at Normal stresses of 0.5,1,1.5 kg/cm$^2$ for SOIL+ 5% CEMENT+ 1.5 kg/m$^3$ ZB

| Test no. | Normal Stress (kg/cm$^2$) | Max Shear Stress (kg/cm$^2$) |
|---|---|---|
| 1 | 0.5 | 0.3 |
| 2 | 1 | 0.59 |
| 3 | 1.5 | 0.98 |

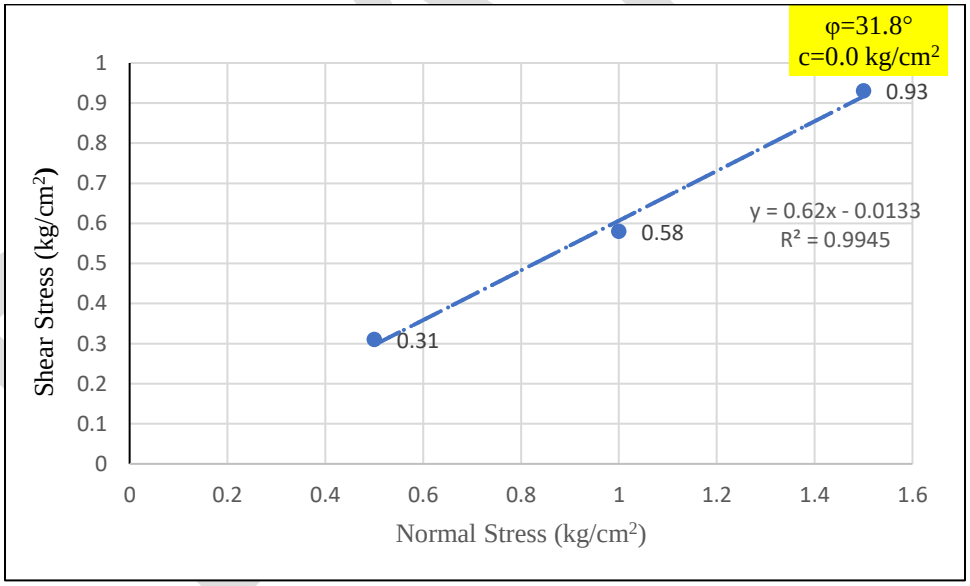


**Figure 5.59** Shear Stress vs.Normal stress Plot for for SOIL+ 5% CEMENT+0.5 kg/m$^3$ ZB

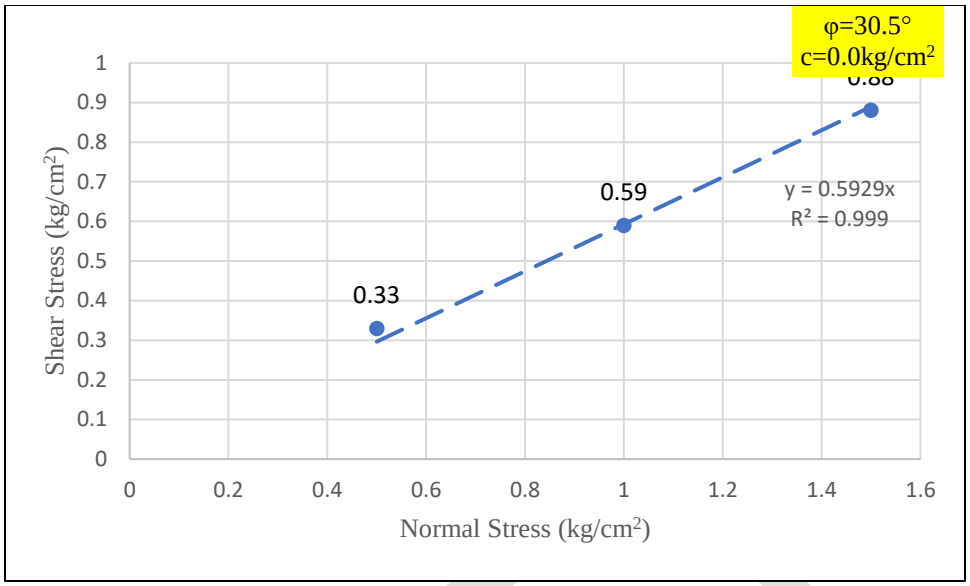


**Figure 5.60** Shear Stress vs.Normal stress Plot for for SOIL+ 5% CEMENT+0.75 kg/m$^3$ ZB

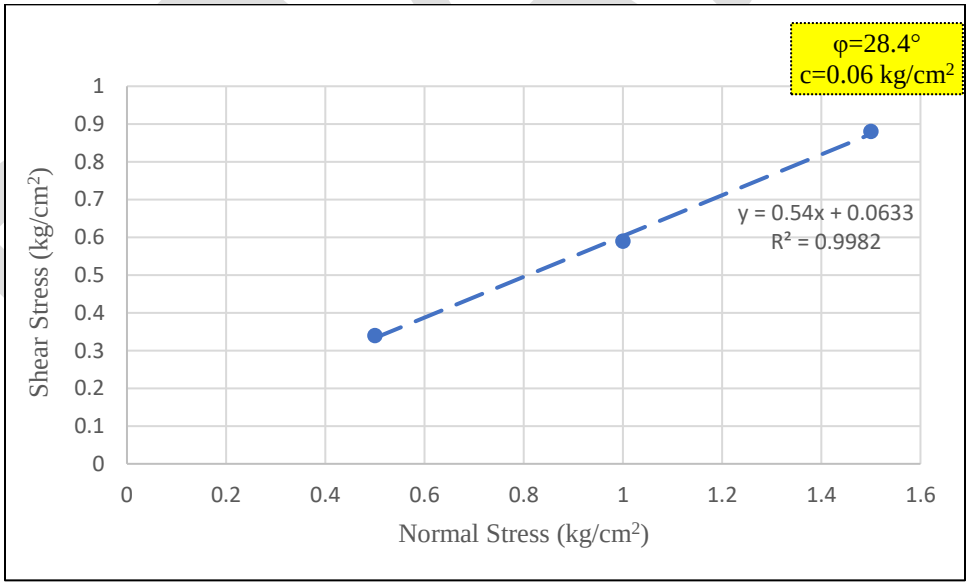


**Figure 5.61** Stress vs.Normal stress Plot for for SOIL+ 5% CEMENT+1.0 kg/m$^3$ ZB

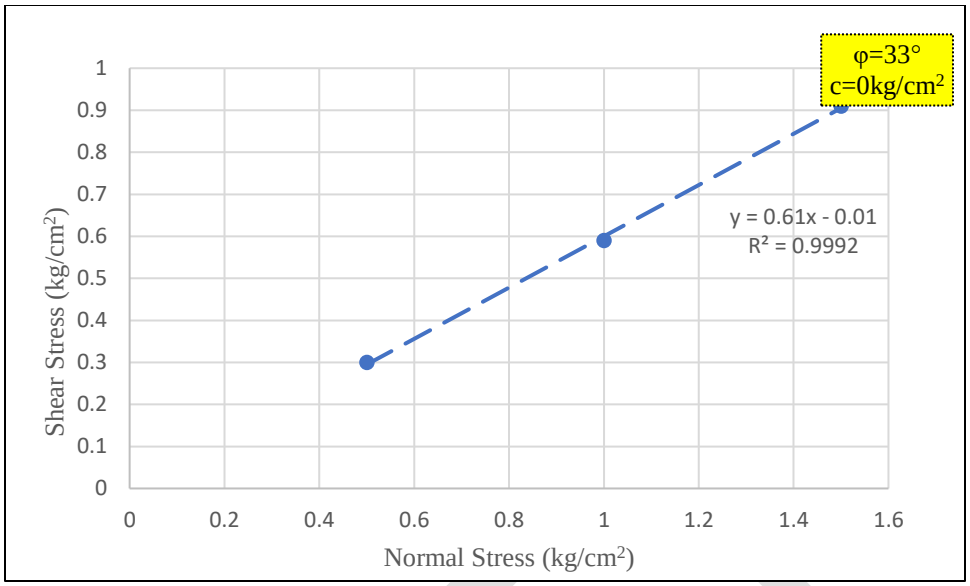


**Figure 5.62** Shear Stress vs.Normal stress Plot for for SOIL+ 5% CEMENT+1.25 kg/m$^3$ ZB

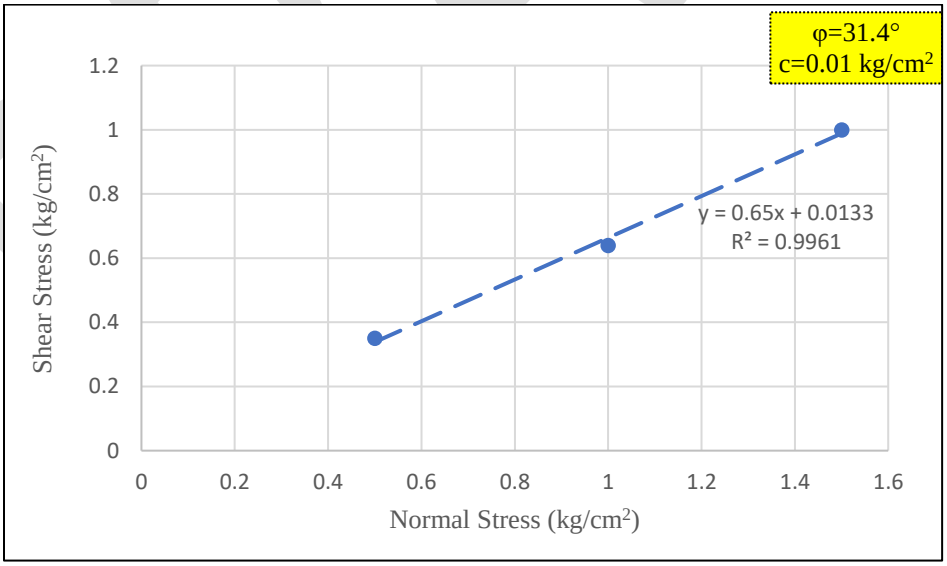


**Figure 5.63** Shear Stress vs.Normal stress Plot for for SOIL+ 5% CEMENT+1.5 kg/m$^3$ ZB

**Table 5.40** Shear Strength parameters for soil+5% cement +ZB

| **Admixture** | **Shear Strength Parameters** | |
|---|---|---|
| | **Angle of Internal Friction (φ)** | **Cohesion ( c )** kg/cm$^2$ |
| **0.50 kg/m$^3$ ZB + 5% Cement** | 31.8 | 0 |
| **0.75 kg/m$^3$ ZB + 5% Cement** | 30.5 | 0 |
| **1.00 kg/m$^3$ ZB + 5% Cement** | 28.4 | 0.06 |
| **1.25 kg/m$^3$ ZB + 5% Cement** | 33.0 | 0 |
| **1.50 kg/m$^3$ ZB + 5% Cement** | 31.4 | 0.01 |

## 5.4 SUMMARY:

- The chapter evaluated the DST test readings for each soil sample through two graphs ,i.e The Plot of Horizontal Displacement vs Shear Stress and Normal stress vs. Shear stress and accordingly from the second plot of shear stress vs.normal stress ,theshear parameters are determined.
- The summarized values of shear parameters obtained for all the soil samples are listed in Table 5.40

**Table 5.40** Shear Strength parameters for all soil sample

| SL.NO | SAMPLE NO. | CONSTITUENT MATERIALS | SHEAR PARAMETERS | | MAXIMUM SHEAR STRESS ($kg/cm^2$) | | |
|---|---|---|---|---|---|---|---|
| | | | Angle of internal Friction ,φ ( in degrees) | c ( $kg/cm^2$) | 0.5 | 1 | 1.5 |
| 1 | **0** | SOIL +0% CEMENT+0 ZB | 27 | 0.006 | 0.3 | 0.54 | 0.86 |
| 2 | 1 | SOIL + 1% CEMENT +0.5 ZB | 28.8 | 0.006 | 0.29 | 0.54 | 0.84 |
| 3 | 2 | SOIL + 1% CEMENT +0.75 ZB | 30.1 | 0 | 0.3 | 0.56 | 0.88 |
| 4 | 3 | SOIL + 1% CEMENT +1.0 ZB | 30.1 | 0.01 | 0.31 | 0.58 | 0.89 |
| 5 | 4 | SOIL + 1% CEMENT +1.25 ZB | 30.5 | 0 | 0.3 | 0.58 | 0.89 |
| 6 | 5 | SOIL + 1% CEMENT +1.5 ZB | 29.7 | 0.01 | 0.3 | 0.57 | 0.87 |
| 7 | 6 | SOIL +2 % CEMENT +0.5 ZB | 31.0 | 0 | 0.28 | 0.57 | 0.88 |
| 8 | 7 | SOIL + 2% CEMENT +0.75 ZB | 29.2 | 0.05 | 0.29 | 0.58 | 0.85 |
| 9 | 8 | SOIL + 2% CEMENT +1.0 ZB | 30.5 | 0 | 0.3 | 0.58 | 0.89 |
| 10 | 9 | SOIL + 2% CEMENT +1.25 ZB | 31.8 | 0 | 0.32 | 0.6 | 0.94 |
| 11 | 10 | SOIL + 2% CEMENT +1.5 ZB | 31.4 | 0 | 0.29 | 0.58 | 0.9 |
| 12 | 11 | SOIL + 3% CEMENT +0.5 ZB | 33.0 | 0 | 0.24 | 0.54 | 0.89 |

| SL.NO | SAMPLE NO. | CONSTITUENT MATERIALS | SHEAR PARAMETERS | | MAXIMUM SHEAR STRESS ($kg/cm^2$) | | |
|---|---|---|---|---|---|---|---|
| | | | Angle of internal Friction ,φ ( in degrees) | c ( $kg/cm^2$) | 0.5 | 1 | 1.5 |
| 13 | 12 | SOIL + 3% CEMENT +0.75 ZB | 31.0 | 0.01 | 0.32 | 0.6 | 0.92 |
| 14 | 13 | SOIL + 3% CEMENT +1.0 ZB | 31.8 | 0.03 | 0.36 | 0.59 | 0.87 |
| 15 | 14 | SOIL + 3% CEMENT +1.25 ZB | 34.6 | 0.006 | 0.37 | 0.66 | 1.06 |
| 16 | 15 | SOIL + 3% CEMENT +1.5 ZB | 33.8 | 0 | 0.35 | 0.64 | 1.02 |
| 17 | 16 | SOIL + 4% CEMENT +0.5 ZB | 31.4 | 0 | 0.29 | 0.59 | 0.9 |
| 18 | 17 | SOIL + 4% CEMENT +0.75 ZB | 28.8 | 0 | 0.3 | 0.53 | 0.83 |
| 19 | 18 | SOIL + 4% CEMENT +1.0 ZB | 29.7 | 0.06 | 0.35 | 0.62 | 0.92 |
| 20 | 19 | SOIL + 4% CEMENT +1.25 ZB | 31.8 | 0.03 | 0.35 | 0.63 | 0.97 |
| 21 | 20 | SOIL + 4% CEMENT +1.5 ZB | 31.0 | 0.02 | 0.32 | 0.62 | 0.92 |
| 22 | 21 | SOIL + 5% CEMENT +0.5 ZB | 31.8 | 0 | 0.31 | 0.58 | 0.93 |
| 23 | 22 | SOIL + 5% CEMENT +0.75 ZB | 30.5 | 0 | 0.33 | 0.59 | 0.88 |
| 24 | 23 | SOIL + 5% CEMENT +1.0 ZB | 28.4 | 0.06 | 0.34 | 0.58 | 0.88 |
| 25 | 24 | SOIL + 5% CEMENT +1.25 ZB | 33.0 | 0 | 0.35 | 0.64 | 1 |

| SL.NO | SAMPLE NO. | CONSTITUENT MATERIALS | SHEAR PARAMETERS | | MAXIMUM SHEAR STRESS ($kg/cm^2$) | | |
|---|---|---|---|---|---|---|---|
| | | | Angle of internal Friction ,φ ( in degrees) | c ( $kg/cm^2$) | 0.5 | 1 | 1.5 |
| 26 | 25 | SOIL + 5% CEMENT +1.5 ZB | 31.4 | 0.01 | 0.3 | 0.59 | 0.98 |

# CHAPTER 6

# ANALYSIS OF TEST RESULTS

**6.1 Effect of particle size:** To investigate the effect of particle size, three load sets (0.5 kg/cm$^2$,1.0 kg/cm$^2$, 1.5 kg/cm$^2$ ) were selected for each of the three different particle-sized sands. It was observed that for each load set, the shear strength properties increased as the particle size increased which shows that particle size influences shear strength behavior as mentioned by Islam et al. (2011) From the plot of Shear stress vs. Horizontal Displacement, for the three categories of sand type FS, MS and CS, we have obtained the maximum shear stress value under each type of loading. It is observed that for each loading (0.5 kg/cm$^2$,1.0 kg/cm$^2$, 1.5 kg/cm$^2$) the increment of particle size gradually increases the shear stress. The comparison of maximum shear stress for different particle size soil samples with respect to variation of loading is shown in Figure 6.1 Selig and Roner (1981) using Triaxial tests have shown that as particle size increases, shear strength increases and void ratio decreases when the volume is kept constant. However, shear strength remains independent of particle size when the void ratio is consistent. This observation is consistent with the results from the present experiment (Direct Shear Test)

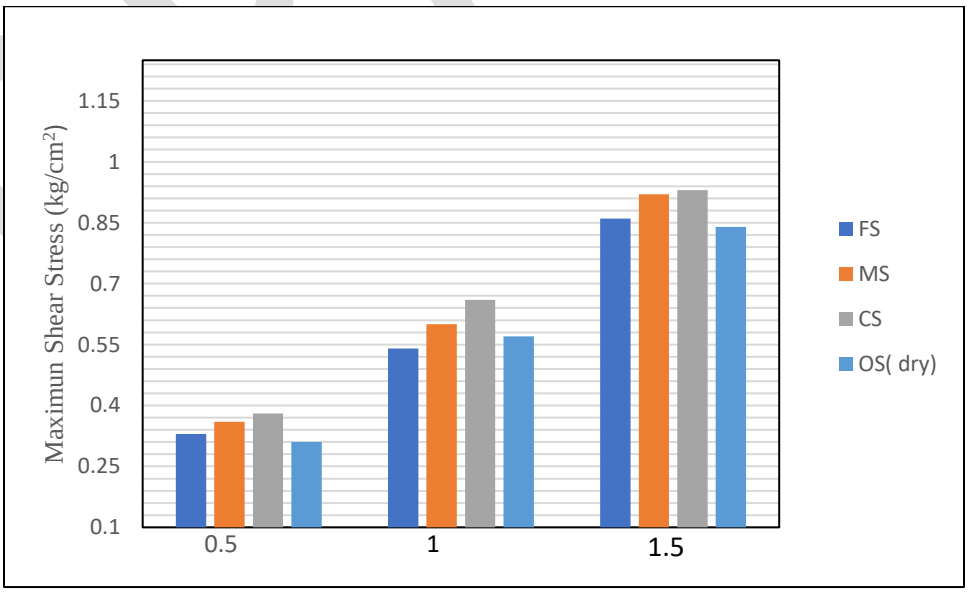


**Figure 6.1** Maximum Shear Stress at Normal stresses 0.5,1,1.5 kg/cm$^2$ for soil samples FS,MS,CS,OS

The friction angle value for the three soil FS, MS and CS,is seen to increase slightly as the particle size increases. This is probably due to the difference in morphology of the particles. Based on the observed patterns, it is seen that there is only a small variation for FS, MS, and CS Therefore based on the explanation given by Alias et al.(2014) the effective internal friction angle can be dependent on particle size. Tests with larger-sized particles produced higher effective internal friction angles and developed high shear strength.

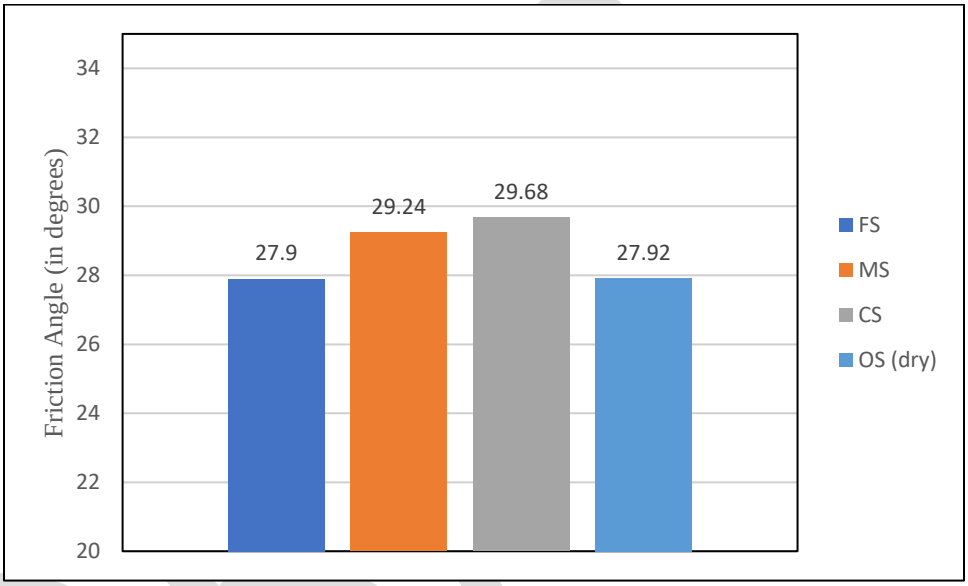


**Figure 6.2** Friction Angle(φ) for soil samples

**Table 6.1**.Shear strength parameters for FS, MS,CS, OS

| SAND TYPE | SHEAR STRENGTH PARAMETERS | |
|---|---|---|
| | Angle of Internal Friction ( Ø ) in degrees | Cohesion ( c ) in kg/cm$^2$ |
| FINE SAND | 27.9 | 0.04 |
| MEDIUM SAND | 29.2 | 0.06 |
| COARSE SAND | 29.6 | 0.08 |
| ORIGINAL SAND at OMC | 27 | 0 |

| SAND TYPE | SHEAR STRENGTH PARAMETERS | |
|---|---|---|
| | Angle of Internal Friction ( Ø ) in degrees | Cohesion ( c ) in kg/cm$^2$ |
| ORIGINAL SAND at Dry State | 27.92 | 0.05 |

## 6.2 Analysis of test results of chemically treated soil samples :

### 6.2.1 Analysis of test result with 1% cement content+ ZB:

Figure 6.3 shows the variation of maximum shear stress attained by the soil samples with variation in ZB proportion added to soil at a constant application of Normal stress 0.5kg/ cm $^2$ at 1% cement content. At 1% cement content, the shear strength increase initially followed by a decrease in value, the optimum value of shear strength is seen at ZB dose of 1kg/m$^3$

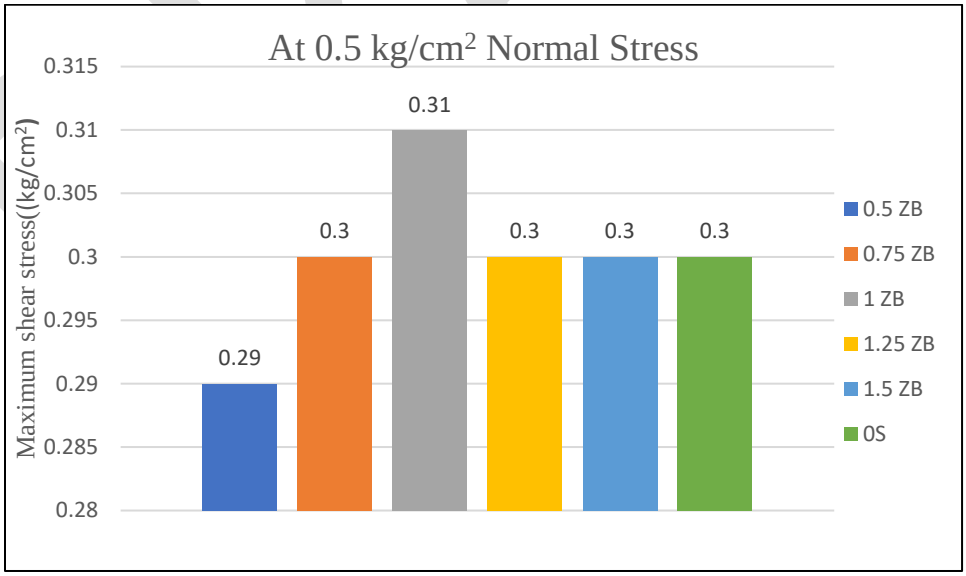


**Figure 6.3** Maximum Shear Stresses of Soil+1% cement + ZB at Normal stress 0.5 kg/m$^3$

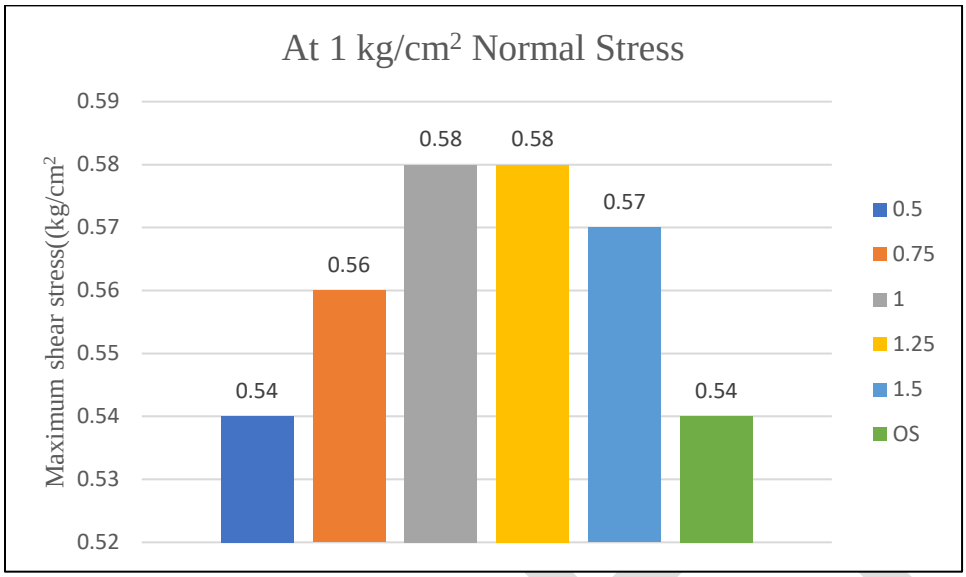


**Figure 6.4** Maximum Shear Stresses of Soil+1% cement + ZB at Normal stress 1.0 kg/cm$^2$

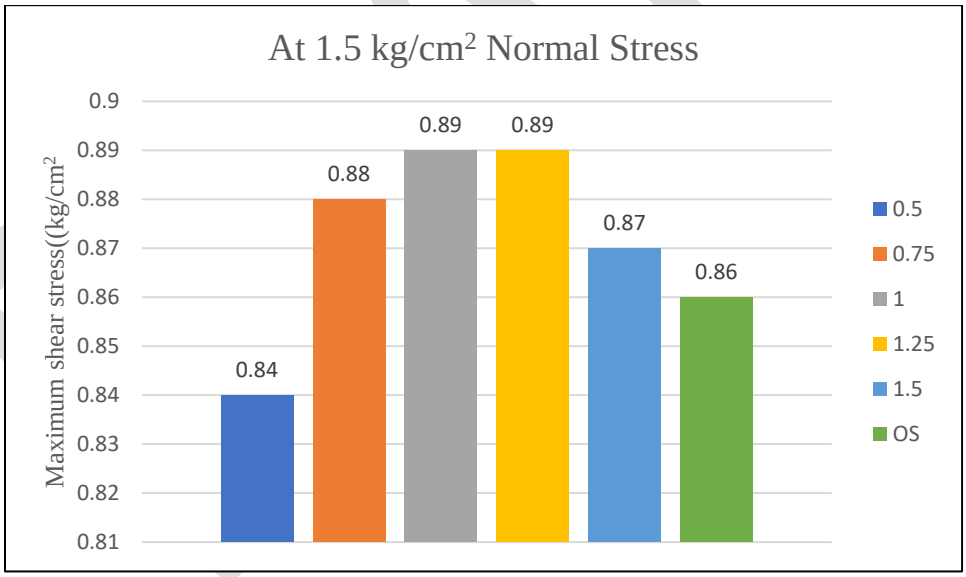


**Figure 6.5** Maximum Shear Stresses of Soil+1% cement + ZB at Normal stress 1.5 kg/cm$^2$

Figure 6.4 and 6.5 show that for 1% CEMENT at 0.5,0.75,1,1.25,1.5 kg/m$^3$ doses of ZB the shear strength gradually increases from 0.5 ZB to 1 ZB and then gradually decreases for 0.5 kg/cm$^2$ Normal Stress ,On application of constant Normal stress 1.0 kg/cm$^2$ and 1.5 kg/cm$^2$,the maximum

value for shear stress is observed at 1 and 1.25 ZB, thus for 1% cement, the shear strength is accounted to be maximum at 1.0 kg/m$^3$ ZB.

### 6.2.2 Analysis of test result with 2% cement content+ZB:

Figures 6.6 show that on the application of constant Normal stress 0.5kg/cm$^2$ 2% CEMENT+ soil+ ZB samples at 0.5,0.75,1,1.25,1.5 kg/m$^3$ doses of ZB the shear strength increases from 0.5 ZB to 1.25 ZB and then decreases and further increases, the optimum value for shear stress is observed at 1.25 ZB, the same trend is seen for on application of constant Normal stress 1.0 kg/cm$^2$,( Figure 6.7) however on application of constant Normal stress 1.5 kg/cm$^2$, there is a slight change in a trend seen, with an increase in ZB content, the value of shear stress initially decreases for 0.75 ZB but later increase till a optimum is reached at 1.25 ZB, which remained in line to the prior loading conditions. Therefore for 2% cement, the shear strength is accounted to be maximum at 1.25 kg/m$^3$ ZB

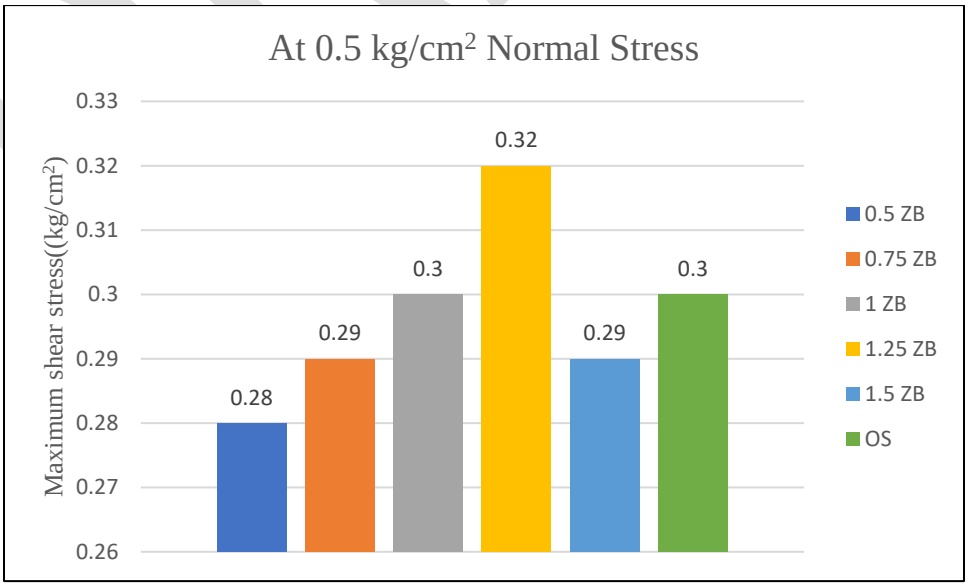


**Figure 6.6** Maximum Shear Stresses of Soil+2% cement + ZB at Normal stress 0.5 kg/cm$^2$

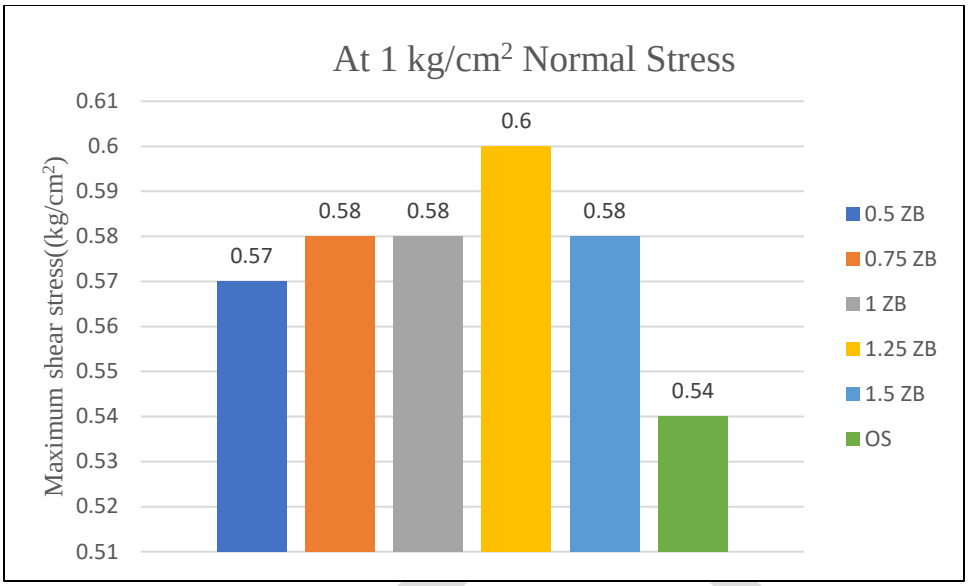


**Figure 6.7** Maximum Shear Stresses of Soil+2% cement + ZB at Normal stress 1.0 kg/cm$^2$

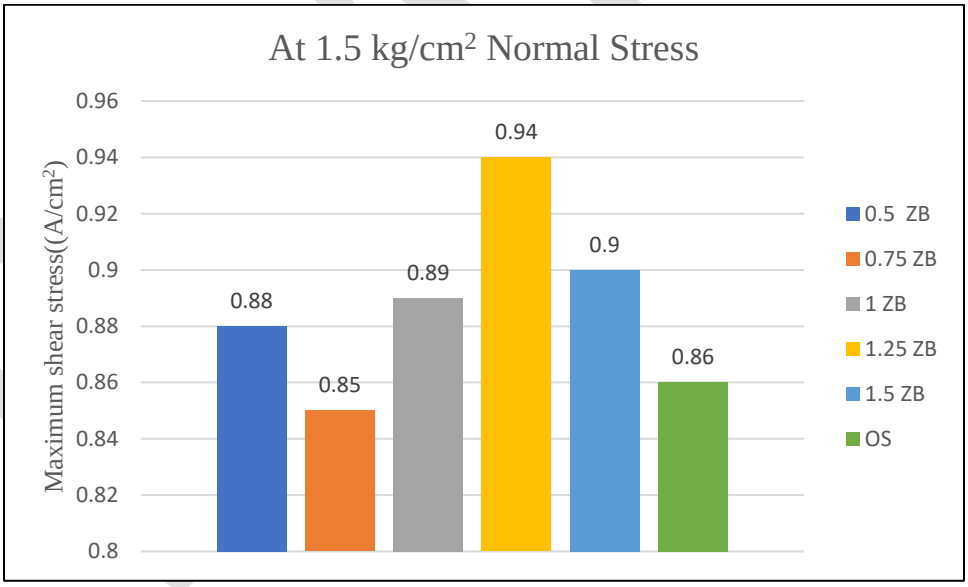


**Figure 6.8** Maximum Shear Stresses of Soil+2% cement + ZB at Normal stress 1.5 kg/cm$^2$

### 6.2.3 Analysis of test results with 3% cement+ ZB content:

In case of 3% CEMENT at 0.5,0.75,1,1. doses of ZB the 25,1.5 kg/m$^3$ doses of ZB, Figures 6.9,6.10,6.11 show that on the application of all the three normal stress loading of 0.5 kg/cm$^2$,1.01.5 kg/cm$^2$, 1.5 kg/cm$^2$, the shear strength shows an increase from 0.5 ZB to 1.25 ZB

and then gradually decreases, the maximum value for shear stress is observed at 1.25 ZB, therefore we can say that on using a cement dose of 3%,the maximum value of shear strength is accounted to be at 1.25 kg/m$^3$ ZB dose.

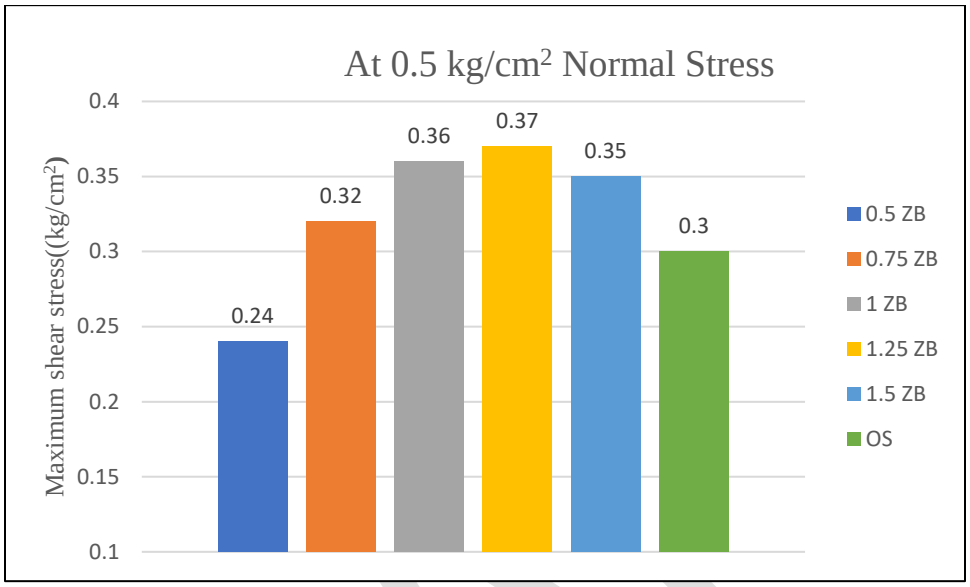


**Figure 6.9** Maximum Shear Stresses of Soil+3% cement + ZB at Normal stress 0.5 kg/cm$^2$

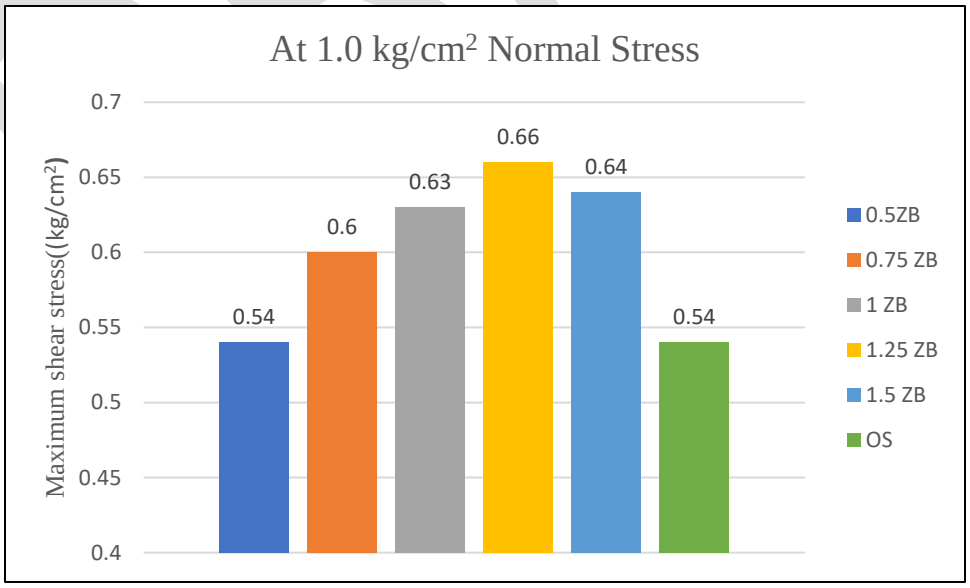


**Figure 6.10** Maximum Shear Stresses of Soil+3% cement + ZB at Normal stress 1.0 kg/cm$^2$

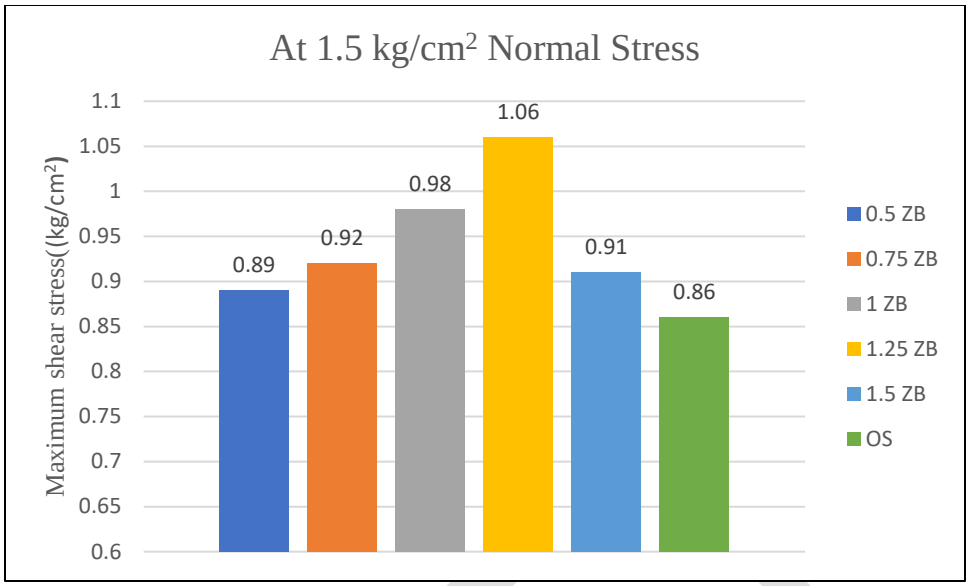


**Figure 6.11** Maximum Shear Stresses of Soil+3% cement + ZB at Normal stress

### 6.2.4 Analysis of test results with 4% cement+ ZB content:

For 4% cement + ZB soil samples Figure 6.12 on the application of constant Normal stress 0.5kg/cm$^2$ ,4% CEMENT+ soil+ ZB samples at 0.5,0.75,1,1.25,1.5 kg/m$^3$ doses of ZB the shear strength increases from 0.5 ZB to 1.0 ZB ,shows constant value at 1 ZB and 1.25 ZB and then decreases on further increase of ZB content ,the maximum value for shear stress is observed at 1.0 ZB and 1.25 ZB,

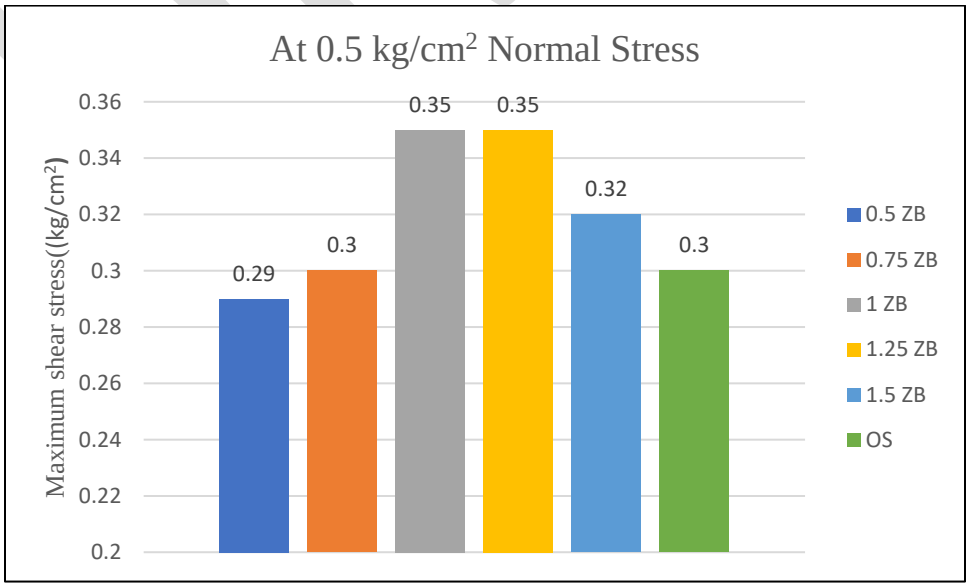

**Figure 6.12** Maximum Shear Stresses of Soil+4% cement + ZB at Normal stress 0.5 kg/cm$^2$

the same trend is seen for on application of constant Normal stress 1.0 kg/cm$^2$,( Figure 6.13) however here initially the value of maximum shear stress shows minimum results at 0.75 ZB but then with further increase in ZB content it increases,the highest value found remains constant at 1.25ZB dose.This trends aligns with the test results performed at a constant normal stress of 1.5 kg/cm$^2$

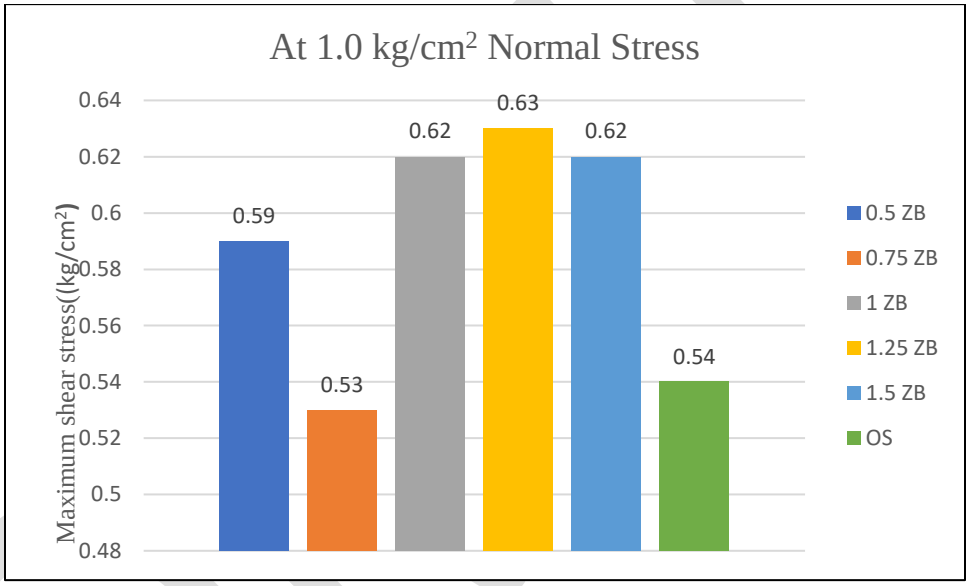


**Figure 6.13** Maximum Shear Stresses of Soil+4% cement + ZB at Normal stress 1.0 kg/cm$^2$

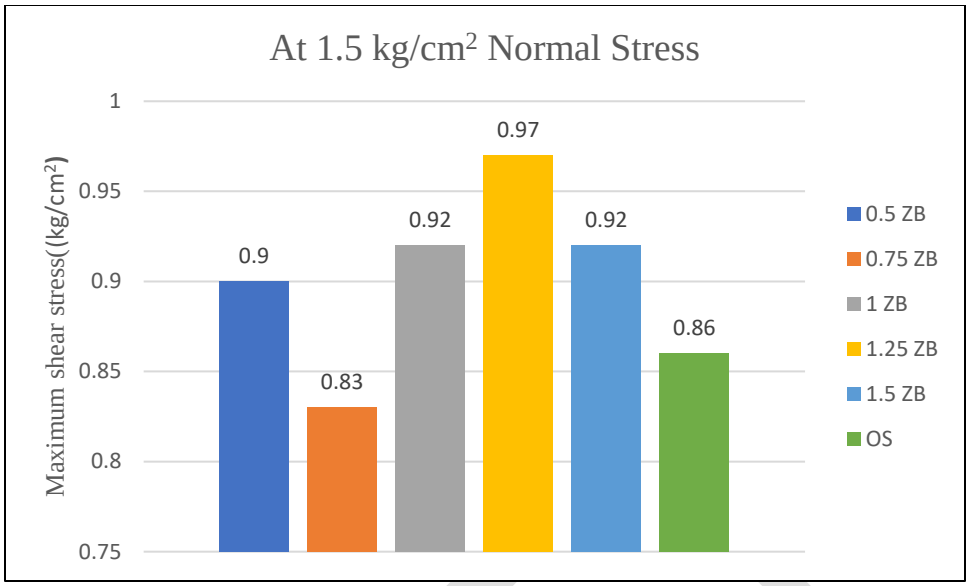


**Figure 6.14** Maximum Shear Stresses of Soil+4% cement + ZB at Normal stress 1.5 kg/cm$^2$

### 6.2.5 Analysis of test results with 5% cement+ZB content:

For 5% CEMENT, at 0.5 kg/cm$^2$ Normal stress Figure 6.15 shows a similar graph of increase in shear stress till it reaches an optimum at 1.25 ZB and further decreases.

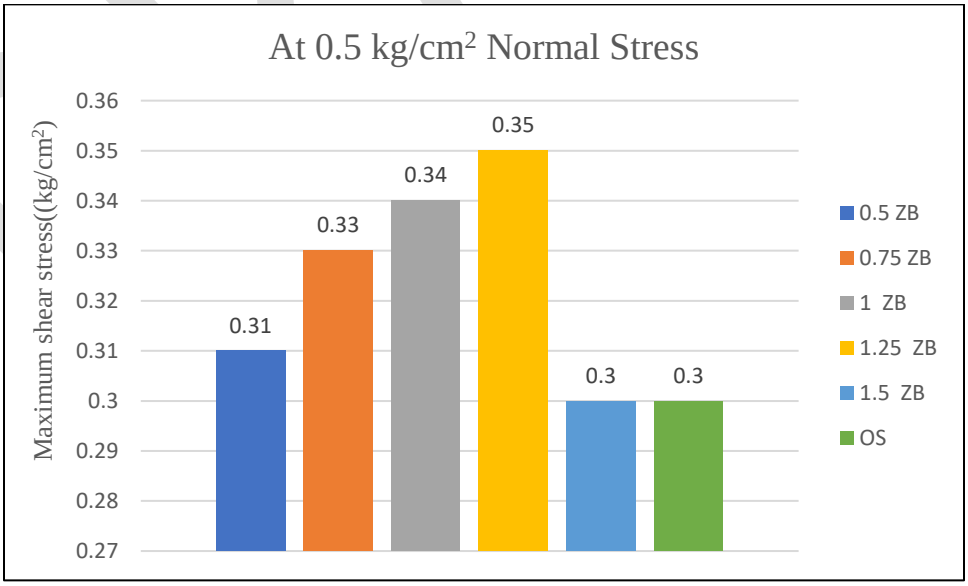


**Figure 6.15** Maximum Shear Stresses of Soil+5% cement + ZB at Normal stress 0.5kg/cm$^2$

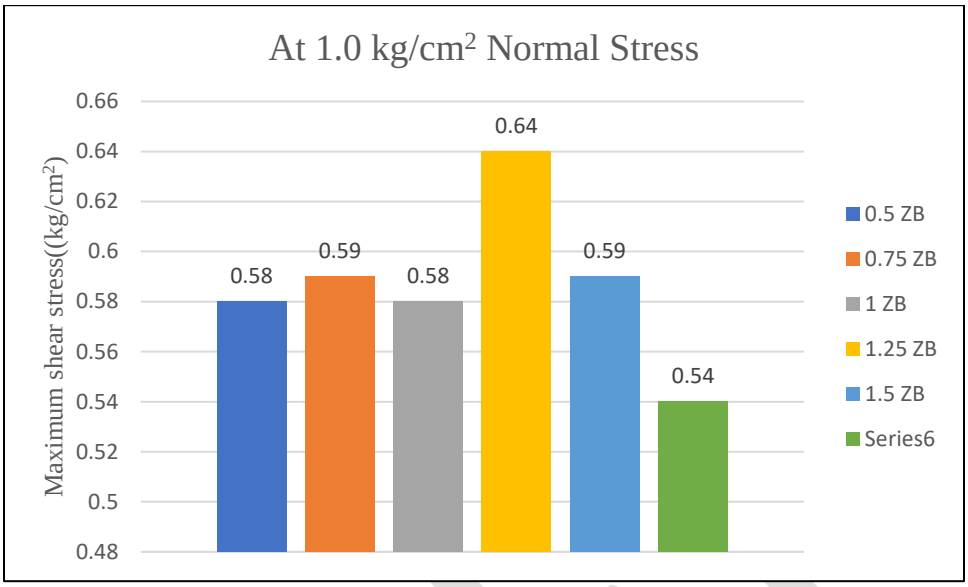


**Figure 6.16** Maximum Shear Stresses of Soil+5% cement + ZB at Normal stress 1 kg/m$^2$

At constant normal loading of 1.0 kg/cm$^2$ Figure 6.16 the shear strength initially shows a constant value of 0.59 from 0.5 ZB to 1.0 ZB but with further increase in ZB content at 1.25 kg/m$^3$it increases substantially followed by a decrease. The maximum value for shear stress is observed at 1.25 ZB. At constant normal loading of 1.5 kg/cm$^2$ Figure 6.17, the shear strength value even though decreases initially but at 1.25 ZB dose, it again shows the optimum which remains constant for almost all the test sets with different proportions of ZB and cement content. Thus for 5% cement, the optimum dose of ZB can be stated as 1.25ZB.

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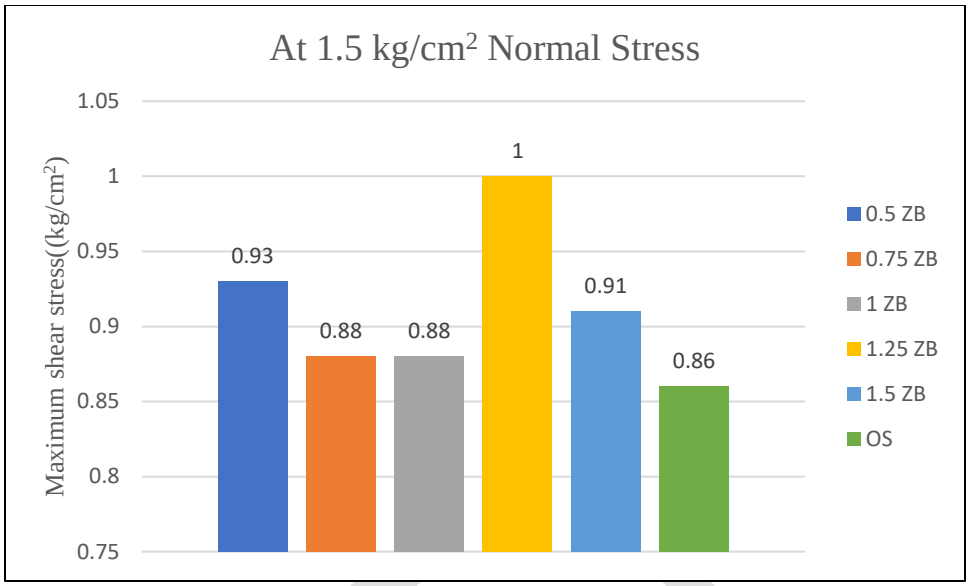



**Figure 6.17** Maximum Shear Stresses of Soil+5% cement + ZB at Normal stress 1.5kg/cm$^2$

**6.3 Effect of cement on soil sample**: PPC cement can enhance and modify the quality of soil, cement addition increases the increases the $\gamma_{dmax}$ of sand. (Habiba Afrin,2017) stated that when cement is used as an additive on soil, the void ratio of soil is decreased, which fills the spaces between the soil particles. After that, cement reacts with water when it is put into the soil, hardening it. Thus, the soil's unit weight is increased (Choobbasti et al.,2015). Cement hardening results in an increase in bearing capacity and shear strength. Figure 6.18 shows the variation of maximum shear stress value obtained for test results of DST at different cement content at varying proportions of ZB at a constant normal stress of 0.5 kg/cm$^2$. The curves show a trend where the Shear stress values increase with ZB doses, attaining a peak at 1 or 1.25 kg/m$^3$ ZB, and then further a fall is seen in the graph. Also, it is evident from the figure that the curve for 3% cement content shows the highest value, followed by 4% and 5% cement content.

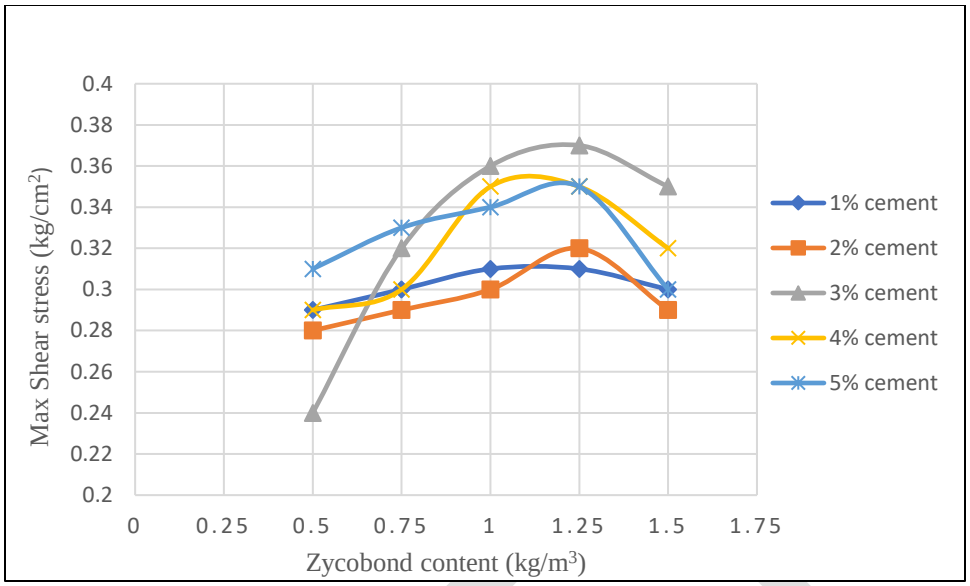



**Figure 6.18** Plot of Maximum Shear Stress vs ZB content for different cement% at 0.5kg/cm$^2$ Normal Stress

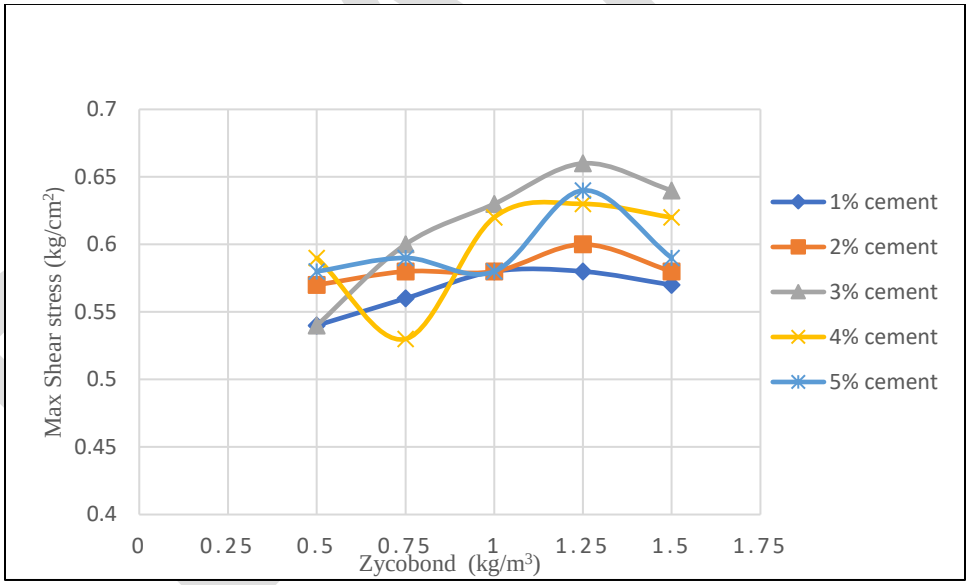



**Figure 6.19** Plot of Maximum Shear Stress vs ZB content for different cement % at1.0 kg/cm$^2$ Normal Stress

When tests were performed at a constant Normal stress of 1 kg/cm$^2$ , the optimum values were reflected at ZB dose 1.25 kg/m$^3$ for 2% ,3% ,5% cement whereas for 1% and 4% cement, the peak values can be seen at ZB dose 1 kg/m$^3$

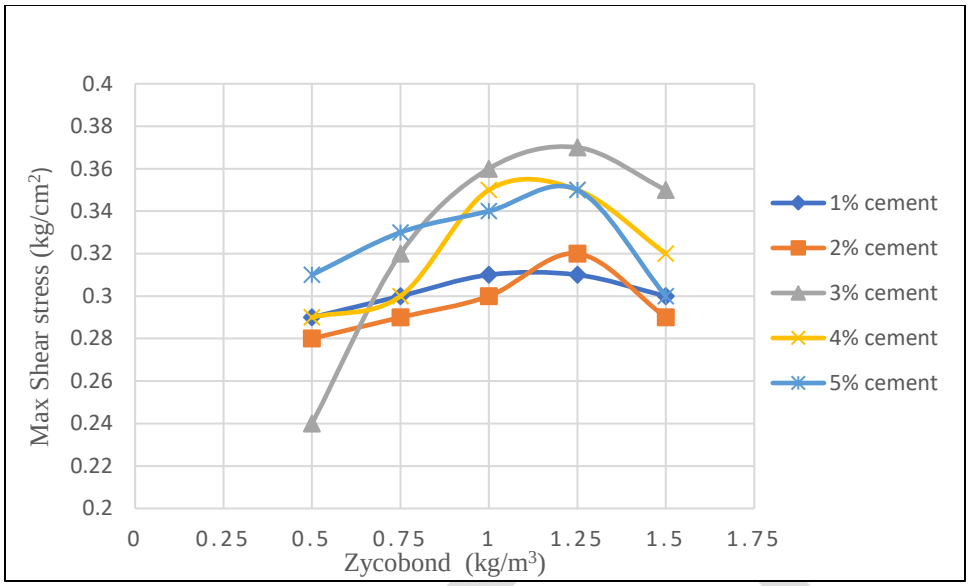
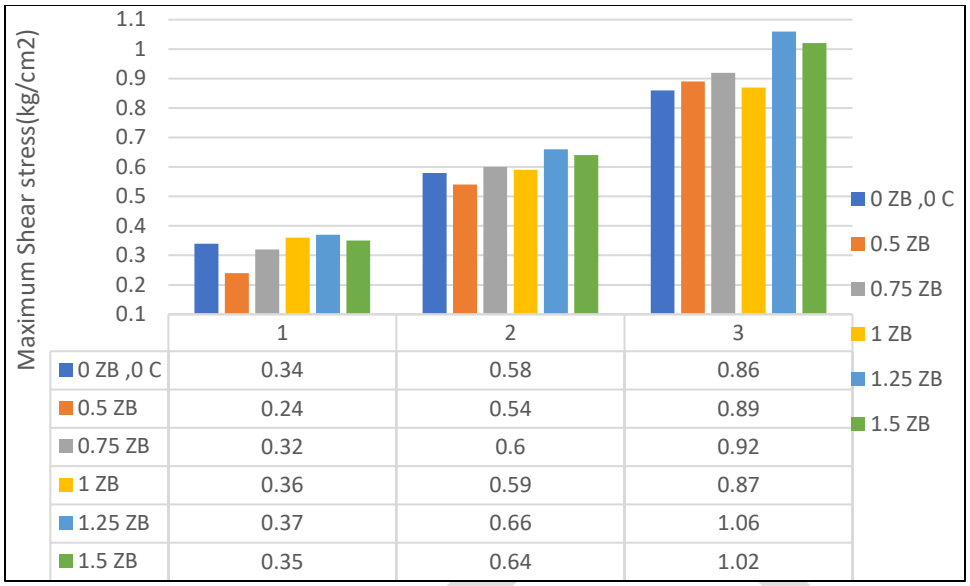



**Figure 6.20** Plot of Maximum Shear Stress vs ZB content for different cement % at1.5 kg/cm$^2$ Normal Stress

Figure 6.20 shows the maximum shear stress variation for different percentages of cement with respect to ZB doses. At constant normal stress of 1.5 kg/cm$^2$, the maximum shear stress increases with an increase in ZB proportion, reaches a maximum at 1.25 ZB, and then gradually decreases, although, for 1% and 4% cement, the optimum value of Maximum stress is attained at 1 kg/m $^3$ ZB.

Figure 6.18, Figure 6.18, and Figure 6.20 showed that the 3% cement curve attained the maximum value of shear strength among the other proportion of cement-soil-ZB samples, Thus considering 3% as the optimum percentage of cement additive, we study the variation of ZB at 3% cement in Figure 6.21 .,




| | 1 | 2 | 3 |
|---|---|---|---|
| 0 ZB ,0 C | 0.34 | 0.58 | 0.86 |
| 0.5 ZB | 0.24 | 0.54 | 0.89 |
| 0.75 ZB | 0.32 | 0.6 | 0.92 |
| 1 ZB | 0.36 | 0.59 | 0.87 |
| 1.25 ZB | 0.37 | 0.66 | 1.06 |
| 1.5 ZB | 0.35 | 0.64 | 1.02 |

**Figure 6.21**.Maximum shear stress plot for 3% cement + soil+ ZB

The bar charts marked 1,2 and 3 on the x-axis (Figure 5.84), represent tests performed at constant normal stress 0.5 kg/cm$^2$,1 kg/cm$^2$,1.5 kg/cm$^2$ respectively. At 0.5 kg/cm$^2$, the increase in shear strength is insignificant when compared with the untreated original soil sample, irrespective of the fact that 1.25 ZB marks the optimum. At 1.5kg/cm$^2$ normal stress, the results are most prominent when compared to the OS sample In a nutshell it can be stated from the comparative analysis at higher application of normal loading, at ZB dose 1.25 kg/m$^3$ and 1.5 kg/m$^3$, the shear strength is observed to increase by 23.3%.

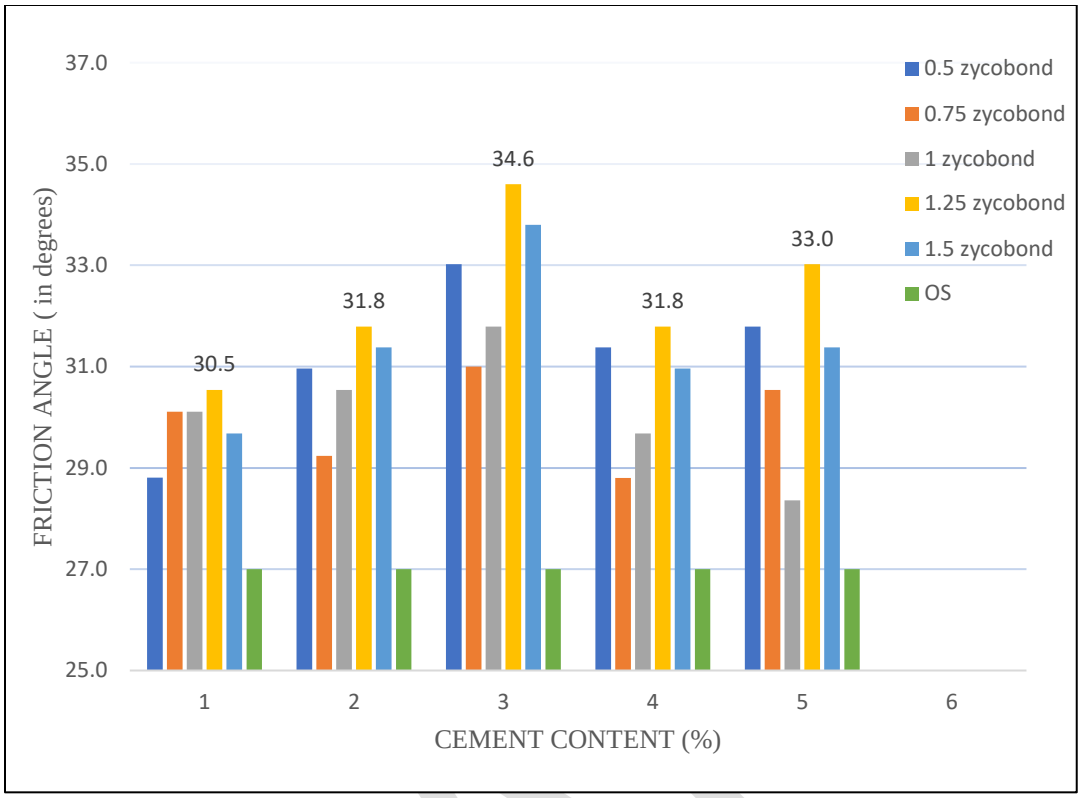



**Figure 6.22** Friction angle for soil samples at varying Zycobond and cement content

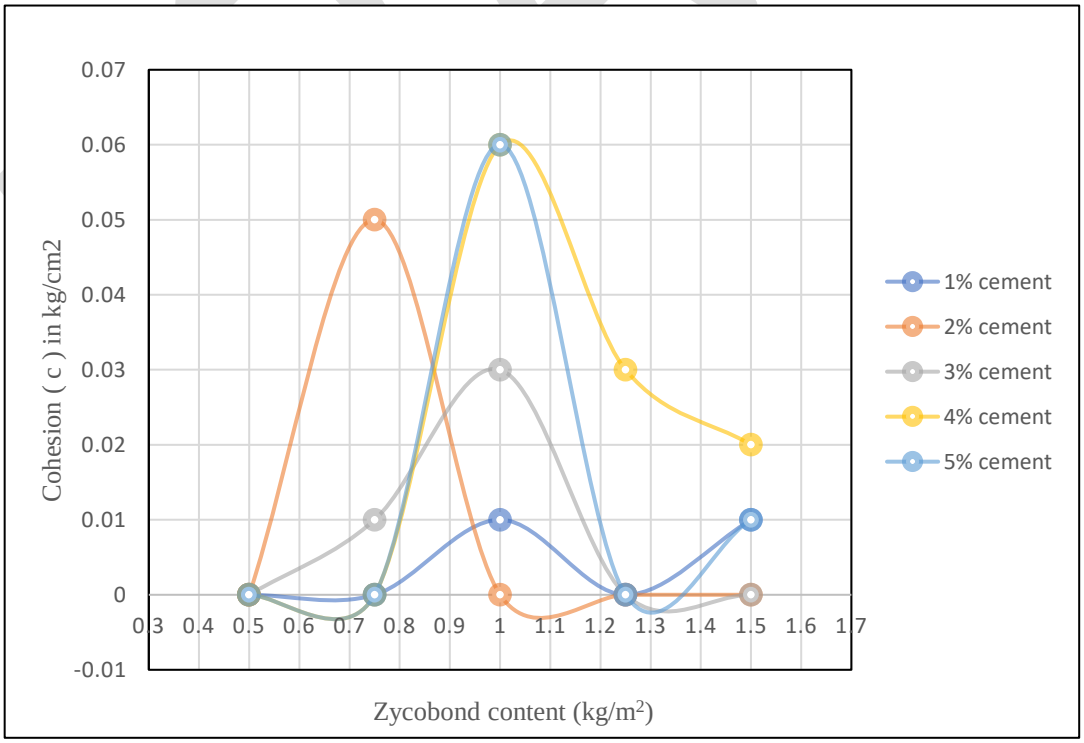



**Figure 6.23** Cohesion ( c ) for soil samples at varying Zycobond and cement content

### 6.4 Failure envelopes and shear strength parameters:

Failure envelops of chemically treated and untreated soil samples as plotted in Figures mentioned in the previous chapter obtained from the test results of the direct shear test. As shown, linear regression was employed to define shear strength parameters. Figure 6.22 shows the summarized value of φ obtained for all the soil samples. In this study not much significance of cohesion is seen, yet when the comparative analysis is done the variation could be seen as shown in Figure 6.22. In this study 'c' is determined from the graph and can be termed as Apparent Cohesion.

Figure 6.22 demonstrates variations in the internal friction angle versus cement content at different doses of ZB. The figures illustrate that the internal friction angle increases as cement content increases and then further reduces. The maximum values for φ can be seen at a cement content of 3%, the internal friction angle at 3% cement at ZB dose of 1.25 kg/m$^3$ increased by 28.2% .And c showed the best results between ZB doses 0.75 kg/m$^3$ to 1 kg/m$^3$ which aligns with the results reported by Zydex company.

### 6.5 Effect of Zycobond and Cement on Soil :

From the Shear Strength parameters obtained from experiments, it can be inferred that soil samples treated with ZB and 3% cement have a better performance compared with the corresponding untreated sandy soil. which aligns with the test findings of (Padmavati et al.,2019),

From the test analysis it is seen that with the increase in ZB content from 0.5 kg/m$^3$ to 1.5 kg/m$^3$, the shear strength is seen to increase,1.25 kg/m$^3$ being the optimum value (Gayathri & Pal,2019) in the study mentioned that soil treated with ZB, showed a maximum strength at optimum 0.8 kg/m$^3$ZB, also soil treated with ZB increased MDD by 9.5% and 24% decrease in OMC. Another study by (G. Surya Teja et al.,2022)stated that soil treated with 1.5% ZB, showed Unconfined Compressive Strength (UCS) values with a significant improvement of 29.75%.In the present study, the optimum value for ZB was found to be 1.25kg/m$^3$, with a significant improvement in shear strength of 23.25% compared to the native soil. Soil samples with 3% cement+ZB, showed an increase in the shear strength of 3.5% for 0.5 kg/m$^3$ ZB,7 % for 0.75 kg/m$^3$ ZB,13.9% for 1 kg/m$^3$ ZB, 23.25% for 1.25 kg/m$^3$ ZB and 18.6% for 1.5 kg/m$^3$ ZB. This is attributed to the fact that cement acts as a strengthening agent (Pandey and Rabbani,2017) . When added with ZB at a specific dose it chemically binds soil particles together into a flexible crosslinked network, leading

to improved load-bearing capacity and enhanced flexibility in soil bases. The higher number of contact points ensures flexible bonding at a nano level, leading to improved fatigue resistance in stabilized soils. It maintains friction values between silt, sand, and clay particles, allowing for strength and deformation resistance management. (Srivastava et al.,2016) also mentioned that the results performed using the chemical additive improved the CBR and UCS of soil. In addition, it helped to reduce the liquid limit, plasticity index, and free swell index of expansive clay soil. Thus indicating the fact the implementation of the chemical additive in different soil types has some soil-enhancing effect which has been proved through rigorous tests.

**6.6 SUMMARY**

- FS,MS,CS showed an increase in the value of the friction angle as the particle size increased slightly with not many variations
- For 1% cement+ZB,the optimum value for ZB content was found at 1 kg/$m^3$ with maximum shear strength found to increase by 3.5% with respect to the native soil and φ showed an increase by 13%
- For 2% cement+ZB,the optimum value for ZB content was found at 1.25 kg/$m^3$ .with maximum shear strength found to increase by 9.3% with respect to the native soil and φ showed an increase by 17.78%
- For 3% cement+ZB,the optimum value for ZB content was found at 1.25 kg/$m^3$ with maximum shear strength found to increase by 23.25% with respect to the native soil and φ showed an increase by 28.2%
- For 4% cement+ZB,the optimum value for ZB content was found at 1.25 kg/$m^3$ with maximum shear strength found to increase by 12% with respect to the native soil and φ showed an increase by 17.78%
- For 5% cement+ZB, the optimum value for ZB content was found at 1.25 kg/$m^3$ with maximum shear strength found to increase by 16.3% with respect to the native soil and φ showed an increase of 22%
- The cohesion showed the best results at an optimum dose between 0.75-1 kg/$m^3$,with % increase of 9 % to the original untreated soil sample
- The optimum dose of cement at which the highest shear strength is obtained is 3%
- The optimum dose of ZB at which the highest shear strength is obtained is 1.25 kg/

# CHAPTER 7
# CONCLUSIONS AND SCOPE FOR FURTHER STUDY

## 7.1 INTRODUCTION:

This chapter encapsulates the conclusions that can be drawn from the investigations performed from the Direct Shear Test results for both the untreated soil as well as for the chemically treated soil samples, Furthermore, this chapter offers insights into potential avenues for future research in the field.

## 7.2 Conclusions for shear strength characteristics of the soil samples:

a. Internal friction plays a role in affecting the shear strength of soil, internal friction angle can be dependent on particle size. Tests with larger-sized particles produced higher internal friction angles and developed high shear strength compared to the particles of lower size.
b. The maximum shear strength obtained for the treated soil samples increased with the addition of cement and Zycobond, the optimum being found at 3% cement and 1.25 kg/$m^3$ ZB
c. At 3% cement under a constant Normal stress application, the shear strength of soil is seen to increase by 3.5% for 0.5 kg/$m^3$ ZB,7 % for 0.75 kg/$m^3$ ZB,13.9% for 1 kg/$m^3$ ZB, 23.25% for 1.25 kg/$m^3$ ZB and 18.6% for 1.5 kg/$m^3$ ZB
d. The percentage increase in shear strength under the optimum ZB dose(1.25 kg/$m^3$) with cement content varied as 3.5%,9.3%,23.25%,12% and 16.3% for 1%,2%,3%,4% and 5% cement respectively. The maximum is a 23.25% increase in strength
e. Also when compared with the native original soil sample, the Friction angle (φ) indicated an increase in value from 27° to 34.6°, with an % increase of 28%.
f. The cohesion showed best results at optimum ZB dose ranging 0.75-1 kg/$m^3$, with an increase of 9%

g. From various literature and laboratory test results, it can be concluded that the chemical soil modifier Zycobond plays a significant role in altering the mechanical properties of soil, test results also indicate that soil type greatly influences the performance of this chemical soil modifier Zycobond.

### 7.3 Scope for further study:

To enhance the understanding of the shear strength properties of soils the following points should be considered for future study:

i. Future studies should investigate the Fine, medium, and coarse sand with admixtures of Zycobond and cement.

ii. Explore the combined effects of multiple additives such as Zycobond+ Terrasil + cement. Investigate interactions between different chemicals and their impact on shear strength.

iii. Conduct field experiments to validate laboratory findings. Study real-world scenarios where sandy soil is stabilized using chemical additives. Compare the results with theoretical predictions.

iv. Assess the long-term effectiveness of chemical additives. Monitor shear strength over extended periods to understand durability, aging, and environmental impacts.

v. Investigate other chemical additives beyond the ones studied so far. Consider exploring organic compounds, biopolymers, or nanomaterials to enhance shear strength.



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## Appendix A

**Table:A1** Direct Shear Test Readings for Fine Sand (FS) at 0.5kg/cm$^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| | | | | | | |
| 0 | 0 | 0 | 0 | 0.00 | 36 | 0.00 |
| 20 | 0.2 | 0.02 | 7 | 2.31 | 35.76 | 0.06 |
| 40 | 0.4 | 0.04 | 13 | 4.29 | 35.52 | 0.12 |
| 60 | 0.6 | 0.06 | 18.2 | 6.01 | 35.28 | 0.17 |
| 80 | 0.8 | 0.08 | 21 | 6.93 | 35.04 | 0.20 |
| 100 | 1 | 0.1 | 22.2 | 7.33 | 34.8 | 0.21 |
| 120 | 1.2 | 0.12 | 23.8 | 7.85 | 34.56 | 0.23 |
| 140 | 1.4 | 0.14 | 24.2 | 7.99 | 34.32 | 0.23 |
| 160 | 1.6 | 0.16 | 24.6 | 8.12 | 34.08 | 0.24 |
| 180 | 1.8 | 0.18 | 24.8 | 8.18 | 33.84 | 0.24 |
| 200 | 2 | 0.2 | 25 | 8.25 | 33.6 | 0.25 |
| 220 | 2.2 | 0.22 | 25.2 | 8.32 | 33.36 | 0.25 |
| 240 | 2.4 | 0.24 | 25.2 | 8.32 | 33.12 | 0.25 |
| 260 | 2.6 | 0.26 | 25.3 | 8.35 | 32.88 | 0.25 |
| 280 | 2.8 | 0.28 | 25.4 | 8.38 | 32.64 | 0.26 |
| 300 | 3 | 0.3 | 25.4 | 8.38 | 32.4 | 0.26 |
| 320 | 3.2 | 0.32 | 25.4 | 8.38 | 32.16 | 0.26 |
| 340 | 3.4 | 0.34 | 25.2 | 8.32 | 31.92 | 0.26 |
| 360 | 3.6 | 0.36 | 25.1 | 8.28 | 31.68 | 0.26 |
| 380 | 3.8 | 0.38 | 25 | 8.25 | 31.44 | 0.26 |
| 400 | 4 | 0.4 | 24.8 | 8.18 | 31.2 | 0.26 |
| 420 | 4.2 | 0.42 | 24.4 | 8.05 | 30.96 | 0.26 |
| 440 | 4.4 | 0.44 | 24.3 | 8.02 | 30.72 | 0.26 |
| 460 | 4.6 | 0.46 | 24.1 | 7.95 | 30.48 | 0.26 |
| 480 | 4.8 | 0.48 | 24 | 7.92 | 30.24 | 0.26 |
| 500 | 5 | 0.5 | 24 | 7.92 | 30 | 0.26 |
| 520 | 5.2 | 0.52 | 23.8 | 7.85 | 29.76 | 0.26 |
| 540 | 5.4 | 0.54 | 23.6 | 7.79 | 29.52 | 0.26 |
| 560 | 5.6 | 0.56 | 23.4 | 7.72 | 29.28 | 0.26 |
| 580 | 5.8 | 0.58 | 23.1 | 7.62 | 29.04 | 0.26 |
| 600 | 6 | 0.6 | 23.1 | 7.62 | 28.8 | 0.26 |
| 620 | 6.2 | 0.62 | 23 | 7.59 | 28.56 | 0.27 |
| 640 | 6.4 | 0.64 | 22.8 | 7.52 | 28.32 | 0.27 |
| 660 | 6.6 | 0.66 | 22.6 | 7.46 | 28.08 | 0.27 |
| 680 | 6.8 | 0.68 | 22.4 | 7.39 | 27.84 | 0.27 |
| 700 | 7 | 0.7 | 22.3 | 7.36 | 27.6 | 0.27 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 720 | 7.2 | 0.72 | 22.2 | 7.33 | 27.36 | 0.27 |
| 740 | 7.4 | 0.74 | 22.2 | 7.33 | 27.12 | 0.27 |
| 760 | 7.6 | 0.76 | 22.3 | 7.36 | 26.88 | 0.27 |
| 780 | 7.8 | 0.78 | 22.3 | 7.36 | 26.64 | 0.28 |
| 800 | 8 | 0.8 | 22.3 | 7.36 | 26.4 | 0.28 |
| 820 | 8.2 | 0.82 | 22.4 | 7.39 | 26.16 | 0.28 |
| 840 | 8.4 | 0.84 | 22.2 | 7.33 | 25.92 | 0.28 |
| 860 | 8.6 | 0.86 | 22.3 | 7.36 | 25.68 | 0.29 |
| 880 | 8.8 | 0.88 | 22.3 | 7.36 | 25.44 | 0.29 |
| 900 | 9 | 0.9 | 22.3 | 7.36 | 25.2 | 0.29 |
| 920 | 9.2 | 0.92 | 22.4 | 7.39 | 24.96 | 0.30 |
| 940 | 9.4 | 0.94 | 22.3 | 7.36 | 24.72 | 0.30 |
| 960 | 9.6 | 0.96 | 22.3 | 7.36 | 24.48 | 0.30 |
| 980 | 9.8 | 0.98 | 22.3 | 7.36 | 24.24 | 0.30 |
| 1000 | 10 | 1 | 22.3 | 7.36 | 24 | 0.31 |
| 1020 | 10.2 | 1.02 | 22.3 | 7.36 | 23.76 | 0.31 |
| 1040 | 10.4 | 1.04 | 22.3 | 7.36 | 23.52 | 0.31 |
| 1060 | 10.6 | 1.06 | 22.3 | 7.36 | 23.28 | 0.32 |
| 1080 | 10.8 | 1.08 | 22.3 | 7.36 | 23.04 | 0.32 |
| 1100 | 11 | 1.1 | 22.2 | 7.33 | 22.8 | 0.32 |
| 1120 | 11.2 | 1.12 | 22.2 | 7.33 | 22.56 | 0.32 |
| 1140 | 11.4 | 1.14 | 22.2 | 7.33 | 22.32 | 0.33 |
| 1160 | 11.6 | 1.16 | 22 | 7.26 | 22.08 | 0.33 |
| 1180 | 11.8 | 1.18 | 21.8 | 7.19 | 21.84 | 0.33 |
| 1200 | 12 | 1.2 | 21.6 | 7.13 | 21.6 | 0.33 |

**Table:A2** Direct Shear Test Readings for Fine Sand (FS) at 1.0 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0 | 0.00 | 36 | 0.00 |
| 20 | 0.2 | 0.02 | 10.8 | 3.56 | 35.76 | 0.10 |
| 40 | 0.4 | 0.04 | 19.8 | 6.53 | 35.52 | 0.18 |
| 60 | 0.6 | 0.06 | 25 | 8.25 | 35.28 | 0.23 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 80 | 0.8 | 0.08 | 29.2 | 9.64 | 35.04 | 0.28 |
| 100 | 1 | 0.1 | 35 | 11.55 | 34.8 | 0.33 |
| 120 | 1.2 | 0.12 | 36.2 | 11.95 | 34.56 | 0.35 |
| 140 | 1.4 | 0.14 | 38.2 | 12.61 | 34.32 | 0.37 |
| 160 | 1.6 | 0.16 | 40.8 | 13.46 | 34.08 | 0.40 |
| 180 | 1.8 | 0.18 | 41.4 | 13.66 | 33.84 | 0.40 |
| 200 | 2 | 0.2 | 41.8 | 13.79 | 33.6 | 0.41 |
| 220 | 2.2 | 0.22 | 41.8 | 13.79 | 33.36 | 0.41 |
| 240 | 2.4 | 0.24 | 41.7 | 13.76 | 33.12 | 0.42 |
| 260 | 2.6 | 0.26 | 41.8 | 13.79 | 32.88 | 0.42 |
| 280 | 2.8 | 0.28 | 41.6 | 13.73 | 32.64 | 0.42 |
| 300 | 3 | 0.3 | 41.8 | 13.79 | 32.4 | 0.43 |
| 320 | 3.2 | 0.32 | 41.8 | 13.79 | 32.16 | 0.43 |
| 340 | 3.4 | 0.34 | 41.4 | 13.66 | 31.92 | 0.43 |
| 360 | 3.6 | 0.36 | 41.2 | 13.60 | 31.68 | 0.43 |
| 380 | 3.8 | 0.38 | 40.6 | 13.40 | 31.44 | 0.43 |
| 400 | 4 | 0.4 | 39.8 | 13.13 | 31.2 | 0.42 |
| 420 | 4.2 | 0.42 | 39.6 | 13.07 | 30.96 | 0.42 |
| 440 | 4.4 | 0.44 | 38.8 | 12.80 | 30.72 | 0.42 |
| 460 | 4.6 | 0.46 | 38.2 | 12.61 | 30.48 | 0.41 |
| 480 | 4.8 | 0.48 | 38 | 12.54 | 30.24 | 0.41 |
| 500 | 5 | 0.5 | 37.8 | 12.47 | 30 | 0.42 |
| 520 | 5.2 | 0.52 | 37.6 | 12.41 | 29.76 | 0.42 |
| 540 | 5.4 | 0.54 | 37.2 | 12.28 | 29.52 | 0.42 |
| 560 | 5.6 | 0.56 | 37 | 12.21 | 29.28 | 0.42 |
| 580 | 5.8 | 0.58 | 36.8 | 12.14 | 29.04 | 0.42 |
| 600 | 6 | 0.6 | 36.6 | 12.08 | 28.8 | 0.42 |
| 620 | 6.2 | 0.62 | 36.6 | 12.08 | 28.56 | 0.42 |
| 640 | 6.4 | 0.64 | 36.4 | 12.01 | 28.32 | 0.42 |
| 660 | 6.6 | 0.66 | 36.4 | 12.01 | 28.08 | 0.43 |
| 680 | 6.8 | 0.68 | 36.2 | 11.95 | 27.84 | 0.43 |
| 700 | 7 | 0.7 | 36.2 | 11.95 | 27.6 | 0.43 |
| 720 | 7.2 | 0.72 | 36.2 | 11.95 | 27.36 | 0.44 |
| 740 | 7.4 | 0.74 | 36.3 | 11.98 | 27.12 | 0.44 |
| 760 | 7.6 | 0.76 | 36.2 | 11.95 | 26.88 | 0.44 |
| 780 | 7.8 | 0.78 | 36.2 | 11.95 | 26.64 | 0.45 |
| 800 | 8 | 0.8 | 36.2 | 11.95 | 26.4 | 0.45 |
| 820 | 8.2 | 0.82 | 36.2 | 11.95 | 26.16 | 0.46 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 840 | 8.4 | 0.84 | 36.2 | 11.95 | 25.92 | 0.46 |
| 860 | 8.6 | 0.86 | 36.2 | 11.95 | 25.68 | 0.47 |
| 880 | 8.8 | 0.88 | 36.3 | 11.98 | 25.44 | 0.47 |
| 900 | 9 | 0.9 | 36.4 | 12.01 | 25.2 | 0.48 |
| 920 | 9.2 | 0.92 | 36.3 | 11.98 | 24.96 | 0.48 |
| 940 | 9.4 | 0.94 | 36.3 | 11.98 | 24.72 | 0.48 |
| 960 | 9.6 | 0.96 | 36.4 | 12.01 | 24.48 | 0.49 |
| 980 | 9.8 | 0.98 | 36.3 | 11.98 | 24.24 | 0.49 |
| 1000 | 10 | 1 | 36.3 | 11.98 | 24 | 0.50 |
| 1020 | 10.2 | 1.02 | 36.2 | 11.95 | 23.76 | 0.50 |
| 1040 | 10.4 | 1.04 | 36.2 | 11.95 | 23.52 | 0.51 |
| 1060 | 10.6 | 1.06 | 36.1 | 11.91 | 23.28 | 0.51 |
| 1080 | 10.8 | 1.08 | 36.1 | 11.91 | 23.04 | 0.52 |
| 1100 | 11 | 1.1 | 36 | 11.88 | 22.8 | 0.52 |
| 1120 | 11.2 | 1.12 | 36 | 11.88 | 22.56 | 0.53 |
| 1140 | 11.4 | 1.14 | 36 | 11.88 | 22.32 | 0.53 |
| 1160 | 11.6 | 1.16 | 35.9 | 11.85 | 22.08 | 0.54 |
| 1180 | 11.8 | 1.18 | 35.8 | 11.81 | 21.84 | 0.54 |
| 1200 | 12 | 1.2 | 35.6 | 11.75 | 21.6 | 0.54 |

**Table:A3** Direct Shear Test Readings for Fine Sand (FS) at 1.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0 | 0.00 | 36 | 0.00 |
| 20 | 0.2 | 0.02 | 15.2 | 5.02 | 35.76 | 0.14 |
| 40 | 0.4 | 0.04 | 28 | 9.24 | 35.52 | 0.26 |
| 60 | 0.6 | 0.06 | 36 | 11.88 | 35.28 | 0.34 |
| 80 | 0.8 | 0.08 | 42 | 13.86 | 35.04 | 0.40 |
| 100 | 1 | 0.1 | 50 | 16.50 | 34.8 | 0.47 |
| 120 | 1.2 | 0.12 | 56 | 18.48 | 34.56 | 0.53 |
| 140 | 1.4 | 0.14 | 58.8 | 19.40 | 34.32 | 0.57 |
| 160 | 1.6 | 0.16 | 60.4 | 19.93 | 34.08 | 0.58 |
| 180 | 1.8 | 0.18 | 62.2 | 20.53 | 33.84 | 0.61 |
| 200 | 2 | 0.2 | 63 | 20.79 | 33.6 | 0.62 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 220 | 2.2 | 0.22 | 62.8 | 20.72 | 33.36 | 0.62 |
| 240 | 2.4 | 0.24 | 62.4 | 20.59 | 33.12 | 0.62 |
| 260 | 2.6 | 0.26 | 61.6 | 20.33 | 32.88 | 0.62 |
| 280 | 2.8 | 0.28 | 60.4 | 19.93 | 32.64 | 0.61 |
| 300 | 3 | 0.3 | 59.4 | 19.60 | 32.4 | 0.61 |
| 320 | 3.2 | 0.32 | 58.4 | 19.27 | 32.16 | 0.60 |
| 340 | 3.4 | 0.34 | 57.2 | 18.88 | 31.92 | 0.59 |
| 360 | 3.6 | 0.36 | 56.6 | 18.68 | 31.68 | 0.59 |
| 380 | 3.8 | 0.38 | 56.2 | 18.55 | 31.44 | 0.59 |
| 400 | 4 | 0.4 | 55.7 | 18.38 | 31.2 | 0.59 |
| 420 | 4.2 | 0.42 | 55.6 | 18.35 | 30.96 | 0.59 |
| 440 | 4.4 | 0.44 | 55.6 | 18.35 | 30.72 | 0.60 |
| 460 | 4.6 | 0.46 | 55.6 | 18.35 | 30.48 | 0.60 |
| 480 | 4.8 | 0.48 | 55.7 | 18.38 | 30.24 | 0.61 |
| 500 | 5 | 0.5 | 55.8 | 18.41 | 30 | 0.61 |
| 520 | 5.2 | 0.52 | 56 | 18.48 | 29.76 | 0.62 |
| 540 | 5.4 | 0.54 | 56.4 | 18.61 | 29.52 | 0.63 |
| 560 | 5.6 | 0.56 | 56.4 | 18.61 | 29.28 | 0.64 |
| 580 | 5.8 | 0.58 | 56.6 | 18.68 | 29.04 | 0.64 |
| 600 | 6 | 0.6 | 56.8 | 18.74 | 28.8 | 0.65 |
| 620 | 6.2 | 0.62 | 56.8 | 18.74 | 28.56 | 0.66 |
| 640 | 6.4 | 0.64 | 57 | 18.81 | 28.32 | 0.66 |
| 660 | 6.6 | 0.66 | 57 | 18.81 | 28.08 | 0.67 |
| 680 | 6.8 | 0.68 | 57 | 18.81 | 27.84 | 0.68 |
| 700 | 7 | 0.7 | 57 | 18.81 | 27.6 | 0.68 |
| 720 | 7.2 | 0.72 | 57.2 | 18.88 | 27.36 | 0.69 |
| 740 | 7.4 | 0.74 | 57.3 | 18.91 | 27.12 | 0.70 |
| 760 | 7.6 | 0.76 | 57.1 | 18.84 | 26.88 | 0.70 |
| 780 | 7.8 | 0.78 | 57.3 | 18.91 | 26.64 | 0.71 |
| 800 | 8 | 0.8 | 57.2 | 18.88 | 26.4 | 0.72 |
| 820 | 8.2 | 0.82 | 57.2 | 18.88 | 26.16 | 0.72 |
| 840 | 8.4 | 0.84 | 57.1 | 18.84 | 25.92 | 0.73 |
| 860 | 8.6 | 0.86 | 57 | 18.81 | 25.68 | 0.73 |
| 880 | 8.8 | 0.88 | 57.1 | 18.84 | 25.44 | 0.74 |
| 900 | 9 | 0.9 | 57.2 | 18.88 | 25.2 | 0.75 |
| 920 | 9.2 | 0.92 | 57 | 18.81 | 24.96 | 0.75 |
| 940 | 9.4 | 0.94 | 57 | 18.81 | 24.72 | 0.76 |
| 960 | 9.6 | 0.96 | 57 | 18.81 | 24.48 | 0.77 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 980 | 9.8 | 0.98 | 56.8 | 18.74 | 24.24 | 0.77 |
| 1000 | 10 | 1 | 56.8 | 18.74 | 24 | 0.78 |
| 1020 | 10.2 | 1.02 | 56.6 | 18.68 | 23.76 | 0.79 |
| 1040 | 10.4 | 1.04 | 56.6 | 18.68 | 23.52 | 0.79 |
| 1060 | 10.6 | 1.06 | 56.6 | 18.68 | 23.28 | 0.80 |
| 1080 | 10.8 | 1.08 | 56.6 | 18.68 | 23.04 | 0.81 |
| 1100 | 11 | 1.1 | 56.6 | 18.68 | 22.8 | 0.82 |
| 1120 | 11.2 | 1.12 | 56.6 | 18.68 | 22.56 | 0.83 |
| 1140 | 11.4 | 1.14 | 56.6 | 18.68 | 22.32 | 0.84 |
| 1160 | 11.6 | 1.16 | 56.6 | 18.68 | 22.08 | 0.85 |
| 1180 | 11.8 | 1.18 | 56.5 | 18.65 | 21.84 | 0.85 |
| 1200 | 12 | 1.2 | 56.4 | 18.61 | 21.6 | 0.86 |

**Table:A4** Direct Shear Test Readings for Medium Sand (MS) at 0.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0 | 0.00 | 36 | 0.00 |
| 20 | 0.2 | 0.02 | 9 | 2.97 | 35.76 | 0.08 |
| 40 | 0.4 | 0.04 | 16 | 5.28 | 35.52 | 0.15 |
| 60 | 0.6 | 0.06 | 22 | 7.26 | 35.28 | 0.21 |
| 80 | 0.8 | 0.08 | 24.2 | 7.99 | 35.04 | 0.23 |
| 100 | 1 | 0.1 | 26 | 8.58 | 34.8 | 0.25 |
| 120 | 1.2 | 0.12 | 27.2 | 8.98 | 34.56 | 0.26 |
| 140 | 1.4 | 0.14 | 28 | 9.24 | 34.32 | 0.27 |
| 160 | 1.6 | 0.16 | 29.2 | 9.64 | 34.08 | 0.28 |
| 180 | 1.8 | 0.18 | 29 | 9.57 | 33.84 | 0.28 |
| 200 | 2 | 0.2 | 29.1 | 9.60 | 33.6 | 0.29 |
| 220 | 2.2 | 0.22 | 29 | 9.57 | 33.36 | 0.29 |
| 240 | 2.4 | 0.24 | 29 | 9.57 | 33.12 | 0.29 |
| 260 | 2.6 | 0.26 | 28.4 | 9.37 | 32.88 | 0.29 |
| 280 | 2.8 | 0.28 | 28.2 | 9.31 | 32.64 | 0.29 |
| 300 | 3 | 0.3 | 27.8 | 9.17 | 32.4 | 0.28 |
| 320 | 3.2 | 0.32 | 27.4 | 9.04 | 32.16 | 0.28 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 340 | 3.4 | 0.34 | 26.8 | 8.84 | 31.92 | 0.28 |
| 360 | 3.6 | 0.36 | 26.4 | 8.71 | 31.68 | 0.28 |
| 380 | 3.8 | 0.38 | 26.2 | 8.65 | 31.44 | 0.28 |
| 400 | 4 | 0.4 | 25.8 | 8.51 | 31.2 | 0.27 |
| 420 | 4.2 | 0.42 | 25 | 8.25 | 30.96 | 0.27 |
| 440 | 4.4 | 0.44 | 25 | 8.25 | 30.72 | 0.27 |
| 460 | 4.6 | 0.46 | 24.4 | 8.05 | 30.48 | 0.26 |
| 480 | 4.8 | 0.48 | 24.2 | 7.99 | 30.24 | 0.26 |
| 500 | 5 | 0.5 | 23.8 | 7.85 | 30 | 0.26 |
| 520 | 5.2 | 0.52 | 23.8 | 7.85 | 29.76 | 0.26 |
| 540 | 5.4 | 0.54 | 23.6 | 7.79 | 29.52 | 0.26 |
| 560 | 5.6 | 0.56 | 23.6 | 7.79 | 29.28 | 0.27 |
| 580 | 5.8 | 0.58 | 23.8 | 7.85 | 29.04 | 0.27 |
| 600 | 6 | 0.6 | 23.4 | 7.72 | 28.8 | 0.27 |
| 620 | 6.2 | 0.62 | 23.5 | 7.76 | 28.56 | 0.27 |
| 640 | 6.4 | 0.64 | 23.5 | 7.76 | 28.32 | 0.27 |
| 660 | 6.6 | 0.66 | 23.2 | 7.66 | 28.08 | 0.27 |
| 680 | 6.8 | 0.68 | 23.4 | 7.72 | 27.84 | 0.28 |
| 700 | 7 | 0.7 | 23.4 | 7.72 | 27.6 | 0.28 |
| 720 | 7.2 | 0.72 | 23.5 | 7.76 | 27.36 | 0.28 |
| 740 | 7.4 | 0.74 | 23.4 | 7.72 | 27.12 | 0.28 |
| 760 | 7.6 | 0.76 | 24 | 7.92 | 26.88 | 0.29 |
| 780 | 7.8 | 0.78 | 23.8 | 7.85 | 26.64 | 0.29 |
| 800 | 8 | 0.8 | 23.4 | 7.72 | 26.4 | 0.29 |
| 820 | 8.2 | 0.82 | 23.6 | 7.79 | 26.16 | 0.30 |
| 840 | 8.4 | 0.84 | 23.8 | 7.85 | 25.92 | 0.30 |
| 860 | 8.6 | 0.86 | 23.7 | 7.82 | 25.68 | 0.30 |
| 880 | 8.8 | 0.88 | 23.6 | 7.79 | 25.44 | 0.31 |
| 900 | 9 | 0.9 | 23.6 | 7.79 | 25.2 | 0.31 |
| 920 | 9.2 | 0.92 | 23.4 | 7.72 | 24.96 | 0.31 |
| 940 | 9.4 | 0.94 | 23 | 7.59 | 24.72 | 0.31 |
| 960 | 9.6 | 0.96 | 23.2 | 7.66 | 24.48 | 0.31 |
| 980 | 9.8 | 0.98 | 23.2 | 7.66 | 24.24 | 0.32 |
| 1000 | 10 | 1 | 23.2 | 7.66 | 24 | 0.32 |
| 1020 | 10.2 | 1.02 | 23.2 | 7.66 | 23.76 | 0.32 |
| 1040 | 10.4 | 1.04 | 23 | 7.59 | 23.52 | 0.32 |
| 1060 | 10.6 | 1.06 | 23 | 7.59 | 23.28 | 0.33 |
| 1080 | 10.8 | 1.08 | 23.8 | 7.85 | 23.04 | 0.34 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 1100 | 11 | 1.1 | 23.2 | 7.66 | 22.8 | 0.34 |
| 1120 | 11.2 | 1.12 | 23.4 | 7.72 | 22.56 | 0.34 |
| 1140 | 11.4 | 1.14 | 23.8 | 7.85 | 22.32 | 0.35 |
| 1160 | 11.6 | 1.16 | 23.8 | 7.85 | 22.08 | 0.36 |
| 1180 | 11.8 | 1.18 | 23.6 | 7.79 | 21.84 | 0.36 |
| 1200 | 12 | 1.2 | 23.4 | 7.72 | 21.6 | 0.36 |
| 1220 | 12.2 | 1.22 | 23.2 | 7.66 | 21.36 | 0.36 |
| 1240 | 12.4 | 1.24 | 23 | 7.59 | 21.12 | 0.36 |

**Table: A5** Direct Shear Test Readings for Medium Sand (MS) at 1.0 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0 | 0.00 | 36 | 0.00 |
| 20 | 0.2 | 0.02 | 29 | 9.57 | 35.76 | 0.27 |
| 40 | 0.4 | 0.04 | 33.2 | 10.96 | 35.52 | 0.31 |
| 60 | 0.6 | 0.06 | 36 | 11.88 | 35.28 | 0.34 |
| 80 | 0.8 | 0.08 | 38 | 12.54 | 35.04 | 0.36 |
| 100 | 1 | 0.1 | 39.8 | 13.13 | 34.8 | 0.38 |
| 120 | 1.2 | 0.12 | 40.8 | 13.46 | 34.56 | 0.39 |
| 140 | 1.4 | 0.14 | 42.2 | 13.93 | 34.32 | 0.41 |
| 160 | 1.6 | 0.16 | 43.4 | 14.32 | 34.08 | 0.42 |
| 180 | 1.8 | 0.18 | 43.8 | 14.45 | 33.84 | 0.43 |
| 200 | 2 | 0.2 | 44.6 | 14.72 | 33.6 | 0.44 |
| 220 | 2.2 | 0.22 | 45.2 | 14.92 | 33.36 | 0.45 |
| 240 | 2.4 | 0.24 | 46 | 15.18 | 33.12 | 0.46 |
| 260 | 2.6 | 0.26 | 46.2 | 15.25 | 32.88 | 0.46 |
| 280 | 2.8 | 0.28 | 46.4 | 15.31 | 32.64 | 0.47 |
| 300 | 3 | 0.3 | 46.4 | 15.31 | 32.4 | 0.47 |
| 320 | 3.2 | 0.32 | 46.4 | 15.31 | 32.16 | 0.48 |
| 340 | 3.4 | 0.34 | 46.2 | 15.25 | 31.92 | 0.48 |
| 360 | 3.6 | 0.36 | 46 | 15.18 | 31.68 | 0.48 |
| 380 | 3.8 | 0.38 | 45.8 | 15.11 | 31.44 | 0.48 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 400 | 4 | 0.4 | 45 | 14.85 | 31.2 | 0.48 |
| 420 | 4.2 | 0.42 | 44.8 | 14.78 | 30.96 | 0.48 |
| 440 | 4.4 | 0.44 | 44.6 | 14.72 | 30.72 | 0.48 |
| 460 | 4.6 | 0.46 | 44.2 | 14.59 | 30.48 | 0.48 |
| 480 | 4.8 | 0.48 | 43.6 | 14.39 | 30.24 | 0.48 |
| 500 | 5 | 0.5 | 43.6 | 14.39 | 30 | 0.48 |
| 520 | 5.2 | 0.52 | 43.6 | 14.39 | 29.76 | 0.48 |
| 540 | 5.4 | 0.54 | 43.4 | 14.32 | 29.52 | 0.49 |
| 560 | 5.6 | 0.56 | 43 | 14.19 | 29.28 | 0.48 |
| 580 | 5.8 | 0.58 | 43 | 14.19 | 29.04 | 0.49 |
| 600 | 6 | 0.6 | 43 | 14.19 | 28.8 | 0.49 |
| 620 | 6.2 | 0.62 | 42.8 | 14.12 | 28.56 | 0.49 |
| 640 | 6.4 | 0.64 | 41.4 | 13.66 | 28.32 | 0.48 |
| 660 | 6.6 | 0.66 | 41.2 | 13.60 | 28.08 | 0.48 |
| 680 | 6.8 | 0.68 | 41 | 13.53 | 27.84 | 0.49 |
| 700 | 7 | 0.7 | 40.6 | 13.40 | 27.6 | 0.49 |
| 720 | 7.2 | 0.72 | 41 | 13.53 | 27.36 | 0.49 |
| 740 | 7.4 | 0.74 | 41 | 13.53 | 27.12 | 0.50 |
| 760 | 7.6 | 0.76 | 40.8 | 13.46 | 26.88 | 0.50 |
| 780 | 7.8 | 0.78 | 40.6 | 13.40 | 26.64 | 0.50 |
| 800 | 8 | 0.8 | 40.4 | 13.33 | 26.4 | 0.51 |
| 820 | 8.2 | 0.82 | 40.3 | 13.30 | 26.16 | 0.51 |
| 840 | 8.4 | 0.84 | 40.2 | 13.27 | 25.92 | 0.51 |
| 860 | 8.6 | 0.86 | 39.8 | 13.13 | 25.68 | 0.51 |
| 880 | 8.8 | 0.88 | 39.8 | 13.13 | 25.44 | 0.52 |
| 900 | 9 | 0.9 | 39.8 | 13.13 | 25.2 | 0.52 |
| 920 | 9.2 | 0.92 | 39.8 | 13.13 | 24.96 | 0.53 |
| 940 | 9.4 | 0.94 | 39.6 | 13.07 | 24.72 | 0.53 |
| 960 | 9.6 | 0.96 | 39.4 | 13.00 | 24.48 | 0.53 |
| 980 | 9.8 | 0.98 | 39.4 | 13.00 | 24.24 | 0.54 |
| 1000 | 10 | 1 | 39 | 12.87 | 24 | 0.54 |
| 1020 | 10.2 | 1.02 | 39.2 | 12.94 | 23.76 | 0.54 |
| 1040 | 10.4 | 1.04 | 39.4 | 13.00 | 23.52 | 0.55 |
| 1060 | 10.6 | 1.06 | 39 | 12.87 | 23.28 | 0.55 |
| 1080 | 10.8 | 1.08 | 39 | 12.87 | 23.04 | 0.56 |
| 1100 | 11 | 1.1 | 38.8 | 12.80 | 22.8 | 0.56 |
| 1120 | 11.2 | 1.12 | 38.9 | 12.84 | 22.56 | 0.57 |
| 1140 | 11.4 | 1.14 | 38.9 | 12.84 | 22.32 | 0.58 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 1160 | 11.6 | 1.16 | 38.8 | 12.80 | 22.08 | 0.58 |
| 1180 | 11.8 | 1.18 | 38.8 | 12.80 | 21.84 | 0.59 |
| 1200 | 12 | 1.2 | 38.8 | 12.80 | 21.6 | 0.59 |
| 1220 | 12.2 | 1.22 | 38.6 | 12.74 | 21.36 | 0.60 |
| 1240 | 12.4 | 1.24 | 38.6 | 12.74 | 21.12 | 0.60 |

**Table: A6** Direct Shear Test Readings for Medium Sand (MS) at 1.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0 | 0.00 | 36 | 0.00 |
| 0 | 0 | 0 | 0 | 0.00 | 36 | 0.00 |
| 20 | 0.2 | 0.02 | 16.4 | 5.41 | 35.76 | 0.15 |
| 40 | 0.4 | 0.04 | 28 | 9.24 | 35.52 | 0.26 |
| 60 | 0.6 | 0.06 | 38.2 | 12.61 | 35.28 | 0.36 |
| 80 | 0.8 | 0.08 | 48.6 | 16.04 | 35.04 | 0.46 |
| 100 | 1 | 0.1 | 56 | 18.48 | 34.8 | 0.53 |
| 120 | 1.2 | 0.12 | 60 | 19.80 | 34.56 | 0.57 |
| 140 | 1.4 | 0.14 | 62.2 | 20.53 | 34.32 | 0.60 |
| 160 | 1.6 | 0.16 | 65.2 | 21.52 | 34.08 | 0.63 |
| 180 | 1.8 | 0.18 | 66.2 | 21.85 | 33.84 | 0.65 |
| 200 | 2 | 0.2 | 66.8 | 22.04 | 33.6 | 0.66 |
| 220 | 2.2 | 0.22 | 67.4 | 22.24 | 33.36 | 0.67 |
| 240 | 2.4 | 0.24 | 67.4 | 22.24 | 33.12 | 0.67 |
| 260 | 2.6 | 0.26 | 68 | 22.44 | 32.88 | 0.68 |
| 280 | 2.8 | 0.28 | 68.2 | 22.51 | 32.64 | 0.69 |
| 300 | 3 | 0.3 | 68.6 | 22.64 | 32.4 | 0.70 |
| 320 | 3.2 | 0.32 | 68.2 | 22.51 | 32.16 | 0.70 |
| 340 | 3.4 | 0.34 | 68 | 22.44 | 31.92 | 0.70 |
| 360 | 3.6 | 0.36 | 67.8 | 22.37 | 31.68 | 0.71 |
| 380 | 3.8 | 0.38 | 66.8 | 22.04 | 31.44 | 0.70 |
| 400 | 4 | 0.4 | 65.6 | 21.65 | 31.2 | 0.69 |
| 420 | 4.2 | 0.42 | 65 | 21.45 | 30.96 | 0.69 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 440 | 4.4 | 0.44 | 64 | 21.12 | 30.72 | 0.69 |
| 460 | 4.6 | 0.46 | 63.4 | 20.92 | 30.48 | 0.69 |
| 480 | 4.8 | 0.48 | 62.4 | 20.59 | 30.24 | 0.68 |
| 500 | 5 | 0.5 | 62.6 | 20.66 | 30 | 0.69 |
| 520 | 5.2 | 0.52 | 62.2 | 20.53 | 29.76 | 0.69 |
| 540 | 5.4 | 0.54 | 62.2 | 20.53 | 29.52 | 0.70 |
| 560 | 5.6 | 0.56 | 62.2 | 20.53 | 29.28 | 0.70 |
| 580 | 5.8 | 0.58 | 62 | 20.46 | 29.04 | 0.70 |
| 600 | 6 | 0.6 | 62 | 20.46 | 28.8 | 0.71 |
| 620 | 6.2 | 0.62 | 62 | 20.46 | 28.56 | 0.72 |
| 640 | 6.4 | 0.64 | 62 | 20.46 | 28.32 | 0.72 |
| 660 | 6.6 | 0.66 | 61.4 | 20.26 | 28.08 | 0.72 |
| 680 | 6.8 | 0.68 | 61.6 | 20.33 | 27.84 | 0.73 |
| 700 | 7 | 0.7 | 60 | 19.80 | 27.6 | 0.72 |
| 720 | 7.2 | 0.72 | 59.6 | 19.67 | 27.36 | 0.72 |
| 740 | 7.4 | 0.74 | 59 | 19.47 | 27.12 | 0.72 |
| 760 | 7.6 | 0.76 | 59.6 | 19.67 | 26.88 | 0.73 |
| 780 | 7.8 | 0.78 | 59.8 | 19.73 | 26.64 | 0.74 |
| 800 | 8 | 0.8 | 59.6 | 19.67 | 26.4 | 0.75 |
| 820 | 8.2 | 0.82 | 59.9 | 19.77 | 26.16 | 0.76 |
| 840 | 8.4 | 0.84 | 59.6 | 19.67 | 25.92 | 0.76 |
| 860 | 8.6 | 0.86 | 59.4 | 19.60 | 25.68 | 0.76 |
| 880 | 8.8 | 0.88 | 58 | 19.14 | 25.44 | 0.75 |
| 900 | 9 | 0.9 | 58.6 | 19.34 | 25.2 | 0.77 |
| 920 | 9.2 | 0.92 | 58.8 | 19.40 | 24.96 | 0.78 |
| 940 | 9.4 | 0.94 | 59 | 19.47 | 24.72 | 0.79 |
| 960 | 9.6 | 0.96 | 59 | 19.47 | 24.48 | 0.80 |
| 980 | 9.8 | 0.98 | 59.2 | 19.54 | 24.24 | 0.81 |
| 1000 | 10 | 1 | 58.8 | 19.40 | 24 | 0.81 |
| 1020 | 10.2 | 1.02 | 58.8 | 19.40 | 23.76 | 0.82 |
| 1040 | 10.4 | 1.04 | 58.8 | 19.40 | 23.52 | 0.82 |
| 1060 | 10.6 | 1.06 | 59 | 19.47 | 23.28 | 0.84 |
| 1080 | 10.8 | 1.08 | 59.1 | 19.50 | 23.04 | 0.85 |
| 1100 | 11 | 1.1 | 59 | 19.47 | 22.8 | 0.85 |
| 1120 | 11.2 | 1.12 | 59 | 19.47 | 22.56 | 0.86 |
| 1140 | 11.4 | 1.14 | 59 | 19.47 | 22.32 | 0.87 |
| 1160 | 11.6 | 1.16 | 59 | 19.47 | 22.08 | 0.88 |
| 1180 | 11.8 | 1.18 | 59 | 19.47 | 21.84 | 0.89 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 1200 | 12 | 1.2 | 59 | 19.47 | 21.6 | 0.90 |
| 1220 | 12.2 | 1.22 | 59 | 19.47 | 21.36 | 0.91 |
| 1240 | 12.4 | 1.24 | 59 | 19.47 | 21.12 | 0.92 |

**Table:A7** Direct Shear Test Readings for Coarse Sand (CS) at 0.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0 | 0.00 | 36 | 0.00 |
| 20 | 0.2 | 0.02 | 6.8 | 2.24 | 35.76 | 0.06 |
| 40 | 0.4 | 0.04 | 11.2 | 3.70 | 35.52 | 0.10 |
| 60 | 0.6 | 0.06 | 12.6 | 4.16 | 35.28 | 0.12 |
| 80 | 0.8 | 0.08 | 14.2 | 4.69 | 35.04 | 0.13 |
| 100 | 1 | 0.1 | 14.6 | 4.82 | 34.8 | 0.14 |
| 120 | 1.2 | 0.12 | 14.7 | 4.85 | 34.56 | 0.14 |
| 140 | 1.4 | 0.14 | 15 | 4.95 | 34.32 | 0.14 |
| 160 | 1.6 | 0.16 | 15.2 | 5.02 | 34.08 | 0.15 |
| 180 | 1.8 | 0.18 | 16.3 | 5.38 | 33.84 | 0.16 |
| 200 | 2 | 0.2 | 16.5 | 5.45 | 33.6 | 0.16 |
| 220 | 2.2 | 0.22 | 16.2 | 5.35 | 33.36 | 0.16 |
| 240 | 2.4 | 0.24 | 16.8 | 5.54 | 33.12 | 0.17 |
| 260 | 2.6 | 0.26 | 16.6 | 5.48 | 32.88 | 0.17 |
| 280 | 2.8 | 0.28 | 16.7 | 5.51 | 32.64 | 0.17 |
| 300 | 3 | 0.3 | 17 | 5.61 | 32.4 | 0.17 |
| 320 | 3.2 | 0.32 | 17.2 | 5.68 | 32.16 | 0.18 |
| 340 | 3.4 | 0.34 | 17.8 | 5.87 | 31.92 | 0.18 |
| 360 | 3.6 | 0.36 | 18.6 | 6.14 | 31.68 | 0.19 |
| 380 | 3.8 | 0.38 | 19.4 | 6.40 | 31.44 | 0.20 |
| 400 | 4 | 0.4 | 20.2 | 6.67 | 31.2 | 0.21 |
| 420 | 4.2 | 0.42 | 20.7 | 6.83 | 30.96 | 0.22 |
| 440 | 4.4 | 0.44 | 21 | 6.93 | 30.72 | 0.23 |
| 460 | 4.6 | 0.46 | 20.8 | 6.86 | 30.48 | 0.23 |
| 480 | 4.8 | 0.48 | 20.2 | 6.67 | 30.24 | 0.22 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 500 | 5 | 0.5 | 20.4 | 6.73 | 30 | 0.22 |
| 520 | 5.2 | 0.52 | 20.6 | 6.80 | 29.76 | 0.23 |
| 540 | 5.4 | 0.54 | 20.6 | 6.80 | 29.52 | 0.23 |
| 560 | 5.6 | 0.56 | 21 | 6.93 | 29.28 | 0.24 |
| 580 | 5.8 | 0.58 | 21.2 | 7.00 | 29.04 | 0.24 |
| 600 | 6 | 0.6 | 21.5 | 7.10 | 28.8 | 0.25 |
| 620 | 6.2 | 0.62 | 21.7 | 7.16 | 28.56 | 0.25 |
| 640 | 6.4 | 0.64 | 21.3 | 7.03 | 28.32 | 0.25 |
| 660 | 6.6 | 0.66 | 21.6 | 7.13 | 28.08 | 0.25 |
| 680 | 6.8 | 0.68 | 21.8 | 7.19 | 27.84 | 0.26 |
| 700 | 7 | 0.7 | 21.9 | 7.23 | 27.6 | 0.26 |
| 720 | 7.2 | 0.72 | 22 | 7.26 | 27.36 | 0.27 |
| 740 | 7.4 | 0.74 | 21.9 | 7.23 | 27.12 | 0.27 |
| 760 | 7.6 | 0.76 | 19.9 | 6.57 | 26.88 | 0.24 |
| 780 | 7.8 | 0.78 | 20.8 | 6.86 | 26.64 | 0.26 |
| 800 | 8 | 0.8 | 22 | 7.26 | 26.4 | 0.28 |
| 820 | 8.2 | 0.82 | 22.7 | 7.49 | 26.16 | 0.29 |
| 840 | 8.4 | 0.84 | 23 | 7.59 | 25.92 | 0.29 |
| 860 | 8.6 | 0.86 | 23 | 7.59 | 25.68 | 0.30 |
| 880 | 8.8 | 0.88 | 22.9 | 7.56 | 25.44 | 0.30 |
| 900 | 9 | 0.9 | 22.4 | 7.39 | 25.2 | 0.29 |
| 920 | 9.2 | 0.92 | 22.6 | 7.46 | 24.96 | 0.30 |
| 940 | 9.4 | 0.94 | 22.2 | 7.33 | 24.72 | 0.30 |
| 960 | 9.6 | 0.96 | 22 | 7.26 | 24.48 | 0.30 |
| 980 | 9.8 | 0.98 | 22.3 | 7.36 | 24.24 | 0.30 |
| 1000 | 10 | 1 | 22.4 | 7.39 | 24 | 0.31 |
| 1020 | 10.2 | 1.02 | 22.2 | 7.33 | 23.76 | 0.31 |
| 1040 | 10.4 | 1.04 | 22.1 | 7.29 | 23.52 | 0.31 |
| 1060 | 10.6 | 1.06 | 22.2 | 7.33 | 23.28 | 0.31 |
| 1080 | 10.8 | 1.08 | 21.8 | 7.19 | 23.04 | 0.31 |
| 1100 | 11 | 1.1 | 20.8 | 6.86 | 22.8 | 0.30 |
| 1120 | 11.2 | 1.12 | 20.8 | 6.86 | 22.56 | 0.30 |
| 1140 | 11.4 | 1.14 | 21.2 | 7.00 | 22.32 | 0.31 |
| 1160 | 11.6 | 1.16 | 21.2 | 7.00 | 22.08 | 0.32 |
| 1180 | 11.8 | 1.18 | 21 | 6.93 | 21.84 | 0.32 |
| 1200 | 12 | 1.2 | 21.4 | 7.06 | 21.6 | 0.33 |
| 1220 | 12.2 | 1.22 | 20.8 | 6.86 | 21.36 | 0.32 |
| 1240 | 12.4 | 1.24 | 20.2 | 6.67 | 21.12 | 0.32 |

**Table: A8** Direct Shear Test Readings for Coarse Sand (CS) at 1.0 kg/cm$^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area (cm$^2$) | Shear Stress (kg/cm$^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0 | 0.00 | 36 | 0.00 |
| 20 | 0.2 | 0.02 | 16.2 | 5.35 | 35.76 | 0.15 |
| 40 | 0.4 | 0.04 | 23.2 | 7.66 | 35.52 | 0.22 |
| 60 | 0.6 | 0.06 | 28.9 | 9.54 | 35.28 | 0.27 |
| 80 | 0.8 | 0.08 | 34.2 | 11.29 | 35.04 | 0.32 |
| 100 | 1 | 0.1 | 37 | 12.21 | 34.8 | 0.35 |
| 120 | 1.2 | 0.12 | 21.6 | 7.13 | 34.56 | 0.21 |
| 140 | 1.4 | 0.14 | 22 | 7.26 | 34.32 | 0.21 |
| 160 | 1.6 | 0.16 | 23 | 7.59 | 34.08 | 0.22 |
| 180 | 1.8 | 0.18 | 23.6 | 7.79 | 33.84 | 0.23 |
| 200 | 2 | 0.2 | 26.8 | 8.84 | 33.6 | 0.26 |
| 220 | 2.2 | 0.22 | 28.9 | 9.54 | 33.36 | 0.29 |
| 240 | 2.4 | 0.24 | 30.4 | 10.03 | 33.12 | 0.30 |
| 260 | 2.6 | 0.26 | 31.4 | 10.36 | 32.88 | 0.32 |
| 280 | 2.8 | 0.28 | 32.5 | 10.73 | 32.64 | 0.33 |
| 300 | 3 | 0.3 | 33.9 | 11.19 | 32.4 | 0.35 |
| 320 | 3.2 | 0.32 | 34.2 | 11.29 | 32.16 | 0.35 |
| 340 | 3.4 | 0.34 | 34.8 | 11.48 | 31.92 | 0.36 |
| 360 | 3.6 | 0.36 | 34.8 | 11.48 | 31.68 | 0.36 |
| 380 | 3.8 | 0.38 | 35 | 11.55 | 31.44 | 0.37 |
| 400 | 4 | 0.4 | 34.8 | 11.48 | 31.2 | 0.37 |
| 420 | 4.2 | 0.42 | 35 | 11.55 | 30.96 | 0.37 |
| 440 | 4.4 | 0.44 | 35.4 | 11.68 | 30.72 | 0.38 |
| 460 | 4.6 | 0.46 | 35.2 | 11.62 | 30.48 | 0.38 |
| 480 | 4.8 | 0.48 | 35.5 | 11.72 | 30.24 | 0.39 |
| 500 | 5 | 0.5 | 35.3 | 11.65 | 30 | 0.39 |
| 520 | 5.2 | 0.52 | 35.5 | 11.72 | 29.76 | 0.39 |
| 540 | 5.4 | 0.54 | 35.9 | 11.85 | 29.52 | 0.40 |
| 560 | 5.6 | 0.56 | 36.3 | 11.98 | 29.28 | 0.41 |
| 580 | 5.8 | 0.58 | 36.5 | 12.05 | 29.04 | 0.41 |
| 600 | 6 | 0.6 | 37.6 | 12.41 | 28.8 | 0.43 |
| 620 | 6.2 | 0.62 | 38 | 12.54 | 28.56 | 0.44 |
| 640 | 6.4 | 0.64 | 38 | 12.54 | 28.32 | 0.44 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 660 | 6.6 | 0.66 | 36 | 11.88 | 28.08 | 0.42 |
| 680 | 6.8 | 0.68 | 37 | 12.21 | 27.84 | 0.44 |
| 700 | 7 | 0.7 | 38.8 | 12.80 | 27.6 | 0.46 |
| 720 | 7.2 | 0.72 | 39.6 | 13.07 | 27.36 | 0.48 |
| 740 | 7.4 | 0.74 | 39.8 | 13.13 | 27.12 | 0.48 |
| 760 | 7.6 | 0.76 | 39 | 12.87 | 26.88 | 0.48 |
| 780 | 7.8 | 0.78 | 39 | 12.87 | 26.64 | 0.48 |
| 800 | 8 | 0.8 | 38.2 | 12.61 | 26.4 | 0.48 |
| 820 | 8.2 | 0.82 | 38.1 | 12.57 | 26.16 | 0.48 |
| 840 | 8.4 | 0.84 | 37.9 | 12.51 | 25.92 | 0.48 |
| 860 | 8.6 | 0.86 | 38.2 | 12.61 | 25.68 | 0.49 |
| 880 | 8.8 | 0.88 | 38.1 | 12.57 | 25.44 | 0.49 |
| 900 | 9 | 0.9 | 37.9 | 12.51 | 25.2 | 0.50 |
| 920 | 9.2 | 0.92 | 38.6 | 12.74 | 24.96 | 0.51 |
| 940 | 9.4 | 0.94 | 38.4 | 12.67 | 24.72 | 0.51 |
| 960 | 9.6 | 0.96 | 38.8 | 12.80 | 24.48 | 0.52 |
| 980 | 9.8 | 0.98 | 39.1 | 12.90 | 24.24 | 0.53 |
| 1000 | 10 | 1 | 38.2 | 12.61 | 24 | 0.53 |
| 1020 | 10.2 | 1.02 | 38.1 | 12.57 | 23.76 | 0.53 |
| 1040 | 10.4 | 1.04 | 37.7 | 12.44 | 23.52 | 0.53 |
| 1060 | 10.6 | 1.06 | 37.6 | 12.41 | 23.28 | 0.53 |
| 1080 | 10.8 | 1.08 | 37.2 | 12.28 | 23.04 | 0.53 |
| 1100 | 11 | 1.1 | 37.2 | 12.28 | 22.8 | 0.54 |
| 1120 | 11.2 | 1.12 | 36.8 | 12.14 | 22.56 | 0.54 |
| 1140 | 11.4 | 1.14 | 35.9 | 11.85 | 22.32 | 0.53 |
| 1160 | 11.6 | 1.16 | 36.4 | 12.01 | 22.08 | 0.54 |
| 1180 | 11.8 | 1.18 | 36.6 | 12.08 | 21.84 | 0.55 |
| 1200 | 12 | 1.2 | 36.4 | 12.01 | 21.6 | 0.56 |
| 1220 | 12.2 | 1.22 | 36.4 | 12.01 | 21.36 | 0.56 |

**Table: A9** Direct Shear Test Readings for Coarse Sand (CS) at 1.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0 | 0.00 | 36 | 0.00 |
| 20 | 0.2 | 0.02 | 16 | 5.28 | 35.76 | 0.15 |
| 40 | 0.4 | 0.04 | 24 | 7.92 | 35.52 | 0.22 |
| 60 | 0.6 | 0.06 | 32 | 10.56 | 35.28 | 0.30 |
| 80 | 0.8 | 0.08 | 38 | 12.54 | 35.04 | 0.36 |
| 100 | 1 | 0.1 | 42 | 13.86 | 34.8 | 0.40 |
| 120 | 1.2 | 0.12 | 46 | 15.18 | 34.56 | 0.44 |
| 140 | 1.4 | 0.14 | 50 | 16.50 | 34.32 | 0.48 |
| 160 | 1.6 | 0.16 | 51.2 | 16.90 | 34.08 | 0.50 |
| 180 | 1.8 | 0.18 | 52.7 | 17.39 | 33.84 | 0.51 |
| 200 | 2 | 0.2 | 53.7 | 17.72 | 33.6 | 0.53 |
| 220 | 2.2 | 0.22 | 55.2 | 18.22 | 33.36 | 0.55 |
| 240 | 2.4 | 0.24 | 57 | 18.81 | 33.12 | 0.57 |
| 260 | 2.6 | 0.26 | 58.2 | 19.21 | 32.88 | 0.58 |
| 280 | 2.8 | 0.28 | 59.2 | 19.54 | 32.64 | 0.60 |
| 300 | 3 | 0.3 | 60.4 | 19.93 | 32.4 | 0.62 |
| 320 | 3.2 | 0.32 | 61.6 | 20.33 | 32.16 | 0.63 |
| 340 | 3.4 | 0.34 | 62.4 | 20.59 | 31.92 | 0.65 |
| 360 | 3.6 | 0.36 | 63.8 | 21.05 | 31.68 | 0.66 |
| 380 | 3.8 | 0.38 | 63.9 | 21.09 | 31.44 | 0.67 |
| 400 | 4 | 0.4 | 64.2 | 21.19 | 31.2 | 0.68 |
| 420 | 4.2 | 0.42 | 64.6 | 21.32 | 30.96 | 0.69 |
| 440 | 4.4 | 0.44 | 64.8 | 21.38 | 30.72 | 0.70 |
| 460 | 4.6 | 0.46 | 65 | 21.45 | 30.48 | 0.70 |
| 480 | 4.8 | 0.48 | 65.2 | 21.52 | 30.24 | 0.71 |
| 500 | 5 | 0.5 | 66.1 | 21.81 | 30 | 0.73 |
| 520 | 5.2 | 0.52 | 66 | 21.78 | 29.76 | 0.73 |
| 540 | 5.4 | 0.54 | 66.6 | 21.98 | 29.52 | 0.74 |
| 560 | 5.6 | 0.56 | 67 | 22.11 | 29.28 | 0.76 |
| 580 | 5.8 | 0.58 | 67.2 | 22.18 | 29.04 | 0.76 |
| 600 | 6 | 0.6 | 67 | 22.11 | 28.8 | 0.77 |
| 620 | 6.2 | 0.62 | 66.2 | 21.85 | 28.56 | 0.76 |
| 640 | 6.4 | 0.64 | 65 | 21.45 | 28.32 | 0.76 |
| 660 | 6.6 | 0.66 | 66 | 21.78 | 28.08 | 0.78 |
| 680 | 6.8 | 0.68 | 65.6 | 21.65 | 27.84 | 0.78 |
| 700 | 7 | 0.7 | 64.2 | 21.19 | 27.6 | 0.77 |
| 720 | 7.2 | 0.72 | 63 | 20.79 | 27.36 | 0.76 |
| 740 | 7.4 | 0.74 | 62.1 | 20.49 | 27.12 | 0.76 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 760 | 7.6 | 0.76 | 61 | 20.13 | 26.88 | 0.75 |
| 780 | 7.8 | 0.78 | 59.8 | 19.73 | 26.64 | 0.74 |
| 800 | 8 | 0.8 | 60.1 | 19.83 | 26.4 | 0.75 |
| 820 | 8.2 | 0.82 | 60 | 19.80 | 26.16 | 0.76 |
| 840 | 8.4 | 0.84 | 59.8 | 19.73 | 25.92 | 0.76 |
| 860 | 8.6 | 0.86 | 59 | 19.47 | 25.68 | 0.76 |
| 880 | 8.8 | 0.88 | 59 | 19.47 | 25.44 | 0.77 |
| 900 | 9 | 0.9 | 60.1 | 19.83 | 25.2 | 0.79 |
| 920 | 9.2 | 0.92 | 58.8 | 19.40 | 24.96 | 0.78 |
| 940 | 9.4 | 0.94 | 58.1 | 19.17 | 24.72 | 0.78 |
| 960 | 9.6 | 0.96 | 58 | 19.14 | 24.48 | 0.78 |
| 980 | 9.8 | 0.98 | 58 | 19.14 | 24.24 | 0.79 |
| 1000 | 10 | 1 | 58.4 | 19.27 | 24 | 0.80 |
| 1020 | 10.2 | 1.02 | 58.6 | 19.34 | 23.76 | 0.81 |
| 1040 | 10.4 | 1.04 | 57.4 | 18.94 | 23.52 | 0.81 |
| 1060 | 10.6 | 1.06 | 58 | 19.14 | 23.28 | 0.82 |
| 1080 | 10.8 | 1.08 | 58.2 | 19.21 | 23.04 | 0.83 |
| 1100 | 11 | 1.1 | 57.9 | 19.11 | 22.8 | 0.84 |
| 1120 | 11.2 | 1.12 | 58 | 19.14 | 22.56 | 0.85 |
| 1140 | 11.4 | 1.14 | 57.9 | 19.11 | 22.32 | 0.86 |
| 1160 | 11.6 | 1.16 | 57.8 | 19.07 | 22.08 | 0.86 |
| 1180 | 11.8 | 1.18 | 57.6 | 19.01 | 21.84 | 0.87 |
| 1200 | 12 | 1.2 | 57.6 | 19.01 | 21.6 | 0.88 |
| 1220 | 12.2 | 1.22 | 57.6 | 19.01 | 21.36 | 0.89 |

**Table:A10** Direct Shear Test Readings for (OS) at 0.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 3.8 | 1.25 | 35.76 | 0.04 |
| 40 | 0.4 | 0.04 | 5.4 | 1.78 | 35.52 | 0.05 |
| 60 | 0.6 | 0.06 | 11.9 | 3.93 | 35.28 | 0.11 |
| 80 | 0.8 | 0.08 | 14.4 | 4.75 | 35.04 | 0.14 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 100 | 1 | 0.1 | 15.4 | 5.08 | 34.80 | 0.15 |
| 120 | 1.2 | 0.12 | 17.2 | 5.68 | 34.56 | 0.16 |
| 140 | 1.4 | 0.14 | 16.4 | 5.41 | 34.32 | 0.16 |
| 160 | 1.6 | 0.16 | 17.2 | 5.68 | 34.08 | 0.17 |
| 180 | 1.8 | 0.18 | 17.6 | 5.81 | 33.84 | 0.17 |
| 200 | 2 | 0.2 | 18 | 5.94 | 33.60 | 0.18 |
| 220 | 2.2 | 0.22 | 18.6 | 6.14 | 33.36 | 0.18 |
| 240 | 2.4 | 0.24 | 18.8 | 6.20 | 33.12 | 0.19 |
| 260 | 2.6 | 0.26 | 19 | 6.27 | 32.88 | 0.19 |
| 280 | 2.8 | 0.28 | 19.4 | 6.40 | 32.64 | 0.20 |
| 300 | 3 | 0.3 | 19.6 | 6.47 | 32.40 | 0.20 |
| 320 | 3.2 | 0.32 | 20 | 6.60 | 32.16 | 0.21 |
| 340 | 3.4 | 0.34 | 20.2 | 6.67 | 31.92 | 0.21 |
| 360 | 3.6 | 0.36 | 20.2 | 6.67 | 31.68 | 0.21 |
| 380 | 3.8 | 0.38 | 20.4 | 6.73 | 31.44 | 0.21 |
| 400 | 4 | 0.4 | 20.4 | 6.73 | 31.20 | 0.22 |
| 420 | 4.2 | 0.42 | 20.6 | 6.80 | 30.96 | 0.22 |
| 440 | 4.4 | 0.44 | 20.6 | 6.80 | 30.72 | 0.22 |
| 460 | 4.6 | 0.46 | 20.8 | 6.86 | 30.48 | 0.23 |
| 480 | 4.8 | 0.48 | 20.8 | 6.86 | 30.24 | 0.23 |
| 500 | 5 | 0.5 | 20.8 | 6.86 | 30.00 | 0.23 |
| 520 | 5.2 | 0.52 | 20.7 | 6.83 | 29.76 | 0.23 |
| 540 | 5.4 | 0.54 | 20.8 | 6.86 | 29.52 | 0.23 |
| 560 | 5.6 | 0.56 | 20.8 | 6.86 | 29.28 | 0.23 |
| 580 | 5.8 | 0.58 | 20.6 | 6.80 | 29.04 | 0.23 |
| 600 | 6 | 0.6 | 20.4 | 6.73 | 28.80 | 0.23 |
| 620 | 6.2 | 0.62 | 20.4 | 6.73 | 28.56 | 0.24 |
| 640 | 6.4 | 0.64 | 20.4 | 6.73 | 28.32 | 0.24 |
| 660 | 6.6 | 0.66 | 20.3 | 6.70 | 28.08 | 0.24 |
| 680 | 6.8 | 0.68 | 20.2 | 6.67 | 27.84 | 0.24 |
| 700 | 7 | 0.7 | 20.1 | 6.63 | 27.60 | 0.24 |
| 720 | 7.2 | 0.72 | 20.1 | 6.63 | 27.36 | 0.24 |
| 740 | 7.4 | 0.74 | 20 | 6.60 | 27.12 | 0.24 |
| 760 | 7.6 | 0.76 | 20 | 6.60 | 26.88 | 0.25 |
| 780 | 7.8 | 0.78 | 20 | 6.60 | 26.64 | 0.25 |
| 800 | 8 | 0.8 | 20 | 6.60 | 26.40 | 0.25 |
| 820 | 8.2 | 0.82 | 20 | 6.60 | 26.16 | 0.25 |
| 840 | 8.4 | 0.84 | 19.8 | 6.53 | 25.92 | 0.25 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 860 | 8.6 | 0.86 | 19.8 | 6.53 | 25.68 | 0.25 |
| 880 | 8.8 | 0.88 | 19.9 | 6.57 | 25.44 | 0.26 |
| 900 | 9 | 0.9 | 19.8 | 6.53 | 25.20 | 0.26 |
| 920 | 9.2 | 0.92 | 19.9 | 6.57 | 24.96 | 0.26 |
| 940 | 9.4 | 0.94 | 19.8 | 6.53 | 24.72 | 0.26 |
| 960 | 9.6 | 0.96 | 19.7 | 6.50 | 24.48 | 0.27 |
| 980 | 9.8 | 0.98 | 19.8 | 6.53 | 24.24 | 0.27 |
| 1000 | 10 | 1 | 19.6 | 6.47 | 24.00 | 0.27 |
| 1020 | 10.2 | 1.02 | 19.7 | 6.50 | 23.76 | 0.27 |
| 1040 | 10.4 | 1.04 | 19.6 | 6.47 | 23.52 | 0.28 |
| 1060 | 10.6 | 1.06 | 19.6 | 6.47 | 23.28 | 0.28 |
| 1080 | 10.8 | 1.08 | 19.6 | 6.47 | 23.04 | 0.28 |
| 1100 | 11 | 1.1 | 19.6 | 6.47 | 22.80 | 0.28 |
| 1120 | 11.2 | 1.12 | 19.6 | 6.47 | 22.56 | 0.29 |
| 1140 | 11.4 | 1.14 | 19.6 | 6.47 | 22.32 | 0.29 |
| 1160 | 11.6 | 1.16 | 19.6 | 6.47 | 22.08 | 0.29 |
| 1180 | 11.8 | 1.18 | 19.6 | 6.47 | 21.84 | 0.30 |
| 1200 | 12 | 1.2 | 19.6 | 6.47 | 21.60 | 0.30 |

**Table:A11** Direct Shear Test Readings for (OS) at 1.0 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 6.20 | 2.05 | 35.76 | 0.06 |
| 40 | 0.4 | 0.04 | 12.00 | 3.96 | 35.52 | 0.11 |
| 60 | 0.6 | 0.06 | 16.00 | 5.28 | 35.28 | 0.15 |
| 80 | 0.8 | 0.08 | 21.40 | 7.06 | 35.04 | 0.20 |
| 100 | 1 | 0.1 | 23.60 | 7.79 | 34.80 | 0.22 |
| 120 | 1.2 | 0.12 | 26.20 | 8.65 | 34.56 | 0.25 |
| 140 | 1.4 | 0.14 | 27.80 | 9.17 | 34.32 | 0.27 |
| 160 | 1.6 | 0.16 | 29.00 | 9.57 | 34.08 | 0.28 |
| 180 | 1.8 | 0.18 | 30.80 | 10.16 | 33.84 | 0.30 |
| 200 | 2 | 0.2 | 31.60 | 10.43 | 33.60 | 0.31 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 220 | 2.2 | 0.22 | 32.20 | 10.63 | 33.36 | 0.32 |
| 240 | 2.4 | 0.24 | 32.80 | 10.82 | 33.12 | 0.33 |
| 260 | 2.6 | 0.26 | 33.40 | 11.02 | 32.88 | 0.34 |
| 280 | 2.8 | 0.28 | 33.80 | 11.15 | 32.64 | 0.34 |
| 300 | 3 | 0.3 | 34.10 | 11.25 | 32.40 | 0.35 |
| 320 | 3.2 | 0.32 | 34.20 | 11.29 | 32.16 | 0.35 |
| 340 | 3.4 | 0.34 | 34.40 | 11.35 | 31.92 | 0.36 |
| 360 | 3.6 | 0.36 | 34.40 | 11.35 | 31.68 | 0.36 |
| 380 | 3.8 | 0.38 | 34.40 | 11.35 | 31.44 | 0.36 |
| 400 | 4 | 0.4 | 34.40 | 11.35 | 31.20 | 0.36 |
| 420 | 4.2 | 0.42 | 34.50 | 11.39 | 30.96 | 0.37 |
| 440 | 4.4 | 0.44 | 34.40 | 11.35 | 30.72 | 0.37 |
| 460 | 4.6 | 0.46 | 34.60 | 11.42 | 30.48 | 0.37 |
| 480 | 4.8 | 0.48 | 34.60 | 11.42 | 30.24 | 0.38 |
| 500 | 5 | 0.5 | 34.60 | 11.42 | 30.00 | 0.38 |
| 520 | 5.2 | 0.52 | 34.40 | 11.35 | 29.76 | 0.38 |
| 540 | 5.4 | 0.54 | 34.40 | 11.35 | 29.52 | 0.38 |
| 560 | 5.6 | 0.56 | 34.40 | 11.35 | 29.28 | 0.39 |
| 580 | 5.8 | 0.58 | 34.20 | 11.29 | 29.04 | 0.39 |
| 600 | 6 | 0.6 | 34.20 | 11.29 | 28.80 | 0.39 |
| 620 | 6.2 | 0.62 | 34.10 | 11.25 | 28.56 | 0.39 |
| 640 | 6.4 | 0.64 | 34.00 | 11.22 | 28.32 | 0.40 |
| 660 | 6.6 | 0.66 | 34.10 | 11.25 | 28.08 | 0.40 |
| 680 | 6.8 | 0.68 | 34.20 | 11.29 | 27.84 | 0.41 |
| 700 | 7 | 0.7 | 34.20 | 11.29 | 27.60 | 0.41 |
| 720 | 7.2 | 0.72 | 34.20 | 11.29 | 27.36 | 0.41 |
| 740 | 7.4 | 0.74 | 34.40 | 11.35 | 27.12 | 0.42 |
| 760 | 7.6 | 0.76 | 34.60 | 11.42 | 26.88 | 0.42 |
| 780 | 7.8 | 0.78 | 34.60 | 11.42 | 26.64 | 0.43 |
| 800 | 8 | 0.8 | 34.70 | 11.45 | 26.40 | 0.43 |
| 820 | 8.2 | 0.82 | 34.80 | 11.48 | 26.16 | 0.44 |
| 840 | 8.4 | 0.84 | 34.80 | 11.48 | 25.92 | 0.44 |
| 860 | 8.6 | 0.86 | 35.00 | 11.55 | 25.68 | 0.45 |
| 880 | 8.8 | 0.88 | 35.20 | 11.62 | 25.44 | 0.46 |
| 900 | 9 | 0.9 | 35.40 | 11.68 | 25.20 | 0.46 |
| 920 | 9.2 | 0.92 | 35.30 | 11.65 | 24.96 | 0.47 |
| 940 | 9.4 | 0.94 | 35.40 | 11.68 | 24.72 | 0.47 |
| 960 | 9.6 | 0.96 | 35.40 | 11.68 | 24.48 | 0.48 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 980 | 9.8 | 0.98 | 35.40 | 11.68 | 24.24 | 0.48 |
| 1000 | 10 | 1 | 35.40 | 11.68 | 24.00 | 0.49 |
| 1020 | 10.2 | 1.02 | 35.40 | 11.68 | 23.76 | 0.49 |
| 1040 | 10.4 | 1.04 | 35.40 | 11.68 | 23.52 | 0.50 |
| 1060 | 10.6 | 1.06 | 35.20 | 11.62 | 23.28 | 0.50 |
| 1080 | 10.8 | 1.08 | 35.40 | 11.68 | 23.04 | 0.51 |
| 1100 | 11 | 1.1 | 35.40 | 11.68 | 22.80 | 0.51 |
| 1120 | 11.2 | 1.12 | 35.40 | 11.68 | 22.56 | 0.52 |
| 1140 | 11.4 | 1.14 | 35.30 | 11.65 | 22.32 | 0.52 |
| 1160 | 11.6 | 1.16 | 35.20 | 11.62 | 22.08 | 0.53 |
| 1180 | 11.8 | 1.18 | 35.20 | 11.62 | 21.84 | 0.53 |
| 1200 | 12 | 1.2 | 35.20 | 11.62 | 21.60 | 0.54 |

**Table:A12** Direct Shear Test Readings for (OS) at 1.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 9.80 | 3.23 | 35.76 | 0.09 |
| 40 | 0.4 | 0.04 | 22.80 | 7.52 | 35.52 | 0.21 |
| 60 | 0.6 | 0.06 | 32.00 | 10.56 | 35.28 | 0.30 |
| 80 | 0.8 | 0.08 | 35.80 | 11.81 | 35.04 | 0.34 |
| 100 | 1 | 0.1 | 39.20 | 12.94 | 34.80 | 0.37 |
| 120 | 1.2 | 0.12 | 40.40 | 13.33 | 34.56 | 0.39 |
| 140 | 1.4 | 0.14 | 42.00 | 13.86 | 34.32 | 0.40 |
| 160 | 1.6 | 0.16 | 43.00 | 14.19 | 34.08 | 0.42 |
| 180 | 1.8 | 0.18 | 44.20 | 14.59 | 33.84 | 0.43 |
| 200 | 2 | 0.2 | 45.40 | 14.98 | 33.60 | 0.45 |
| 220 | 2.2 | 0.22 | 46.10 | 15.21 | 33.36 | 0.46 |
| 240 | 2.4 | 0.24 | 46.80 | 15.44 | 33.12 | 0.47 |
| 260 | 2.6 | 0.26 | 47.60 | 15.71 | 32.88 | 0.48 |
| 280 | 2.8 | 0.28 | 48.00 | 15.84 | 32.64 | 0.49 |
| 300 | 3 | 0.3 | 49.00 | 16.17 | 32.40 | 0.50 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 320 | 3.2 | 0.32 | 49.60 | 16.37 | 32.16 | 0.51 |
| 340 | 3.4 | 0.34 | 50.00 | 16.50 | 31.92 | 0.52 |
| 360 | 3.6 | 0.36 | 50.40 | 16.63 | 31.68 | 0.53 |
| 380 | 3.8 | 0.38 | 51.00 | 16.83 | 31.44 | 0.54 |
| 400 | 4 | 0.4 | 51.60 | 17.03 | 31.20 | 0.55 |
| 420 | 4.2 | 0.42 | 51.80 | 17.09 | 30.96 | 0.55 |
| 440 | 4.4 | 0.44 | 52.20 | 17.23 | 30.72 | 0.56 |
| 460 | 4.6 | 0.46 | 52.40 | 17.29 | 30.48 | 0.57 |
| 480 | 4.8 | 0.48 | 52.80 | 17.42 | 30.24 | 0.58 |
| 500 | 5 | 0.5 | 53.30 | 17.59 | 30.00 | 0.59 |
| 520 | 5.2 | 0.52 | 53.40 | 17.62 | 29.76 | 0.59 |
| 540 | 5.4 | 0.54 | 54.00 | 17.82 | 29.52 | 0.60 |
| 560 | 5.6 | 0.56 | 54.20 | 17.89 | 29.28 | 0.61 |
| 580 | 5.8 | 0.58 | 54.40 | 17.95 | 29.04 | 0.62 |
| 600 | 6 | 0.6 | 54.70 | 18.05 | 28.80 | 0.63 |
| 620 | 6.2 | 0.62 | 54.80 | 18.08 | 28.56 | 0.63 |
| 640 | 6.4 | 0.64 | 54.80 | 18.08 | 28.32 | 0.64 |
| 660 | 6.6 | 0.66 | 55.00 | 18.15 | 28.08 | 0.65 |
| 680 | 6.8 | 0.68 | 55.20 | 18.22 | 27.84 | 0.65 |
| 700 | 7 | 0.7 | 55.20 | 18.22 | 27.60 | 0.66 |
| 720 | 7.2 | 0.72 | 55.30 | 18.25 | 27.36 | 0.67 |
| 740 | 7.4 | 0.74 | 55.40 | 18.28 | 27.12 | 0.67 |
| 760 | 7.6 | 0.76 | 55.50 | 18.32 | 26.88 | 0.68 |
| 780 | 7.8 | 0.78 | 55.60 | 18.35 | 26.64 | 0.69 |
| 800 | 8 | 0.8 | 55.80 | 18.41 | 26.40 | 0.70 |
| 820 | 8.2 | 0.82 | 55.80 | 18.41 | 26.16 | 0.70 |
| 840 | 8.4 | 0.84 | 55.90 | 18.45 | 25.92 | 0.71 |
| 860 | 8.6 | 0.86 | 55.90 | 18.45 | 25.68 | 0.72 |
| 880 | 8.8 | 0.88 | 56.00 | 18.48 | 25.44 | 0.73 |
| 900 | 9 | 0.9 | 56.00 | 18.48 | 25.20 | 0.73 |
| 920 | 9.2 | 0.92 | 56.00 | 18.48 | 24.96 | 0.74 |
| 940 | 9.4 | 0.94 | 56.10 | 18.51 | 24.72 | 0.75 |
| 960 | 9.6 | 0.96 | 56.20 | 18.55 | 24.48 | 0.76 |
| 980 | 9.8 | 0.98 | 56.20 | 18.55 | 24.24 | 0.77 |
| 1000 | 10 | 1 | 56.10 | 18.51 | 24.00 | 0.77 |
| 1020 | 10.2 | 1.02 | 56.30 | 18.58 | 23.76 | 0.78 |
| 1040 | 10.4 | 1.04 | 56.40 | 18.61 | 23.52 | 0.79 |
| 1060 | 10.6 | 1.06 | 56.20 | 18.55 | 23.28 | 0.80 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 1080 | 10.8 | 1.08 | 56.30 | 18.58 | 23.04 | 0.81 |
| 1100 | 11 | 1.1 | 56.20 | 18.55 | 22.80 | 0.81 |
| 1120 | 11.2 | 1.12 | 56.10 | 18.51 | 22.56 | 0.82 |
| 1140 | 11.4 | 1.14 | 56.00 | 18.48 | 22.32 | 0.83 |
| 1160 | 11.6 | 1.16 | 56.00 | 18.48 | 22.08 | 0.84 |
| 1180 | 11.8 | 1.18 | 56.00 | 18.48 | 21.84 | 0.85 |
| 1200 | 12 | 1.2 | 56.00 | 18.48 | 21.60 | 0.86 |

**Table:A13** Direct Shear Test Readings for (OS) at dry state at 0.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0.00 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 4.60 | 1.52 | 35.76 | 0.04 |
| 40 | 0.4 | 0.04 | 8.60 | 2.84 | 35.52 | 0.08 |
| 60 | 0.6 | 0.06 | 14.20 | 4.69 | 35.28 | 0.13 |
| 80 | 0.8 | 0.08 | 18.40 | 6.07 | 35.04 | 0.17 |
| 100 | 1 | 0.10 | 20.00 | 6.60 | 34.80 | 0.19 |
| 120 | 1.2 | 0.12 | 21.20 | 7.00 | 34.56 | 0.20 |
| 140 | 1.4 | 0.14 | 22.20 | 7.33 | 34.32 | 0.21 |
| 160 | 1.6 | 0.16 | 23.00 | 7.59 | 34.08 | 0.22 |
| 180 | 1.8 | 0.18 | 23.60 | 7.79 | 33.84 | 0.23 |
| 200 | 2 | 0.20 | 24.00 | 7.92 | 33.60 | 0.24 |
| 220 | 2.2 | 0.22 | 24.40 | 8.05 | 33.36 | 0.24 |
| 240 | 2.4 | 0.24 | 24.80 | 8.18 | 33.12 | 0.25 |
| 260 | 2.6 | 0.26 | 25.00 | 8.25 | 32.88 | 0.25 |
| 280 | 2.8 | 0.28 | 25.00 | 8.25 | 32.64 | 0.25 |
| 300 | 3 | 0.30 | 25.00 | 8.25 | 32.40 | 0.25 |
| 320 | 3.2 | 0.32 | 24.80 | 8.18 | 32.16 | 0.25 |
| 340 | 3.4 | 0.34 | 24.60 | 8.12 | 31.92 | 0.25 |
| 360 | 3.6 | 0.36 | 24.40 | 8.05 | 31.68 | 0.25 |
| 380 | 3.8 | 0.38 | 24.20 | 7.99 | 31.44 | 0.25 |
| 400 | 4 | 0.40 | 24.00 | 7.92 | 31.20 | 0.25 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 420 | 4.2 | 0.42 | 23.60 | 7.79 | 30.96 | 0.25 |
| 440 | 4.4 | 0.44 | 23.40 | 7.72 | 30.72 | 0.25 |
| 460 | 4.6 | 0.46 | 23.20 | 7.66 | 30.48 | 0.25 |
| 480 | 4.8 | 0.48 | 23.00 | 7.59 | 30.24 | 0.25 |
| 500 | 5 | 0.50 | 23.00 | 7.59 | 30.00 | 0.25 |
| 520 | 5.2 | 0.52 | 23.00 | 7.59 | 29.76 | 0.26 |
| 540 | 5.4 | 0.54 | 22.80 | 7.52 | 29.52 | 0.25 |
| 560 | 5.6 | 0.56 | 22.60 | 7.46 | 29.28 | 0.25 |
| 580 | 5.8 | 0.58 | 22.60 | 7.46 | 29.04 | 0.26 |
| 600 | 6 | 0.60 | 22.50 | 7.43 | 28.80 | 0.26 |
| 620 | 6.2 | 0.62 | 22.60 | 7.46 | 28.56 | 0.26 |
| 640 | 6.4 | 0.64 | 22.70 | 7.49 | 28.32 | 0.26 |
| 660 | 6.6 | 0.66 | 22.60 | 7.46 | 28.08 | 0.27 |
| 680 | 6.8 | 0.68 | 22.60 | 7.46 | 27.84 | 0.27 |
| 700 | 7 | 0.70 | 22.40 | 7.39 | 27.60 | 0.27 |
| 720 | 7.2 | 0.72 | 22.40 | 7.39 | 27.36 | 0.27 |
| 740 | 7.4 | 0.74 | 22.40 | 7.39 | 27.12 | 0.27 |
| 760 | 7.6 | 0.76 | 22.40 | 7.39 | 26.88 | 0.28 |
| 780 | 7.8 | 0.78 | 22.50 | 7.43 | 26.64 | 0.28 |
| 800 | 8 | 0.80 | 22.40 | 7.39 | 26.40 | 0.28 |
| 820 | 8.2 | 0.82 | 22.20 | 7.33 | 26.16 | 0.28 |
| 840 | 8.4 | 0.84 | 22.30 | 7.36 | 25.92 | 0.28 |
| 860 | 8.6 | 0.86 | 22.40 | 7.39 | 25.68 | 0.29 |
| 880 | 8.8 | 0.88 | 22.40 | 7.39 | 25.44 | 0.29 |
| 900 | 9 | 0.90 | 22.40 | 7.39 | 25.20 | 0.29 |
| 920 | 9.2 | 0.92 | 22.40 | 7.39 | 24.96 | 0.30 |
| 940 | 9.4 | 0.94 | 22.40 | 7.39 | 24.72 | 0.30 |
| 960 | 9.6 | 0.96 | 22.40 | 7.39 | 24.48 | 0.30 |
| 980 | 9.8 | 0.98 | 22.30 | 7.36 | 24.24 | 0.30 |
| 1000 | 10 | 1.00 | 22.20 | 7.33 | 24.00 | 0.31 |
| 1020 | 10.2 | 1.02 | 22.20 | 7.33 | 23.76 | 0.31 |
| 1040 | 10.4 | 1.04 | 22.20 | 7.33 | 23.52 | 0.31 |
| 1060 | 10.6 | 1.06 | 22.00 | 7.26 | 23.28 | 0.31 |
| 1080 | 10.8 | 1.08 | 22.00 | 7.26 | 23.04 | 0.32 |
| 1100 | 11 | 1.10 | 21.80 | 7.19 | 22.80 | 0.32 |
| 1120 | 11.2 | 1.12 | 21.60 | 7.13 | 22.56 | 0.32 |
| 1140 | 11.4 | 1.14 | 21.4 | 7.06 | 22.32 | 0.32 |
| 1160 | 11.6 | 1.16 | 21 | 6.93 | 22.08 | 0.31 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 1180 | 11.8 | 1.18 | 21 | 6.93 | 21.84 | 0.32 |
| 1200 | 12 | 1.2 | 21 | 6.93 | 21.60 | 0.32 |
| 1220 | 12.2 | 1.22 | 20.8 | 6.86 | 21.36 | 0.32 |

**Table: A14** Direct Shear Test Readings for (OS) at dry state at 1.0 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 10.6 | 3.43 | 35.76 | 0.10 |
| 40 | 0.4 | 0.04 | 19 | 6.53 | 35.52 | 0.18 |
| 60 | 0.6 | 0.06 | 22 | 8.91 | 35.28 | 0.25 |
| 80 | 0.8 | 0.08 | 25 | 11.29 | 35.04 | 0.32 |
| 100 | 1 | 0.1 | 27.2 | 13.20 | 34.80 | 0.38 |
| 120 | 1.2 | 0.12 | 28.6 | 14.39 | 34.56 | 0.42 |
| 140 | 1.4 | 0.14 | 29.2 | 14.59 | 34.32 | 0.43 |
| 160 | 1.6 | 0.16 | 29.6 | 14.72 | 34.08 | 0.43 |
| 180 | 1.8 | 0.18 | 29.6 | 14.72 | 33.84 | 0.43 |
| 200 | 2 | 0.2 | 29.4 | 14.65 | 33.60 | 0.44 |
| 220 | 2.2 | 0.22 | 28.8 | 14.45 | 33.36 | 0.43 |
| 240 | 2.4 | 0.24 | 27.6 | 14.06 | 33.12 | 0.42 |
| 260 | 2.6 | 0.26 | 26.2 | 13.60 | 32.88 | 0.41 |
| 280 | 2.8 | 0.28 | 25.2 | 13.27 | 32.64 | 0.41 |
| 300 | 3 | 0.3 | 24 | 12.87 | 32.40 | 0.40 |
| 320 | 3.2 | 0.32 | 23.4 | 12.67 | 32.16 | 0.39 |
| 340 | 3.4 | 0.34 | 23 | 12.54 | 31.92 | 0.39 |
| 360 | 3.6 | 0.36 | 22.8 | 12.47 | 31.68 | 0.39 |
| 380 | 3.8 | 0.38 | 22.6 | 12.41 | 31.44 | 0.39 |
| 400 | 4 | 0.4 | 22.4 | 12.34 | 31.20 | 0.40 |
| 420 | 4.2 | 0.42 | 22.5 | 12.38 | 30.96 | 0.40 |
| 440 | 4.4 | 0.44 | 22.4 | 12.34 | 30.72 | 0.40 |
| 460 | 4.6 | 0.46 | 22.6 | 12.41 | 30.48 | 0.41 |
| 480 | 4.8 | 0.48 | 22.6 | 12.41 | 30.24 | 0.41 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 500 | 5 | 0.5 | 22.8 | 12.47 | 30.00 | 0.42 |
| 520 | 5.2 | 0.52 | 22.8 | 12.47 | 29.76 | 0.42 |
| 540 | 5.4 | 0.54 | 22.8 | 12.47 | 29.52 | 0.42 |
| 560 | 5.6 | 0.56 | 22.6 | 12.41 | 29.28 | 0.42 |
| 580 | 5.8 | 0.58 | 22.6 | 12.41 | 29.04 | 0.43 |
| 600 | 6 | 0.6 | 22.6 | 12.41 | 28.80 | 0.43 |
| 620 | 6.2 | 0.62 | 22.6 | 12.41 | 28.56 | 0.43 |
| 640 | 6.4 | 0.64 | 22.6 | 12.41 | 28.32 | 0.44 |
| 660 | 6.6 | 0.66 | 22.6 | 12.41 | 28.08 | 0.44 |
| 680 | 6.8 | 0.68 | 22.5 | 12.38 | 27.84 | 0.44 |
| 700 | 7 | 0.7 | 22.5 | 12.38 | 27.60 | 0.45 |
| 720 | 7.2 | 0.72 | 22.5 | 12.38 | 27.36 | 0.45 |
| 740 | 7.4 | 0.74 | 22.8 | 12.47 | 27.12 | 0.46 |
| 760 | 7.6 | 0.76 | 22.8 | 12.47 | 26.88 | 0.46 |
| 780 | 7.8 | 0.78 | 22.7 | 12.44 | 26.64 | 0.47 |
| 800 | 8 | 0.8 | 22.8 | 12.47 | 26.40 | 0.47 |
| 820 | 8.2 | 0.82 | 23 | 12.54 | 26.16 | 0.48 |
| 840 | 8.4 | 0.84 | 23 | 12.54 | 25.92 | 0.48 |
| 860 | 8.6 | 0.86 | 22.8 | 12.47 | 25.68 | 0.49 |
| 880 | 8.8 | 0.88 | 22.8 | 12.47 | 25.44 | 0.49 |
| 900 | 9 | 0.9 | 22.8 | 12.47 | 25.20 | 0.50 |
| 920 | 9.2 | 0.92 | 22.8 | 12.47 | 24.96 | 0.50 |
| 940 | 9.4 | 0.94 | 22.6 | 12.41 | 24.72 | 0.50 |
| 960 | 9.6 | 0.96 | 22.6 | 12.41 | 24.48 | 0.51 |
| 980 | 9.8 | 0.98 | 22.6 | 12.41 | 24.24 | 0.51 |
| 1000 | 10 | 1 | 22.6 | 12.41 | 24.00 | 0.52 |
| 1020 | 10.2 | 1.02 | 22.6 | 12.41 | 23.76 | 0.52 |
| 1040 | 10.4 | 1.04 | 22.5 | 12.38 | 23.52 | 0.53 |
| 1060 | 10.6 | 1.06 | 22.4 | 12.34 | 23.28 | 0.53 |
| 1080 | 10.8 | 1.08 | 22.4 | 12.34 | 23.04 | 0.54 |
| 1100 | 11 | 1.1 | 22.2 | 12.28 | 22.80 | 0.54 |
| 1120 | 11.2 | 1.12 | 22 | 12.21 | 22.56 | 0.54 |
| 1140 | 11.4 | 1.14 | 22 | 12.21 | 22.32 | 0.55 |
| 1160 | 11.6 | 1.16 | 22 | 12.21 | 22.08 | 0.55 |
| 1180 | 11.8 | 1.18 | 22 | 12.21 | 21.84 | 0.56 |
| 1200 | 12 | 1.2 | 21.8 | 12.14 | 21.60 | 0.56 |
| 1220 | 12.2 | 1.22 | 21.8 | 12.14 | 21.36 | 0.57 |

**Table: A15** Direct Shear Test Readings for (OS) at dry state at 1.5 kg/cm$^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area (cm$^2$) | Shear Stress (kg/cm$^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 15.20 | 5.02 | 35.76 | 0.14 |
| 40 | 0.4 | 0.04 | 25.20 | 8.32 | 35.52 | 0.23 |
| 60 | 0.6 | 0.06 | 34.20 | 11.29 | 35.28 | 0.32 |
| 80 | 0.8 | 0.08 | 45.20 | 14.92 | 35.04 | 0.43 |
| 100 | 1 | 0.1 | 53.00 | 17.49 | 34.80 | 0.50 |
| 120 | 1.2 | 0.12 | 57.40 | 18.94 | 34.56 | 0.55 |
| 140 | 1.4 | 0.14 | 60.40 | 19.93 | 34.32 | 0.58 |
| 160 | 1.6 | 0.16 | 63.20 | 20.86 | 34.08 | 0.61 |
| 180 | 1.8 | 0.18 | 65.40 | 21.58 | 33.84 | 0.64 |
| 200 | 2 | 0.2 | 66.80 | 22.04 | 33.60 | 0.66 |
| 220 | 2.2 | 0.22 | 67.00 | 22.11 | 33.36 | 0.66 |
| 240 | 2.4 | 0.24 | 67.60 | 22.31 | 33.12 | 0.67 |
| 260 | 2.6 | 0.26 | 67.40 | 22.24 | 32.88 | 0.68 |
| 280 | 2.8 | 0.28 | 67.00 | 22.11 | 32.64 | 0.68 |
| 300 | 3 | 0.3 | 66.20 | 21.85 | 32.40 | 0.67 |
| 320 | 3.2 | 0.32 | 65.60 | 21.65 | 32.16 | 0.67 |
| 340 | 3.4 | 0.34 | 65.00 | 21.45 | 31.92 | 0.67 |
| 360 | 3.6 | 0.36 | 64.20 | 21.19 | 31.68 | 0.67 |
| 380 | 3.8 | 0.38 | 63.40 | 20.92 | 31.44 | 0.67 |
| 400 | 4 | 0.4 | 62.20 | 20.53 | 31.20 | 0.66 |
| 420 | 4.2 | 0.42 | 61.20 | 20.20 | 30.96 | 0.65 |
| 440 | 4.4 | 0.44 | 60.80 | 20.06 | 30.72 | 0.65 |
| 460 | 4.6 | 0.46 | 60.00 | 19.80 | 30.48 | 0.65 |
| 480 | 4.8 | 0.48 | 59.40 | 19.60 | 30.24 | 0.65 |
| 500 | 5 | 0.5 | 58.80 | 19.40 | 30.00 | 0.65 |
| 520 | 5.2 | 0.52 | 58.60 | 19.34 | 29.76 | 0.65 |
| 540 | 5.4 | 0.54 | 58.60 | 19.34 | 29.52 | 0.66 |
| 560 | 5.6 | 0.56 | 58.20 | 19.21 | 29.28 | 0.66 |
| 580 | 5.8 | 0.58 | 58.30 | 19.24 | 29.04 | 0.66 |
| 600 | 6 | 0.6 | 58.20 | 19.21 | 28.80 | 0.67 |
| 620 | 6.2 | 0.62 | 58.20 | 19.21 | 28.56 | 0.67 |
| 640 | 6.4 | 0.64 | 58.20 | 19.21 | 28.32 | 0.68 |
| 660 | 6.6 | 0.66 | 58.20 | 19.21 | 28.08 | 0.68 |
| 680 | 6.8 | 0.68 | 58.40 | 19.27 | 27.84 | 0.69 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 700 | 7 | 0.7 | 58.20 | 19.21 | 27.60 | 0.70 |
| 720 | 7.2 | 0.72 | 58.20 | 19.21 | 27.36 | 0.70 |
| 740 | 7.4 | 0.74 | 58.00 | 19.14 | 27.12 | 0.71 |
| 760 | 7.6 | 0.76 | 58.00 | 19.14 | 26.88 | 0.71 |
| 780 | 7.8 | 0.78 | 57.80 | 19.07 | 26.64 | 0.72 |
| 800 | 8 | 0.8 | 57.70 | 19.04 | 26.40 | 0.72 |
| 820 | 8.2 | 0.82 | 57.60 | 19.01 | 26.16 | 0.73 |
| 840 | 8.4 | 0.84 | 57.70 | 19.04 | 25.92 | 0.73 |
| 860 | 8.6 | 0.86 | 57.50 | 18.98 | 25.68 | 0.74 |
| 880 | 8.8 | 0.88 | 57.20 | 18.88 | 25.44 | 0.74 |
| 900 | 9 | 0.9 | 57.10 | 18.84 | 25.20 | 0.75 |
| 920 | 9.2 | 0.92 | 57.00 | 18.81 | 24.96 | 0.75 |
| 940 | 9.4 | 0.94 | 57.00 | 18.81 | 24.72 | 0.76 |
| 960 | 9.6 | 0.96 | 56.80 | 18.74 | 24.48 | 0.77 |
| 980 | 9.8 | 0.98 | 56.60 | 18.68 | 24.24 | 0.77 |
| 1000 | 10 | 1 | 56.40 | 18.61 | 24.00 | 0.78 |
| 1020 | 10.2 | 1.02 | 56.20 | 18.55 | 23.76 | 0.78 |
| 1040 | 10.4 | 1.04 | 56.10 | 18.51 | 23.52 | 0.79 |
| 1060 | 10.6 | 1.06 | 56.00 | 18.48 | 23.28 | 0.79 |
| 1080 | 10.8 | 1.08 | 56.00 | 18.48 | 23.04 | 0.80 |
| 1100 | 11 | 1.1 | 56.00 | 18.48 | 22.80 | 0.81 |
| 1120 | 11.2 | 1.12 | 55.60 | 18.35 | 22.56 | 0.81 |
| 1140 | 11.4 | 1.14 | 55.40 | 18.28 | 22.32 | 0.82 |
| 1160 | 11.6 | 1.16 | 55.20 | 18.22 | 22.08 | 0.82 |
| 1180 | 11.8 | 1.18 | 55.20 | 18.22 | 21.84 | 0.83 |
| 1200 | 12 | 1.2 | 54.80 | 18.08 | 21.60 | 0.84 |
| 1220 | 12.2 | 1.22 | 54.40 | 17.95 | 21.36 | 0.84 |

## Appendix B

**Table: B1** Direct Shear Test Readings for ( Soil +1% cement + 0.5 $kg/m^3$ZB) at 0.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 3 | 0.99 | 35.76 | 0.03 |
| 40 | 0.4 | 0.04 | 9 | 2.97 | 35.52 | 0.08 |
| 60 | 0.6 | 0.06 | 10 | 3.30 | 35.28 | 0.09 |
| 80 | 0.8 | 0.08 | 13 | 4.29 | 35.04 | 0.12 |
| 100 | 1 | 0.1 | 14.2 | 4.69 | 34.80 | 0.13 |
| 120 | 1.2 | 0.12 | 15 | 4.95 | 34.56 | 0.14 |
| 140 | 1.4 | 0.14 | 15.8 | 5.21 | 34.32 | 0.15 |
| 160 | 1.6 | 0.16 | 16 | 5.28 | 34.08 | 0.15 |
| 180 | 1.8 | 0.18 | 16.2 | 5.35 | 33.84 | 0.16 |
| 200 | 2 | 0.2 | 16.8 | 5.54 | 33.60 | 0.17 |
| 220 | 2.2 | 0.22 | 17.2 | 5.68 | 33.36 | 0.17 |
| 240 | 2.4 | 0.24 | 17.6 | 5.81 | 33.12 | 0.18 |
| 260 | 2.6 | 0.26 | 18 | 5.94 | 32.88 | 0.18 |
| 280 | 2.8 | 0.28 | 18.4 | 6.07 | 32.64 | 0.19 |
| 300 | 3 | 0.3 | 18.6 | 6.14 | 32.40 | 0.19 |
| 320 | 3.2 | 0.32 | 19 | 6.27 | 32.16 | 0.19 |
| 340 | 3.4 | 0.34 | 19.4 | 6.40 | 31.92 | 0.20 |
| 360 | 3.6 | 0.36 | 19.6 | 6.47 | 31.68 | 0.20 |
| 380 | 3.8 | 0.38 | 19.8 | 6.53 | 31.44 | 0.21 |
| 400 | 4 | 0.4 | 20 | 6.60 | 31.20 | 0.21 |
| 420 | 4.2 | 0.42 | 20.2 | 6.67 | 30.96 | 0.22 |
| 440 | 4.4 | 0.44 | 20.4 | 6.73 | 30.72 | 0.22 |
| 460 | 4.6 | 0.46 | 20.5 | 6.77 | 30.48 | 0.22 |
| 480 | 4.8 | 0.48 | 20.6 | 6.80 | 30.24 | 0.22 |
| 500 | 5 | 0.5 | 20.7 | 6.83 | 30.00 | 0.23 |
| 520 | 5.2 | 0.52 | 20.8 | 6.86 | 29.76 | 0.23 |
| 540 | 5.4 | 0.54 | 20.8 | 6.86 | 29.52 | 0.23 |
| 560 | 5.6 | 0.56 | 20.9 | 6.90 | 29.28 | 0.24 |
| 580 | 5.8 | 0.58 | 20.9 | 6.90 | 29.04 | 0.24 |
| 600 | 6 | 0.6 | 20.8 | 6.86 | 28.80 | 0.24 |
| 620 | 6.2 | 0.62 | 20.8 | 6.86 | 28.56 | 0.24 |
| 640 | 6.4 | 0.64 | 20.8 | 6.86 | 28.32 | 0.24 |
| 660 | 6.6 | 0.66 | 20.7 | 6.83 | 28.08 | 0.24 |
| 680 | 6.8 | 0.68 | 20.6 | 6.80 | 27.84 | 0.24 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 700 | 7 | 0.7 | 20.7 | 6.83 | 27.60 | 0.25 |
| 720 | 7.2 | 0.72 | 20.6 | 6.80 | 27.36 | 0.25 |
| 740 | 7.4 | 0.74 | 20.6 | 6.80 | 27.12 | 0.25 |
| 760 | 7.6 | 0.76 | 20.6 | 6.80 | 26.88 | 0.25 |
| 780 | 7.8 | 0.78 | 20.6 | 6.80 | 26.64 | 0.26 |
| 800 | 8 | 0.8 | 20.6 | 6.80 | 26.40 | 0.26 |
| 820 | 8.2 | 0.82 | 20.6 | 6.80 | 26.16 | 0.26 |
| 840 | 8.4 | 0.84 | 20.5 | 6.77 | 25.92 | 0.26 |
| 860 | 8.6 | 0.86 | 20.5 | 6.77 | 25.68 | 0.26 |
| 880 | 8.8 | 0.88 | 20.5 | 6.77 | 25.44 | 0.27 |
| 900 | 9 | 0.9 | 20.7 | 6.83 | 25.20 | 0.27 |
| 920 | 9.2 | 0.92 | 20.8 | 6.86 | 24.96 | 0.28 |
| 940 | 9.4 | 0.94 | 20.6 | 6.80 | 24.72 | 0.28 |
| 960 | 9.6 | 0.96 | 20.6 | 6.80 | 24.48 | 0.28 |
| 980 | 9.8 | 0.98 | 20.6 | 6.80 | 24.24 | 0.28 |
| 1000 | 10 | 1 | 20.4 | 6.73 | 24.00 | 0.28 |
| 1020 | 10.2 | 1.02 | 20.4 | 6.73 | 23.76 | 0.28 |
| 1040 | 10.4 | 1.04 | 19.8 | 6.53 | 23.52 | 0.28 |
| 1060 | 10.6 | 1.06 | 19.8 | 6.53 | 23.28 | 0.28 |
| 1080 | 10.8 | 1.08 | 19.8 | 6.53 | 23.04 | 0.28 |
| 1100 | 11 | 1.1 | 19.8 | 6.53 | 22.80 | 0.29 |
| 1120 | 11.2 | 1.12 | 19.8 | 6.53 | 22.56 | 0.29 |
| 1140 | 11.4 | 1.14 | 19.4 | 6.40 | 22.32 | 0.29 |
| 1160 | 11.6 | 1.16 | 19 | 6.27 | 22.08 | 0.28 |
| 1180 | 11.8 | 1.18 | 19 | 6.27 | 21.84 | 0.29 |
| 1200 | 12 | 1.2 | 19 | 6.27 | 21.60 | 0.29 |
| 1220 | 12.2 | 1.22 | 19 | 6.27 | 21.36 | 0.29 |

**Table:B2** Direct Shear Test Readings for ( Soil +1% cement + 0.5 $kg/m^3$ZB) at 1.0 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0.0 | 0.0 | 0.0 | 0.0 | 36.0 | 0.00 |
| 0 | 0 | 0 | 0 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 10.6 | 3.43 | 35.76 | 0.10 |
| 40 | 0.4 | 0.04 | 19 | 6.53 | 35.52 | 0.18 |
| 60 | 0.6 | 0.06 | 22 | 8.91 | 35.28 | 0.25 |
| 80 | 0.8 | 0.08 | 25 | 11.29 | 35.04 | 0.32 |
| 100 | 1 | 0.1 | 27.2 | 13.20 | 34.80 | 0.38 |
| 120 | 1.2 | 0.12 | 28.6 | 14.39 | 34.56 | 0.42 |
| 140 | 1.4 | 0.14 | 29.2 | 14.59 | 34.32 | 0.43 |
| 160 | 1.6 | 0.16 | 29.6 | 14.72 | 34.08 | 0.43 |
| 180 | 1.8 | 0.18 | 29.6 | 14.72 | 33.84 | 0.43 |
| 200 | 2 | 0.2 | 29.4 | 14.65 | 33.60 | 0.44 |
| 220 | 2.2 | 0.22 | 28.8 | 14.45 | 33.36 | 0.43 |
| 240 | 2.4 | 0.24 | 27.6 | 14.06 | 33.12 | 0.42 |
| 260 | 2.6 | 0.26 | 26.2 | 13.60 | 32.88 | 0.41 |
| 280 | 2.8 | 0.28 | 25.2 | 13.27 | 32.64 | 0.41 |
| 300 | 3 | 0.3 | 24 | 12.87 | 32.40 | 0.40 |
| 320 | 3.2 | 0.32 | 23.4 | 12.67 | 32.16 | 0.39 |
| 340 | 3.4 | 0.34 | 23 | 12.54 | 31.92 | 0.39 |
| 360 | 3.6 | 0.36 | 22.8 | 12.47 | 31.68 | 0.39 |
| 380 | 3.8 | 0.38 | 22.6 | 12.41 | 31.44 | 0.39 |
| 400 | 4 | 0.4 | 22.4 | 12.34 | 31.20 | 0.40 |
| 420 | 4.2 | 0.42 | 22.5 | 12.38 | 30.96 | 0.40 |
| 440 | 4.4 | 0.44 | 22.4 | 12.34 | 30.72 | 0.40 |
| 460 | 4.6 | 0.46 | 22.6 | 12.41 | 30.48 | 0.41 |
| 480 | 4.8 | 0.48 | 22.6 | 12.41 | 30.24 | 0.41 |
| 500 | 5 | 0.5 | 22.8 | 12.47 | 30.00 | 0.42 |
| 520 | 5.2 | 0.52 | 22.8 | 12.47 | 29.76 | 0.42 |
| 540 | 5.4 | 0.54 | 22.8 | 12.47 | 29.52 | 0.42 |
| 560 | 5.6 | 0.56 | 22.6 | 12.41 | 29.28 | 0.42 |
| 580 | 5.8 | 0.58 | 22.6 | 12.41 | 29.04 | 0.43 |
| 600 | 6 | 0.6 | 22.6 | 12.41 | 28.80 | 0.43 |
| 620 | 6.2 | 0.62 | 22.6 | 12.41 | 28.56 | 0.43 |
| 640 | 6.4 | 0.64 | 22.6 | 12.41 | 28.32 | 0.44 |
| 660 | 6.6 | 0.66 | 22.6 | 12.41 | 28.08 | 0.44 |
| 680 | 6.8 | 0.68 | 22.5 | 12.38 | 27.84 | 0.44 |
| 700 | 7 | 0.7 | 22.5 | 12.38 | 27.60 | 0.45 |
| 720 | 7.2 | 0.72 | 22.5 | 12.38 | 27.36 | 0.45 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 740 | 7.4 | 0.74 | 22.8 | 12.47 | 27.12 | 0.46 |
| 760 | 7.6 | 0.76 | 22.8 | 12.47 | 26.88 | 0.46 |
| 780 | 7.8 | 0.78 | 22.7 | 12.44 | 26.64 | 0.47 |
| 800 | 8 | 0.8 | 22.8 | 12.47 | 26.40 | 0.47 |
| 820 | 8.2 | 0.82 | 23 | 12.54 | 26.16 | 0.48 |
| 840 | 8.4 | 0.84 | 23 | 12.54 | 25.92 | 0.48 |
| 860 | 8.6 | 0.86 | 22.8 | 12.47 | 25.68 | 0.49 |
| 880 | 8.8 | 0.88 | 22.8 | 12.47 | 25.44 | 0.49 |
| 900 | 9 | 0.9 | 22.8 | 12.47 | 25.20 | 0.50 |
| 920 | 9.2 | 0.92 | 22.8 | 12.47 | 24.96 | 0.50 |
| 940 | 9.4 | 0.94 | 22.6 | 12.41 | 24.72 | 0.50 |
| 960 | 9.6 | 0.96 | 22.6 | 12.41 | 24.48 | 0.51 |
| 980 | 9.8 | 0.98 | 22.6 | 12.41 | 24.24 | 0.51 |
| 1000 | 10 | 1 | 22.6 | 12.41 | 24.00 | 0.52 |
| 1020 | 10.2 | 1.02 | 22.6 | 12.41 | 23.76 | 0.52 |
| 1040 | 10.4 | 1.04 | 22.5 | 12.38 | 23.52 | 0.53 |
| 1060 | 10.6 | 1.06 | 22.4 | 12.34 | 23.28 | 0.53 |
| 1080 | 10.8 | 1.08 | 22.4 | 12.34 | 23.04 | 0.54 |
| 1100 | 11 | 1.1 | 22.2 | 12.28 | 22.80 | 0.54 |
| 1120 | 11.2 | 1.12 | 22 | 12.21 | 22.56 | 0.54 |
| 1140 | 11.4 | 1.14 | 22 | 12.21 | 22.32 | 0.55 |
| 1160 | 11.6 | 1.16 | 22 | 12.21 | 22.08 | 0.55 |
| 1180 | 11.8 | 1.18 | 22 | 12.21 | 21.84 | 0.56 |
| 1200 | 12 | 1.2 | 21.8 | 12.14 | 21.60 | 0.56 |
| 1220 | 12.2 | 1.22 | 21.8 | 12.14 | 21.36 | 0.57 |

**Table:B3** Direct Shear Test Readings for ( Soil +1% cement + 0.5 $kg/m^3$ZB) at 1.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 14 | 4.62 | 35.76 | 0.13 |
| 40 | 0.4 | 0.04 | 24 | 7.92 | 35.52 | 0.22 |
| 60 | 0.6 | 0.06 | 30 | 9.90 | 35.28 | 0.28 |
| 80 | 0.8 | 0.08 | 35 | 11.55 | 35.04 | 0.33 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 100 | 1 | 0.1 | 38 | 12.54 | 34.80 | 0.36 |
| 120 | 1.2 | 0.12 | 42 | 13.86 | 34.56 | 0.40 |
| 140 | 1.4 | 0.14 | 44.6 | 14.72 | 34.32 | 0.43 |
| 160 | 1.6 | 0.16 | 45.6 | 15.05 | 34.08 | 0.44 |
| 180 | 1.8 | 0.18 | 46.6 | 15.38 | 33.84 | 0.45 |
| 200 | 2 | 0.2 | 49 | 16.17 | 33.60 | 0.48 |
| 220 | 2.2 | 0.22 | 49.6 | 16.37 | 33.36 | 0.49 |
| 240 | 2.4 | 0.24 | 50.8 | 16.76 | 33.12 | 0.51 |
| 260 | 2.6 | 0.26 | 52.6 | 17.36 | 32.88 | 0.53 |
| 280 | 2.8 | 0.28 | 54.8 | 18.08 | 32.64 | 0.55 |
| 300 | 3 | 0.3 | 55.2 | 18.22 | 32.40 | 0.56 |
| 320 | 3.2 | 0.32 | 55.8 | 18.41 | 32.16 | 0.57 |
| 340 | 3.4 | 0.34 | 57 | 18.81 | 31.92 | 0.59 |
| 360 | 3.6 | 0.36 | 58 | 19.14 | 31.68 | 0.60 |
| 380 | 3.8 | 0.38 | 58.6 | 19.34 | 31.44 | 0.62 |
| 400 | 4 | 0.4 | 59 | 19.47 | 31.20 | 0.62 |
| 420 | 4.2 | 0.42 | 59.6 | 19.67 | 30.96 | 0.64 |
| 440 | 4.4 | 0.44 | 60 | 19.80 | 30.72 | 0.64 |
| 460 | 4.6 | 0.46 | 60.1 | 19.83 | 30.48 | 0.65 |
| 480 | 4.8 | 0.48 | 60.1 | 19.83 | 30.24 | 0.66 |
| 500 | 5 | 0.5 | 60 | 19.80 | 30.00 | 0.66 |
| 520 | 5.2 | 0.52 | 59.8 | 19.73 | 29.76 | 0.66 |
| 540 | 5.4 | 0.54 | 59.6 | 19.67 | 29.52 | 0.67 |
| 560 | 5.6 | 0.56 | 59.2 | 19.54 | 29.28 | 0.67 |
| 580 | 5.8 | 0.58 | 59 | 19.47 | 29.04 | 0.67 |
| 600 | 6 | 0.6 | 58.7 | 19.37 | 28.80 | 0.67 |
| 620 | 6.2 | 0.62 | 57.8 | 19.07 | 28.56 | 0.67 |
| 640 | 6.4 | 0.64 | 57.6 | 19.01 | 28.32 | 0.67 |
| 660 | 6.6 | 0.66 | 57 | 18.81 | 28.08 | 0.67 |
| 680 | 6.8 | 0.68 | 57 | 18.81 | 27.84 | 0.68 |
| 700 | 7 | 0.7 | 57 | 18.81 | 27.60 | 0.68 |
| 720 | 7.2 | 0.72 | 57 | 18.81 | 27.36 | 0.69 |
| 740 | 7.4 | 0.74 | 56.8 | 18.74 | 27.12 | 0.69 |
| 760 | 7.6 | 0.76 | 56.6 | 18.68 | 26.88 | 0.69 |
| 780 | 7.8 | 0.78 | 56.5 | 18.65 | 26.64 | 0.70 |
| 800 | 8 | 0.8 | 56.4 | 18.61 | 26.40 | 0.71 |
| 820 | 8.2 | 0.82 | 56.3 | 18.58 | 26.16 | 0.71 |
| 840 | 8.4 | 0.84 | 56.2 | 18.55 | 25.92 | 0.72 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 860 | 8.6 | 0.86 | 56.2 | 18.55 | 25.68 | 0.72 |
| 880 | 8.8 | 0.88 | 56 | 18.48 | 25.44 | 0.73 |
| 900 | 9 | 0.9 | 56.1 | 18.51 | 25.20 | 0.73 |
| 920 | 9.2 | 0.92 | 56 | 18.48 | 24.96 | 0.74 |
| 940 | 9.4 | 0.94 | 55.8 | 18.41 | 24.72 | 0.74 |
| 960 | 9.6 | 0.96 | 55.6 | 18.35 | 24.48 | 0.75 |
| 980 | 9.8 | 0.98 | 55.4 | 18.28 | 24.24 | 0.75 |
| 1000 | 10 | 1 | 55.2 | 18.22 | 24.00 | 0.76 |
| 1020 | 10.2 | 1.02 | 55 | 18.15 | 23.76 | 0.76 |
| 1040 | 10.4 | 1.04 | 54.9 | 18.12 | 23.52 | 0.77 |
| 1060 | 10.6 | 1.06 | 54.8 | 18.08 | 23.28 | 0.78 |
| 1080 | 10.8 | 1.08 | 54.8 | 18.08 | 23.04 | 0.78 |
| 1100 | 11 | 1.1 | 54.6 | 18.02 | 22.80 | 0.79 |
| 1120 | 11.2 | 1.12 | 54.3 | 17.92 | 22.56 | 0.79 |
| 1140 | 11.4 | 1.14 | 54.3 | 17.92 | 22.32 | 0.80 |
| 1160 | 11.6 | 1.16 | 54.3 | 17.92 | 22.08 | 0.81 |
| 1180 | 11.8 | 1.18 | 54.3 | 17.92 | 21.84 | 0.82 |
| 1200 | 12 | 1.2 | 54.3 | 17.92 | 21.60 | 0.83 |
| 1220 | 12.2 | 1.22 | 54.3 | 17.92 | 21.36 | 0.84 |

**Table:B4** Direct Shear Test Readings for ( Soil +1% cement + 0.75 $kg/m^3$ ZB) at 0.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| | | | | | | |
| 0 | 0 | 0 | 0 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 5 | 1.65 | 35.76 | 0.05 |
| 40 | 0.4 | 0.04 | 10 | 3.30 | 35.52 | 0.09 |
| 60 | 0.6 | 0.06 | 12 | 3.96 | 35.28 | 0.11 |
| 80 | 0.8 | 0.08 | 14 | 4.62 | 35.04 | 0.13 |
| 100 | 1 | 0.1 | 15 | 4.95 | 34.80 | 0.14 |
| 120 | 1.2 | 0.12 | 15.8 | 5.21 | 34.56 | 0.15 |
| 140 | 1.4 | 0.14 | 17 | 5.61 | 34.32 | 0.16 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 160 | 1.6 | 0.16 | 18 | 5.94 | 34.08 | 0.17 |
| 180 | 1.8 | 0.18 | 19 | 6.27 | 33.84 | 0.19 |
| 200 | 2 | 0.2 | 20 | 6.60 | 33.60 | 0.20 |
| 220 | 2.2 | 0.22 | 20.6 | 6.80 | 33.36 | 0.20 |
| 240 | 2.4 | 0.24 | 21 | 6.93 | 33.12 | 0.21 |
| 260 | 2.6 | 0.26 | 21.4 | 7.06 | 32.88 | 0.21 |
| 280 | 2.8 | 0.28 | 21.6 | 7.13 | 32.64 | 0.22 |
| 300 | 3 | 0.3 | 22 | 7.26 | 32.40 | 0.22 |
| 320 | 3.2 | 0.32 | 22.1 | 7.29 | 32.16 | 0.23 |
| 340 | 3.4 | 0.34 | 22.4 | 7.39 | 31.92 | 0.23 |
| 360 | 3.6 | 0.36 | 22.6 | 7.46 | 31.68 | 0.24 |
| 380 | 3.8 | 0.38 | 22.8 | 7.52 | 31.44 | 0.24 |
| 400 | 4 | 0.4 | 22.8 | 7.52 | 31.20 | 0.24 |
| 420 | 4.2 | 0.42 | 22.9 | 7.56 | 30.96 | 0.24 |
| 440 | 4.4 | 0.44 | 23.1 | 7.62 | 30.72 | 0.25 |
| 460 | 4.6 | 0.46 | 23.2 | 7.66 | 30.48 | 0.25 |
| 480 | 4.8 | 0.48 | 23.2 | 7.66 | 30.24 | 0.25 |
| 500 | 5 | 0.5 | 23.2 | 7.66 | 30.00 | 0.26 |
| 520 | 5.2 | 0.52 | 23.2 | 7.66 | 29.76 | 0.26 |
| 540 | 5.4 | 0.54 | 23 | 7.59 | 29.52 | 0.26 |
| 560 | 5.6 | 0.56 | 23 | 7.59 | 29.28 | 0.26 |
| 580 | 5.8 | 0.58 | 23 | 7.59 | 29.04 | 0.26 |
| 600 | 6 | 0.6 | 23 | 7.59 | 28.80 | 0.26 |
| 620 | 6.2 | 0.62 | 22.8 | 7.52 | 28.56 | 0.26 |
| 640 | 6.4 | 0.64 | 22.8 | 7.52 | 28.32 | 0.27 |
| 660 | 6.6 | 0.66 | 22.8 | 7.52 | 28.08 | 0.27 |
| 680 | 6.8 | 0.68 | 22.8 | 7.52 | 27.84 | 0.27 |
| 700 | 7 | 0.7 | 22.4 | 7.39 | 27.60 | 0.27 |
| 720 | 7.2 | 0.72 | 22.4 | 7.39 | 27.36 | 0.27 |
| 740 | 7.4 | 0.74 | 22.2 | 7.33 | 27.12 | 0.27 |
| 760 | 7.6 | 0.76 | 22.2 | 7.33 | 26.88 | 0.27 |
| 780 | 7.8 | 0.78 | 22.1 | 7.29 | 26.64 | 0.27 |
| 800 | 8 | 0.8 | 22 | 7.26 | 26.40 | 0.28 |
| 820 | 8.2 | 0.82 | 22 | 7.26 | 26.16 | 0.28 |
| 840 | 8.4 | 0.84 | 22 | 7.26 | 25.92 | 0.28 |
| 860 | 8.6 | 0.86 | 21.6 | 7.13 | 25.68 | 0.28 |
| 880 | 8.8 | 0.88 | 21.6 | 7.13 | 25.44 | 0.28 |
| 900 | 9 | 0.9 | 21.4 | 7.06 | 25.20 | 0.28 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 920 | 9.2 | 0.92 | 21.4 | 7.06 | 24.96 | 0.28 |
| 940 | 9.4 | 0.94 | 21.2 | 7.00 | 24.72 | 0.28 |
| 960 | 9.6 | 0.96 | 21.2 | 7.00 | 24.48 | 0.29 |
| 980 | 9.8 | 0.98 | 21 | 6.93 | 24.24 | 0.29 |
| 1000 | 10 | 1 | 20.9 | 6.90 | 24.00 | 0.29 |
| 1020 | 10.2 | 1.02 | 20.7 | 6.83 | 23.76 | 0.29 |
| 1040 | 10.4 | 1.04 | 20.7 | 6.83 | 23.52 | 0.29 |
| 1060 | 10.6 | 1.06 | 20.6 | 6.80 | 23.28 | 0.29 |
| 1080 | 10.8 | 1.08 | 20.6 | 6.80 | 23.04 | 0.30 |
| 1100 | 11 | 1.1 | 20.3 | 6.70 | 22.80 | 0.29 |
| 1120 | 11.2 | 1.12 | 20.2 | 6.67 | 22.56 | 0.30 |
| 1140 | 11.4 | 1.14 | 20 | 6.60 | 22.32 | 0.30 |
| 1160 | 11.6 | 1.16 | 20 | 6.60 | 22.08 | 0.30 |
| 1180 | 11.8 | 1.18 | 20 | 6.60 | 21.84 | 0.30 |
| 1200 | 12 | 1.2 | 19.8 | 6.53 | 21.60 | 0.30 |
| 1220 | 12.2 | 1.22 | 19.6 | 6.47 | 21.36 | 0.30 |
| 1240 | 12.4 | 1.24 | 19.4 | 6.40 | 21.12 | 0.30 |

**Table:B5** Direct Shear Test Readings for ( Soil +1% cement + 0.75 $kg/m^3$ZB) at 1.0 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 10 | 3.30 | 35.76 | 0.09 |
| 40 | 0.4 | 0.04 | 18 | 5.94 | 35.52 | 0.17 |
| 60 | 0.6 | 0.06 | 21.8 | 7.19 | 35.28 | 0.20 |
| 80 | 0.8 | 0.08 | 23 | 7.59 | 35.04 | 0.22 |
| 100 | 1 | 0.1 | 24.4 | 8.05 | 34.80 | 0.23 |
| 120 | 1.2 | 0.12 | 26.4 | 8.71 | 34.56 | 0.25 |
| 140 | 1.4 | 0.14 | 27.8 | 9.17 | 34.32 | 0.27 |
| 160 | 1.6 | 0.16 | 29 | 9.57 | 34.08 | 0.28 |
| 180 | 1.8 | 0.18 | 29.8 | 9.83 | 33.84 | 0.29 |
| 200 | 2 | 0.2 | 30.6 | 10.10 | 33.60 | 0.30 |
| 220 | 2.2 | 0.22 | 31 | 10.23 | 33.36 | 0.31 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 240 | 2.4 | 0.24 | 31.8 | 10.49 | 33.12 | 0.32 |
| 260 | 2.6 | 0.26 | 32.2 | 10.63 | 32.88 | 0.32 |
| 280 | 2.8 | 0.28 | 32.8 | 10.82 | 32.64 | 0.33 |
| 300 | 3 | 0.3 | 33.2 | 10.96 | 32.40 | 0.34 |
| 320 | 3.2 | 0.32 | 34 | 11.22 | 32.16 | 0.35 |
| 340 | 3.4 | 0.34 | 34.4 | 11.35 | 31.92 | 0.36 |
| 360 | 3.6 | 0.36 | 34.8 | 11.48 | 31.68 | 0.36 |
| 380 | 3.8 | 0.38 | 35.2 | 11.62 | 31.44 | 0.37 |
| 400 | 4 | 0.4 | 35.8 | 11.81 | 31.20 | 0.38 |
| 420 | 4.2 | 0.42 | 36 | 11.88 | 30.96 | 0.38 |
| 440 | 4.4 | 0.44 | 36.4 | 12.01 | 30.72 | 0.39 |
| 460 | 4.6 | 0.46 | 36.8 | 12.14 | 30.48 | 0.40 |
| 480 | 4.8 | 0.48 | 37 | 12.21 | 30.24 | 0.40 |
| 500 | 5 | 0.5 | 37 | 12.21 | 30.00 | 0.41 |
| 520 | 5.2 | 0.52 | 37.2 | 12.28 | 29.76 | 0.41 |
| 540 | 5.4 | 0.54 | 37.2 | 12.28 | 29.52 | 0.42 |
| 560 | 5.6 | 0.56 | 37.4 | 12.34 | 29.28 | 0.42 |
| 580 | 5.8 | 0.58 | 37.4 | 12.34 | 29.04 | 0.43 |
| 600 | 6 | 0.6 | 37.4 | 12.34 | 28.80 | 0.43 |
| 620 | 6.2 | 0.62 | 37.4 | 12.34 | 28.56 | 0.43 |
| 640 | 6.4 | 0.64 | 37.4 | 12.34 | 28.32 | 0.44 |
| 660 | 6.6 | 0.66 | 37.5 | 12.38 | 28.08 | 0.44 |
| 680 | 6.8 | 0.68 | 37.6 | 12.41 | 27.84 | 0.45 |
| 700 | 7 | 0.7 | 37.5 | 12.38 | 27.60 | 0.45 |
| 720 | 7.2 | 0.72 | 37.4 | 12.34 | 27.36 | 0.45 |
| 740 | 7.4 | 0.74 | 37.3 | 12.31 | 27.12 | 0.45 |
| 760 | 7.6 | 0.76 | 37.4 | 12.34 | 26.88 | 0.46 |
| 780 | 7.8 | 0.78 | 37.4 | 12.34 | 26.64 | 0.46 |
| 800 | 8 | 0.8 | 37.4 | 12.34 | 26.40 | 0.47 |
| 820 | 8.2 | 0.82 | 37.3 | 12.31 | 26.16 | 0.47 |
| 840 | 8.4 | 0.84 | 37.3 | 12.31 | 25.92 | 0.47 |
| 860 | 8.6 | 0.86 | 37.3 | 12.31 | 25.68 | 0.48 |
| 880 | 8.8 | 0.88 | 37 | 12.21 | 25.44 | 0.48 |
| 900 | 9 | 0.9 | 37 | 12.21 | 25.20 | 0.48 |
| 920 | 9.2 | 0.92 | 37 | 12.21 | 24.96 | 0.49 |
| 940 | 9.4 | 0.94 | 37 | 12.21 | 24.72 | 0.49 |
| 960 | 9.6 | 0.96 | 37 | 12.21 | 24.48 | 0.50 |
| 980 | 9.8 | 0.98 | 37 | 12.21 | 24.24 | 0.50 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 1000 | 10 | 1 | 37 | 12.21 | 24.00 | 0.51 |
| 1020 | 10.2 | 1.02 | 36.9 | 12.18 | 23.76 | 0.51 |
| 1040 | 10.4 | 1.04 | 36.6 | 12.08 | 23.52 | 0.51 |
| 1060 | 10.6 | 1.06 | 36.6 | 12.08 | 23.28 | 0.52 |
| 1080 | 10.8 | 1.08 | 36.6 | 12.08 | 23.04 | 0.52 |
| 1100 | 11 | 1.1 | 36.6 | 12.08 | 22.80 | 0.53 |
| 1120 | 11.2 | 1.12 | 36.6 | 12.08 | 22.56 | 0.54 |
| 1140 | 11.4 | 1.14 | 36 | 11.88 | 22.32 | 0.53 |
| 1160 | 11.6 | 1.16 | 36 | 11.88 | 22.08 | 0.54 |
| 1180 | 11.8 | 1.18 | 36 | 11.88 | 21.84 | 0.54 |
| 1200 | 12 | 1.2 | 36 | 11.88 | 21.60 | 0.55 |
| 1220 | 12.2 | 1.22 | 36 | 11.88 | 21.36 | 0.56 |
| 1240 | 12.4 | 1.24 | 36 | 11.88 | 21.12 | 0.56 |

**Table:B6** Direct Shear Test Readings for ( Soil +1% cement + 0.75 $kg/m^3$ZB) at 1.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| | | | | | | |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20.00 | 0.20 | 0.02 | 10.00 | 3.30 | 35.76 | 0.09 |
| 40.00 | 0.40 | 0.04 | 14.60 | 4.82 | 35.52 | 0.14 |
| 60.00 | 0.60 | 0.06 | 25.00 | 8.25 | 35.28 | 0.23 |
| 80.00 | 0.80 | 0.08 | 29.80 | 9.83 | 35.04 | 0.28 |
| 100.00 | 1.00 | 0.10 | 36.60 | 12.08 | 34.80 | 0.35 |
| 120.00 | 1.20 | 0.12 | 42.20 | 13.93 | 34.56 | 0.40 |
| 140.00 | 1.40 | 0.14 | 46.20 | 15.25 | 34.32 | 0.44 |
| 160.00 | 1.60 | 0.16 | 48.00 | 15.84 | 34.08 | 0.46 |
| 180.00 | 1.80 | 0.18 | 49.20 | 16.24 | 33.84 | 0.48 |
| 200.00 | 2.00 | 0.20 | 51.20 | 16.90 | 33.60 | 0.50 |
| 220.00 | 2.20 | 0.22 | 52.20 | 17.23 | 33.36 | 0.52 |
| 240.00 | 2.40 | 0.24 | 52.80 | 17.42 | 33.12 | 0.53 |
| 260.00 | 2.60 | 0.26 | 53.40 | 17.62 | 32.88 | 0.54 |
| 280.00 | 2.80 | 0.28 | 53.90 | 17.79 | 32.64 | 0.54 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 300.00 | 3.00 | 0.30 | 54.20 | 17.89 | 32.40 | 0.55 |
| 320.00 | 3.20 | 0.32 | 54.20 | 17.89 | 32.16 | 0.56 |
| 340.00 | 3.40 | 0.34 | 54.60 | 18.02 | 31.92 | 0.56 |
| 360.00 | 3.60 | 0.36 | 54.60 | 18.02 | 31.68 | 0.57 |
| 380.00 | 3.80 | 0.38 | 54.50 | 17.99 | 31.44 | 0.57 |
| 400.00 | 4.00 | 0.40 | 55.00 | 18.15 | 31.20 | 0.58 |
| 420.00 | 4.20 | 0.42 | 55.20 | 18.22 | 30.96 | 0.59 |
| 440.00 | 4.40 | 0.44 | 55.40 | 18.28 | 30.72 | 0.60 |
| 460.00 | 4.60 | 0.46 | 55.40 | 18.28 | 30.48 | 0.60 |
| 480.00 | 4.80 | 0.48 | 55.40 | 18.28 | 30.24 | 0.60 |
| 500.00 | 5.00 | 0.50 | 55.20 | 18.22 | 30.00 | 0.61 |
| 520.00 | 5.20 | 0.52 | 55.20 | 18.22 | 29.76 | 0.61 |
| 540.00 | 5.40 | 0.54 | 55.10 | 18.18 | 29.52 | 0.62 |
| 560.00 | 5.60 | 0.56 | 55.00 | 18.15 | 29.28 | 0.62 |
| 580.00 | 5.80 | 0.58 | 55.10 | 18.18 | 29.04 | 0.63 |
| 600.00 | 6.00 | 0.60 | 55.30 | 18.25 | 28.80 | 0.63 |
| 620.00 | 6.20 | 0.62 | 55.30 | 18.25 | 28.56 | 0.64 |
| 640.00 | 6.40 | 0.64 | 55.20 | 18.22 | 28.32 | 0.64 |
| 660.00 | 6.60 | 0.66 | 55.40 | 18.28 | 28.08 | 0.65 |
| 680.00 | 6.80 | 0.68 | 55.60 | 18.35 | 27.84 | 0.66 |
| 700.00 | 7.00 | 0.70 | 55.70 | 18.38 | 27.60 | 0.67 |
| 720.00 | 7.20 | 0.72 | 55.60 | 18.35 | 27.36 | 0.67 |
| 740.00 | 7.40 | 0.74 | 55.60 | 18.35 | 27.12 | 0.68 |
| 760.00 | 7.60 | 0.76 | 55.80 | 18.41 | 26.88 | 0.69 |
| 780.00 | 7.80 | 0.78 | 55.70 | 18.38 | 26.64 | 0.69 |
| 800.00 | 8.00 | 0.80 | 55.60 | 18.35 | 26.40 | 0.70 |
| 820.00 | 8.20 | 0.82 | 55.60 | 18.35 | 26.16 | 0.70 |
| 840.00 | 8.40 | 0.84 | 55.80 | 18.41 | 25.92 | 0.71 |
| 860.00 | 8.60 | 0.86 | 55.80 | 18.41 | 25.68 | 0.72 |
| 880.00 | 8.80 | 0.88 | 55.60 | 18.35 | 25.44 | 0.72 |
| 900.00 | 9.00 | 0.90 | 55.80 | 18.41 | 25.20 | 0.73 |
| 920.00 | 9.20 | 0.92 | 55.80 | 18.41 | 24.96 | 0.74 |
| 940.00 | 9.40 | 0.94 | 55.80 | 18.41 | 24.72 | 0.74 |
| 960.00 | 9.60 | 0.96 | 55.80 | 18.41 | 24.48 | 0.75 |
| 980.00 | 9.80 | 0.98 | 55.70 | 18.38 | 24.24 | 0.76 |
| 1000.00 | 10.00 | 1.00 | 55.80 | 18.41 | 24.00 | 0.77 |
| 1020.00 | 10.20 | 1.02 | 56.00 | 18.48 | 23.76 | 0.78 |
| 1040.00 | 10.40 | 1.04 | 56.00 | 18.48 | 23.52 | 0.79 |
| 1060.00 | 10.60 | 1.06 | 56.20 | 18.55 | 23.28 | 0.80 |
| 1080.00 | 10.80 | 1.08 | 56.40 | 18.61 | 23.04 | 0.81 |
| 1100.00 | 11.00 | 1.10 | 56.60 | 18.68 | 22.80 | 0.82 |
| 1120.00 | 11.20 | 1.12 | 56.70 | 18.71 | 22.56 | 0.83 |
| 1140.00 | 11.40 | 1.14 | 56.60 | 18.68 | 22.32 | 0.84 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1160.00 | 11.60 | 1.16 | 56.60 | 18.68 | 22.08 | 0.85 |
| 1180.00 | 11.80 | 1.18 | 56.50 | 18.65 | 21.84 | 0.85 |
| 1200.00 | 12.00 | 1.20 | 56.40 | 18.61 | 21.60 | 0.86 |
| 1220.00 | 12.20 | 1.22 | 56.40 | 18.61 | 21.36 | 0.87 |
| 1240.00 | 12.40 | 1.24 | 56.40 | 18.61 | 21.12 | 0.88 |

**Table:B7** Direct Shear Test Readings for ( Soil +1% cement + 1.0 kg/m$^3$) at 0.5 kg/cm$^2$

| **Dial Gauge Reading (D) (div)** | **Horizontal Displacement (0.01 mm/div*D)** | | **Stress Dial Reading (div)** | **Shear Force (0.33*stress dial reading) (kg)** | **Corrected Area (cm$^2$)** | **Shear Stress (kg/cm$^2$)** |
|---|---|---|---|---|---|---|
| | **mm** | **cm** | | | | |
| | | | | | | |
| 0 | 0 | 0 | 0 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 2.8 | 0.92 | 35.76 | 0.03 |
| 40 | 0.4 | 0.04 | 5.2 | 1.72 | 35.52 | 0.05 |
| 60 | 0.6 | 0.06 | 9 | 2.97 | 35.28 | 0.08 |
| 80 | 0.8 | 0.08 | 13 | 4.29 | 35.04 | 0.12 |
| 100 | 1 | 0.1 | 15.4 | 5.08 | 34.80 | 0.15 |
| 120 | 1.2 | 0.12 | 17.4 | 5.74 | 34.56 | 0.17 |
| 140 | 1.4 | 0.14 | 18.4 | 6.07 | 34.32 | 0.18 |
| 160 | 1.6 | 0.16 | 19.2 | 6.34 | 34.08 | 0.19 |
| 180 | 1.8 | 0.18 | 19.8 | 6.53 | 33.84 | 0.19 |
| 200 | 2 | 0.2 | 20.4 | 6.73 | 33.60 | 0.20 |
| 220 | 2.2 | 0.22 | 20.8 | 6.86 | 33.36 | 0.21 |
| 240 | 2.4 | 0.24 | 21.2 | 7.00 | 33.12 | 0.21 |
| 260 | 2.6 | 0.26 | 21.4 | 7.06 | 32.88 | 0.21 |
| 280 | 2.8 | 0.28 | 21.4 | 7.06 | 32.64 | 0.22 |
| 300 | 3 | 0.3 | 21.6 | 7.13 | 32.40 | 0.22 |
| 320 | 3.2 | 0.32 | 21.8 | 7.19 | 32.16 | 0.22 |
| 340 | 3.4 | 0.34 | 21.7 | 7.16 | 31.92 | 0.22 |
| 360 | 3.6 | 0.36 | 21.8 | 7.19 | 31.68 | 0.23 |
| 380 | 3.8 | 0.38 | 21.8 | 7.19 | 31.44 | 0.23 |
| 400 | 4 | 0.4 | 21.8 | 7.19 | 31.20 | 0.23 |
| 420 | 4.2 | 0.42 | 21.8 | 7.19 | 30.96 | 0.23 |
| 440 | 4.4 | 0.44 | 21.7 | 7.16 | 30.72 | 0.23 |
| 460 | 4.6 | 0.46 | 21.6 | 7.13 | 30.48 | 0.23 |
| 480 | 4.8 | 0.48 | 21.4 | 7.06 | 30.24 | 0.23 |
| 500 | 5 | 0.5 | 21.5 | 7.10 | 30.00 | 0.24 |
| 520 | 5.2 | 0.52 | 21.4 | 7.06 | 29.76 | 0.24 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 540 | 5.4 | 0.54 | 21.3 | 7.03 | 29.52 | 0.24 |
| 560 | 5.6 | 0.56 | 21.2 | 7.00 | 29.28 | 0.24 |
| 580 | 5.8 | 0.58 | 21.1 | 6.96 | 29.04 | 0.24 |
| 600 | 6 | 0.6 | 21 | 6.93 | 28.80 | 0.24 |
| 620 | 6.2 | 0.62 | 21 | 6.93 | 28.56 | 0.24 |
| 640 | 6.4 | 0.64 | 20.9 | 6.90 | 28.32 | 0.24 |
| 660 | 6.6 | 0.66 | 20.9 | 6.90 | 28.08 | 0.25 |
| 680 | 6.8 | 0.68 | 20.9 | 6.90 | 27.84 | 0.25 |
| 700 | 7 | 0.7 | 20.9 | 6.90 | 27.60 | 0.25 |
| 720 | 7.2 | 0.72 | 20.8 | 6.86 | 27.36 | 0.25 |
| 740 | 7.4 | 0.74 | 20.8 | 6.86 | 27.12 | 0.25 |
| 760 | 7.6 | 0.76 | 20.8 | 6.86 | 26.88 | 0.26 |
| 780 | 7.8 | 0.78 | 20.8 | 6.86 | 26.64 | 0.26 |
| 800 | 8 | 0.8 | 20.7 | 6.83 | 26.40 | 0.26 |
| 820 | 8.2 | 0.82 | 20.7 | 6.83 | 26.16 | 0.26 |
| 840 | 8.4 | 0.84 | 20.7 | 6.83 | 25.92 | 0.26 |
| 860 | 8.6 | 0.86 | 20.6 | 6.80 | 25.68 | 0.26 |
| 880 | 8.8 | 0.88 | 20.6 | 6.80 | 25.44 | 0.27 |
| 900 | 9 | 0.9 | 20.6 | 6.80 | 25.20 | 0.27 |
| 920 | 9.2 | 0.92 | 20.6 | 6.80 | 24.96 | 0.27 |
| 940 | 9.4 | 0.94 | 20.6 | 6.80 | 24.72 | 0.28 |
| 960 | 9.6 | 0.96 | 20.5 | 6.77 | 24.48 | 0.28 |
| 980 | 9.8 | 0.98 | 20.5 | 6.77 | 24.24 | 0.28 |
| 1000 | 10 | 1 | 20.5 | 6.77 | 24.00 | 0.28 |
| 1020 | 10.2 | 1.02 | 20.4 | 6.73 | 23.76 | 0.28 |
| 1040 | 10.4 | 1.04 | 20.2 | 6.67 | 23.52 | 0.28 |
| 1060 | 10.6 | 1.06 | 20.2 | 6.67 | 23.28 | 0.29 |
| 1080 | 10.8 | 1.08 | 20 | 6.60 | 23.04 | 0.29 |
| 1100 | 11 | 1.1 | 20.1 | 6.63 | 22.80 | 0.29 |
| 1120 | 11.2 | 1.12 | 20 | 6.60 | 22.56 | 0.29 |
| 1140 | 11.4 | 1.14 | 19.8 | 6.53 | 22.32 | 0.29 |
| 1160 | 11.6 | 1.16 | 19.8 | 6.53 | 22.08 | 0.30 |
| 1180 | 11.8 | 1.18 | 19.8 | 6.53 | 21.84 | 0.30 |
| 1200 | 12 | 1.2 | 19.8 | 6.53 | 21.60 | 0.30 |
| 1220 | 12.2 | 1.22 | 19.6 | 6.47 | 21.36 | 0.30 |
| 1240 | 12.4 | 1.24 | 19.6 | 6.47 | 21.12 | 0.31 |
| 1260 | 12.6 | 1.26 | 19.6 | 6.47 | 20.88 | 0.31 |

**Table:B8**Direct Shear Test Readings for ( Soil +1% cement + 1.0 kg/$m^3$) at 1.0 kg/$cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 7.6 | 2.51 | 35.76 | 0.07 |
| 40 | 0.4 | 0.04 | 14.2 | 4.69 | 35.52 | 0.13 |
| 60 | 0.6 | 0.06 | 20.9 | 6.90 | 35.28 | 0.20 |
| 80 | 0.8 | 0.08 | 24 | 7.92 | 35.04 | 0.23 |
| 100 | 1 | 0.1 | 26.4 | 8.71 | 34.80 | 0.25 |
| 120 | 1.2 | 0.12 | 28.1 | 9.27 | 34.56 | 0.27 |
| 140 | 1.4 | 0.14 | 29.4 | 9.70 | 34.32 | 0.28 |
| 160 | 1.6 | 0.16 | 30.4 | 10.03 | 34.08 | 0.29 |
| 180 | 1.8 | 0.18 | 31.2 | 10.30 | 33.84 | 0.30 |
| 200 | 2 | 0.2 | 31.8 | 10.49 | 33.60 | 0.31 |
| 220 | 2.2 | 0.22 | 32.4 | 10.69 | 33.36 | 0.32 |
| 240 | 2.4 | 0.24 | 33 | 10.89 | 33.12 | 0.33 |
| 260 | 2.6 | 0.26 | 33.4 | 11.02 | 32.88 | 0.34 |
| 280 | 2.8 | 0.28 | 33.8 | 11.15 | 32.64 | 0.34 |
| 300 | 3 | 0.3 | 34.4 | 11.35 | 32.40 | 0.35 |
| 320 | 3.2 | 0.32 | 34.8 | 11.48 | 32.16 | 0.36 |
| 340 | 3.4 | 0.34 | 35 | 11.55 | 31.92 | 0.36 |
| 360 | 3.6 | 0.36 | 35.4 | 11.68 | 31.68 | 0.37 |
| 380 | 3.8 | 0.38 | 35.5 | 11.72 | 31.44 | 0.37 |
| 400 | 4 | 0.4 | 35.7 | 11.78 | 31.20 | 0.38 |
| 420 | 4.2 | 0.42 | 35.8 | 11.81 | 30.96 | 0.38 |
| 440 | 4.4 | 0.44 | 35.8 | 11.81 | 30.72 | 0.38 |
| 460 | 4.6 | 0.46 | 36 | 11.88 | 30.48 | 0.39 |
| 480 | 4.8 | 0.48 | 36.1 | 11.91 | 30.24 | 0.39 |
| 500 | 5 | 0.5 | 36.2 | 11.95 | 30.00 | 0.40 |
| 520 | 5.2 | 0.52 | 36.2 | 11.95 | 29.76 | 0.40 |
| 540 | 5.4 | 0.54 | 36.2 | 11.95 | 29.52 | 0.40 |
| 560 | 5.6 | 0.56 | 36.2 | 11.95 | 29.28 | 0.41 |
| 580 | 5.8 | 0.58 | 36.2 | 11.95 | 29.04 | 0.41 |
| 600 | 6 | 0.6 | 36.2 | 11.95 | 28.80 | 0.41 |
| 620 | 6.2 | 0.62 | 36.4 | 12.01 | 28.56 | 0.42 |
| 640 | 6.4 | 0.64 | 36.4 | 12.01 | 28.32 | 0.42 |
| 660 | 6.6 | 0.66 | 36.4 | 12.01 | 28.08 | 0.43 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 680 | 6.8 | 0.68 | 36.5 | 12.05 | 27.84 | 0.43 |
| 700 | 7 | 0.7 | 36.4 | 12.01 | 27.60 | 0.44 |
| 720 | 7.2 | 0.72 | 36.2 | 11.95 | 27.36 | 0.44 |
| 740 | 7.4 | 0.74 | 36.1 | 11.91 | 27.12 | 0.44 |
| 760 | 7.6 | 0.76 | 36 | 11.88 | 26.88 | 0.44 |
| 780 | 7.8 | 0.78 | 35.8 | 11.81 | 26.64 | 0.44 |
| 800 | 8 | 0.8 | 35.8 | 11.81 | 26.40 | 0.45 |
| 820 | 8.2 | 0.82 | 35.7 | 11.78 | 26.16 | 0.45 |
| 840 | 8.4 | 0.84 | 35.7 | 11.78 | 25.92 | 0.45 |
| 860 | 8.6 | 0.86 | 35.7 | 11.78 | 25.68 | 0.46 |
| 880 | 8.8 | 0.88 | 35.6 | 11.75 | 25.44 | 0.46 |
| 900 | 9 | 0.9 | 35.6 | 11.75 | 25.20 | 0.47 |
| 920 | 9.2 | 0.92 | 35.6 | 11.75 | 24.96 | 0.47 |
| 940 | 9.4 | 0.94 | 35.6 | 11.75 | 24.72 | 0.48 |
| 960 | 9.6 | 0.96 | 35.6 | 11.75 | 24.48 | 0.48 |
| 980 | 9.8 | 0.98 | 35.6 | 11.75 | 24.24 | 0.48 |
| 1000 | 10 | 1 | 35.6 | 11.75 | 24.00 | 0.49 |
| 1020 | 10.2 | 1.02 | 35.6 | 11.75 | 23.76 | 0.49 |
| 1040 | 10.4 | 1.04 | 35.6 | 11.75 | 23.52 | 0.50 |
| 1060 | 10.6 | 1.06 | 35.6 | 11.75 | 23.28 | 0.50 |
| 1080 | 10.8 | 1.08 | 35.6 | 11.75 | 23.04 | 0.51 |
| 1100 | 11 | 1.1 | 35.6 | 11.75 | 22.80 | 0.52 |
| 1120 | 11.2 | 1.12 | 35.6 | 11.75 | 22.56 | 0.52 |
| 1140 | 11.4 | 1.14 | 35.4 | 11.68 | 22.32 | 0.52 |
| 1160 | 11.6 | 1.16 | 35.4 | 11.68 | 22.08 | 0.53 |
| 1180 | 11.8 | 1.18 | 35.4 | 11.68 | 21.84 | 0.53 |
| 1200 | 12 | 1.2 | 35.4 | 11.68 | 21.60 | 0.54 |
| 1220 | 12.2 | 1.22 | 35.4 | 11.68 | 21.36 | 0.55 |
| 1240 | 12.4 | 1.24 | 35.4 | 11.68 | 21.12 | 0.55 |
| 1260 | 12.6 | 1.26 | 35.4 | 11.68 | 20.88 | 0.56 |

**Table:B9** Direct Shear Test Readings for ( Soil +1% cement + 1.0 $kg/m^3$) at 1.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 10 | 3.30 | 35.76 | 0.09 |
| 40 | 0.4 | 0.04 | 18.2 | 6.01 | 35.52 | 0.17 |
| 60 | 0.6 | 0.06 | 29.2 | 9.64 | 35.28 | 0.27 |
| 80 | 0.8 | 0.08 | 36.6 | 12.08 | 35.04 | 0.34 |
| 100 | 1 | 0.1 | 40.1 | 13.23 | 34.80 | 0.38 |
| 120 | 1.2 | 0.12 | 43.8 | 14.45 | 34.56 | 0.42 |
| 140 | 1.4 | 0.14 | 46.2 | 15.25 | 34.32 | 0.44 |
| 160 | 1.6 | 0.16 | 48.4 | 15.97 | 34.08 | 0.47 |
| 180 | 1.8 | 0.18 | 50.2 | 16.57 | 33.84 | 0.49 |
| 200 | 2 | 0.2 | 51.6 | 17.03 | 33.60 | 0.51 |
| 220 | 2.2 | 0.22 | 53 | 17.49 | 33.36 | 0.52 |
| 240 | 2.4 | 0.24 | 54.2 | 17.89 | 33.12 | 0.54 |
| 260 | 2.6 | 0.26 | 55.2 | 18.22 | 32.88 | 0.55 |
| 280 | 2.8 | 0.28 | 56.2 | 18.55 | 32.64 | 0.57 |
| 300 | 3 | 0.3 | 57 | 18.81 | 32.40 | 0.58 |
| 320 | 3.2 | 0.32 | 57.6 | 19.01 | 32.16 | 0.59 |
| 340 | 3.4 | 0.34 | 58.2 | 19.21 | 31.92 | 0.60 |
| 360 | 3.6 | 0.36 | 58.7 | 19.37 | 31.68 | 0.61 |
| 380 | 3.8 | 0.38 | 59 | 19.47 | 31.44 | 0.62 |
| 400 | 4 | 0.4 | 59.4 | 19.60 | 31.20 | 0.63 |
| 420 | 4.2 | 0.42 | 59.6 | 19.67 | 30.96 | 0.64 |
| 440 | 4.4 | 0.44 | 59.8 | 19.73 | 30.72 | 0.64 |
| 460 | 4.6 | 0.46 | 60 | 19.80 | 30.48 | 0.65 |
| 480 | 4.8 | 0.48 | 60.4 | 19.93 | 30.24 | 0.66 |
| 500 | 5 | 0.5 | 60.4 | 19.93 | 30.00 | 0.66 |
| 520 | 5.2 | 0.52 | 60.3 | 19.90 | 29.76 | 0.67 |
| 540 | 5.4 | 0.54 | 60.4 | 19.93 | 29.52 | 0.68 |
| 560 | 5.6 | 0.56 | 60.4 | 19.93 | 29.28 | 0.68 |
| 580 | 5.8 | 0.58 | 60.4 | 19.93 | 29.04 | 0.69 |
| 600 | 6 | 0.6 | 60.1 | 19.83 | 28.80 | 0.69 |
| 620 | 6.2 | 0.62 | 60 | 19.80 | 28.56 | 0.69 |
| 640 | 6.4 | 0.64 | 59.9 | 19.77 | 28.32 | 0.70 |
| 660 | 6.6 | 0.66 | 59.6 | 19.67 | 28.08 | 0.70 |
| 680 | 6.8 | 0.68 | 59.6 | 19.67 | 27.84 | 0.71 |
| 700 | 7 | 0.7 | 59.4 | 19.60 | 27.60 | 0.71 |
| 720 | 7.2 | 0.72 | 59.4 | 19.60 | 27.36 | 0.72 |
| 740 | 7.4 | 0.74 | 59.5 | 19.64 | 27.12 | 0.72 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 760 | 7.6 | 0.76 | 59.4 | 19.60 | 26.88 | 0.73 |
| 780 | 7.8 | 0.78 | 59.2 | 19.54 | 26.64 | 0.73 |
| 800 | 8 | 0.8 | 59.2 | 19.54 | 26.40 | 0.74 |
| 820 | 8.2 | 0.82 | 59.1 | 19.50 | 26.16 | 0.75 |
| 840 | 8.4 | 0.84 | 59 | 19.47 | 25.92 | 0.75 |
| 860 | 8.6 | 0.86 | 59 | 19.47 | 25.68 | 0.76 |
| 880 | 8.8 | 0.88 | 59 | 19.47 | 25.44 | 0.77 |
| 900 | 9 | 0.9 | 59 | 19.47 | 25.20 | 0.77 |
| 920 | 9.2 | 0.92 | 58.8 | 19.40 | 24.96 | 0.78 |
| 940 | 9.4 | 0.94 | 58.4 | 19.27 | 24.72 | 0.78 |
| 960 | 9.6 | 0.96 | 58.4 | 19.27 | 24.48 | 0.79 |
| 980 | 9.8 | 0.98 | 58.2 | 19.21 | 24.24 | 0.79 |
| 1000 | 10 | 1 | 58 | 19.14 | 24.00 | 0.80 |
| 1020 | 10.2 | 1.02 | 58.1 | 19.17 | 23.76 | 0.81 |
| 1040 | 10.4 | 1.04 | 58 | 19.14 | 23.52 | 0.81 |
| 1060 | 10.6 | 1.06 | 57.6 | 19.01 | 23.28 | 0.82 |
| 1080 | 10.8 | 1.08 | 57.6 | 19.01 | 23.04 | 0.83 |
| 1100 | 11 | 1.1 | 57.5 | 18.98 | 22.80 | 0.83 |
| 1120 | 11.2 | 1.12 | 57.2 | 18.88 | 22.56 | 0.84 |
| 1140 | 11.4 | 1.14 | 57.1 | 18.84 | 22.32 | 0.84 |
| 1160 | 11.6 | 1.16 | 57.2 | 18.88 | 22.08 | 0.85 |
| 1180 | 11.8 | 1.18 | 57.1 | 18.84 | 21.84 | 0.86 |
| 1200 | 12 | 1.2 | 57 | 18.81 | 21.60 | 0.87 |
| 1220 | 12.2 | 1.22 | 57 | 18.81 | 21.36 | 0.88 |
| 1240 | 12.4 | 1.24 | 57 | 18.81 | 21.12 | 0.89 |

**Table:B10** Direct Shear Test Readings for ( Soil +1% cement + 1.25 $kg/m^3$) at 0.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 6.2 | 2.05 | 35.76 | 0.06 |
| 40 | 0.4 | 0.04 | 9.6 | 3.17 | 35.52 | 0.09 |
| 60 | 0.6 | 0.06 | 12.2 | 4.03 | 35.28 | 0.11 |
| 80 | 0.8 | 0.08 | 14.2 | 4.69 | 35.04 | 0.13 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 100 | 1 | 0.1 | 16.8 | 5.54 | 34.80 | 0.16 |
| 120 | 1.2 | 0.12 | 17.4 | 5.74 | 34.56 | 0.17 |
| 140 | 1.4 | 0.14 | 18.6 | 6.14 | 34.32 | 0.18 |
| 160 | 1.6 | 0.16 | 18.8 | 6.20 | 34.08 | 0.18 |
| 180 | 1.8 | 0.18 | 19.2 | 6.34 | 33.84 | 0.19 |
| 200 | 2 | 0.2 | 19.4 | 6.40 | 33.60 | 0.19 |
| 220 | 2.2 | 0.22 | 19.6 | 6.47 | 33.36 | 0.19 |
| 240 | 2.4 | 0.24 | 19.8 | 6.53 | 33.12 | 0.20 |
| 260 | 2.6 | 0.26 | 20 | 6.60 | 32.88 | 0.20 |
| 280 | 2.8 | 0.28 | 20.2 | 6.67 | 32.64 | 0.20 |
| 300 | 3 | 0.3 | 20.4 | 6.73 | 32.40 | 0.21 |
| 320 | 3.2 | 0.32 | 20.6 | 6.80 | 32.16 | 0.21 |
| 340 | 3.4 | 0.34 | 20.8 | 6.86 | 31.92 | 0.22 |
| 360 | 3.6 | 0.36 | 20.8 | 6.86 | 31.68 | 0.22 |
| 380 | 3.8 | 0.38 | 20.9 | 6.90 | 31.44 | 0.22 |
| 400 | 4 | 0.4 | 21 | 6.93 | 31.20 | 0.22 |
| 420 | 4.2 | 0.42 | 21.2 | 7.00 | 30.96 | 0.23 |
| 440 | 4.4 | 0.44 | 21.3 | 7.03 | 30.72 | 0.23 |
| 460 | 4.6 | 0.46 | 21.4 | 7.06 | 30.48 | 0.23 |
| 480 | 4.8 | 0.48 | 21.4 | 7.06 | 30.24 | 0.23 |
| 500 | 5 | 0.5 | 21.6 | 7.13 | 30.00 | 0.24 |
| 520 | 5.2 | 0.52 | 21.4 | 7.06 | 29.76 | 0.24 |
| 540 | 5.4 | 0.54 | 21.4 | 7.06 | 29.52 | 0.24 |
| 560 | 5.6 | 0.56 | 21.5 | 7.10 | 29.28 | 0.24 |
| 580 | 5.8 | 0.58 | 21.4 | 7.06 | 29.04 | 0.24 |
| 600 | 6 | 0.6 | 21.2 | 7.00 | 28.80 | 0.24 |
| 620 | 6.2 | 0.62 | 21.2 | 7.00 | 28.56 | 0.24 |
| 640 | 6.4 | 0.64 | 21.2 | 7.00 | 28.32 | 0.25 |
| 660 | 6.6 | 0.66 | 21.2 | 7.00 | 28.08 | 0.25 |
| 680 | 6.8 | 0.68 | 21.2 | 7.00 | 27.84 | 0.25 |
| 700 | 7 | 0.7 | 21.2 | 7.00 | 27.60 | 0.25 |
| 720 | 7.2 | 0.72 | 21.4 | 7.06 | 27.36 | 0.26 |
| 740 | 7.4 | 0.74 | 21.3 | 7.03 | 27.12 | 0.26 |
| 760 | 7.6 | 0.76 | 21.2 | 7.00 | 26.88 | 0.26 |
| 780 | 7.8 | 0.78 | 21.3 | 7.03 | 26.64 | 0.26 |
| 800 | 8 | 0.8 | 21.2 | 7.00 | 26.40 | 0.27 |
| 820 | 8.2 | 0.82 | 21.2 | 7.00 | 26.16 | 0.27 |
| 840 | 8.4 | 0.84 | 21.1 | 6.96 | 25.92 | 0.27 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 860 | 8.6 | 0.86 | 21 | 6.93 | 25.68 | 0.27 |
| 880 | 8.8 | 0.88 | 21 | 6.93 | 25.44 | 0.27 |
| 900 | 9 | 0.9 | 21 | 6.93 | 25.20 | 0.28 |
| 920 | 9.2 | 0.92 | 21 | 6.93 | 24.96 | 0.28 |
| 940 | 9.4 | 0.94 | 20.8 | 6.86 | 24.72 | 0.28 |
| 960 | 9.6 | 0.96 | 20.6 | 6.80 | 24.48 | 0.28 |
| 980 | 9.8 | 0.98 | 20.5 | 6.77 | 24.24 | 0.28 |
| 1000 | 10 | 1 | 20.4 | 6.73 | 24.00 | 0.28 |
| 1020 | 10.2 | 1.02 | 20.4 | 6.73 | 23.76 | 0.28 |
| 1040 | 10.4 | 1.04 | 20.2 | 6.67 | 23.52 | 0.28 |
| 1060 | 10.6 | 1.06 | 20.2 | 6.67 | 23.28 | 0.29 |
| 1080 | 10.8 | 1.08 | 20.2 | 6.67 | 23.04 | 0.29 |
| 1100 | 11 | 1.1 | 20.2 | 6.67 | 22.80 | 0.29 |
| 1120 | 11.2 | 1.12 | 20 | 6.60 | 22.56 | 0.29 |
| 1140 | 11.4 | 1.14 | 19.8 | 6.53 | 22.32 | 0.29 |
| 1160 | 11.6 | 1.16 | 19.6 | 6.47 | 22.08 | 0.29 |
| 1180 | 11.8 | 1.18 | 19.2 | 6.34 | 21.84 | 0.29 |
| 1200 | 12 | 1.2 | 19.1 | 6.30 | 21.60 | 0.29 |
| 1220 | 12.2 | 1.22 | 19 | 6.27 | 21.36 | 0.29 |
| 1240 | 12.4 | 1.24 | 19 | 6.27 | 21.12 | 0.30 |

**Table:B11** Direct Shear Test Readings for ( Soil +1% cement + 1.25 $kg/m^3$) at 1.0 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 9 | 2.97 | 35.76 | 0.08 |
| 40 | 0.4 | 0.04 | 16 | 5.28 | 35.52 | 0.15 |
| 60 | 0.6 | 0.06 | 19.8 | 6.53 | 35.28 | 0.19 |
| 80 | 0.8 | 0.08 | 21.2 | 7.00 | 35.04 | 0.20 |
| 100 | 1 | 0.1 | 22.8 | 7.52 | 34.80 | 0.22 |
| 120 | 1.2 | 0.12 | 24.6 | 8.12 | 34.56 | 0.23 |
| 140 | 1.4 | 0.14 | 26.8 | 8.84 | 34.32 | 0.26 |
| 160 | 1.6 | 0.16 | 28.2 | 9.31 | 34.08 | 0.27 |
| 180 | 1.8 | 0.18 | 29.6 | 9.77 | 33.84 | 0.29 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 200 | 2 | 0.2 | 30.8 | 10.16 | 33.60 | 0.30 |
| 220 | 2.2 | 0.22 | 31.5 | 10.40 | 33.36 | 0.31 |
| 240 | 2.4 | 0.24 | 32.4 | 10.69 | 33.12 | 0.32 |
| 260 | 2.6 | 0.26 | 33 | 10.89 | 32.88 | 0.33 |
| 280 | 2.8 | 0.28 | 33.6 | 11.09 | 32.64 | 0.34 |
| 300 | 3 | 0.3 | 34.4 | 11.35 | 32.40 | 0.35 |
| 320 | 3.2 | 0.32 | 34.8 | 11.48 | 32.16 | 0.36 |
| 340 | 3.4 | 0.34 | 35.2 | 11.62 | 31.92 | 0.36 |
| 360 | 3.6 | 0.36 | 35.8 | 11.81 | 31.68 | 0.37 |
| 380 | 3.8 | 0.38 | 36 | 11.88 | 31.44 | 0.38 |
| 400 | 4 | 0.4 | 36.4 | 12.01 | 31.20 | 0.39 |
| 420 | 4.2 | 0.42 | 36.6 | 12.08 | 30.96 | 0.39 |
| 440 | 4.4 | 0.44 | 37 | 12.21 | 30.72 | 0.40 |
| 460 | 4.6 | 0.46 | 37.4 | 12.34 | 30.48 | 0.40 |
| 480 | 4.8 | 0.48 | 37.6 | 12.41 | 30.24 | 0.41 |
| 500 | 5 | 0.5 | 37.8 | 12.47 | 30.00 | 0.42 |
| 520 | 5.2 | 0.52 | 37.9 | 12.51 | 29.76 | 0.42 |
| 540 | 5.4 | 0.54 | 38 | 12.54 | 29.52 | 0.42 |
| 560 | 5.6 | 0.56 | 38.1 | 12.57 | 29.28 | 0.43 |
| 580 | 5.8 | 0.58 | 38.2 | 12.61 | 29.04 | 0.43 |
| 600 | 6 | 0.6 | 38.2 | 12.61 | 28.80 | 0.44 |
| 620 | 6.2 | 0.62 | 38.2 | 12.61 | 28.56 | 0.44 |
| 640 | 6.4 | 0.64 | 38.2 | 12.61 | 28.32 | 0.45 |
| 660 | 6.6 | 0.66 | 38 | 12.54 | 28.08 | 0.45 |
| 680 | 6.8 | 0.68 | 37.8 | 12.47 | 27.84 | 0.45 |
| 700 | 7 | 0.7 | 37.7 | 12.44 | 27.60 | 0.45 |
| 720 | 7.2 | 0.72 | 37.7 | 12.44 | 27.36 | 0.45 |
| 740 | 7.4 | 0.74 | 37.7 | 12.44 | 27.12 | 0.46 |
| 760 | 7.6 | 0.76 | 37.6 | 12.41 | 26.88 | 0.46 |
| 780 | 7.8 | 0.78 | 37.6 | 12.41 | 26.64 | 0.47 |
| 800 | 8 | 0.8 | 37.6 | 12.41 | 26.40 | 0.47 |
| 820 | 8.2 | 0.82 | 37.6 | 12.41 | 26.16 | 0.47 |
| 840 | 8.4 | 0.84 | 37.3 | 12.31 | 25.92 | 0.47 |
| 860 | 8.6 | 0.86 | 37.3 | 12.31 | 25.68 | 0.48 |
| 880 | 8.8 | 0.88 | 37.3 | 12.31 | 25.44 | 0.48 |
| 900 | 9 | 0.9 | 37.4 | 12.34 | 25.20 | 0.49 |
| 920 | 9.2 | 0.92 | 37.4 | 12.34 | 24.96 | 0.49 |
| 940 | 9.4 | 0.94 | 37.4 | 12.34 | 24.72 | 0.50 |
| 960 | 9.6 | 0.96 | 37.4 | 12.34 | 24.48 | 0.50 |
| 980 | 9.8 | 0.98 | 37.4 | 12.34 | 24.24 | 0.51 |
| 1000 | 10 | 1 | 37.4 | 12.34 | 24.00 | 0.51 |
| 1020 | 10.2 | 1.02 | 37.4 | 12.34 | 23.76 | 0.52 |
| 1040 | 10.4 | 1.04 | 37.4 | 12.34 | 23.52 | 0.52 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1060 | 10.6 | 1.06 | 37.4 | 12.34 | 23.28 | 0.53 |
| 1080 | 10.8 | 1.08 | 37.4 | 12.34 | 23.04 | 0.54 |
| 1100 | 11 | 1.1 | 37.4 | 12.34 | 22.80 | 0.54 |
| 1120 | 11.2 | 1.12 | 37.4 | 12.34 | 22.56 | 0.55 |
| 1140 | 11.4 | 1.14 | 37.4 | 12.34 | 22.32 | 0.55 |
| 1160 | 11.6 | 1.16 | 37.2 | 12.28 | 22.08 | 0.56 |
| 1180 | 11.8 | 1.18 | 37.2 | 12.28 | 21.84 | 0.56 |
| 1200 | 12 | 1.2 | 37.2 | 12.28 | 21.60 | 0.57 |
| 1220 | 12.2 | 1.22 | 37.2 | 12.28 | 21.36 | 0.57 |
| 1240 | 12.4 | 1.24 | 37.2 | 12.28 | 21.12 | 0.58 |

**Table:B12**Direct Shear Test Readings for ( Soil +1% cement + 1.25 kg/m$^3$) at 1.5 kg/cm$^2$

| **Dial Gauge Reading (D) (div)** | **Horizontal Displacement (0.01 mm/div*D)** | | **Stress Dial Reading (div)** | **Shear Force (0.33*stress dial reading) (kg)** | **Corrected Area (cm$^2$)** | **Shear Stress (kg/cm$^2$)** |
|---|---|---|---|---|---|---|
| | **mm** | **cm** | | | | |
| 0 | 0 | 0 | 0 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 11 | 3.63 | 35.76 | 0.10 |
| 40 | 0.4 | 0.04 | 19 | 6.27 | 35.52 | 0.18 |
| 60 | 0.6 | 0.06 | 26 | 8.58 | 35.28 | 0.24 |
| 80 | 0.8 | 0.08 | 34.2 | 11.29 | 35.04 | 0.32 |
| 100 | 1 | 0.1 | 37.6 | 12.41 | 34.80 | 0.36 |
| 120 | 1.2 | 0.12 | 40 | 13.20 | 34.56 | 0.38 |
| 140 | 1.4 | 0.14 | 42.6 | 14.06 | 34.32 | 0.41 |
| 160 | 1.6 | 0.16 | 44.8 | 14.78 | 34.08 | 0.43 |
| 180 | 1.8 | 0.18 | 46.2 | 15.25 | 33.84 | 0.45 |
| 200 | 2 | 0.2 | 47.8 | 15.77 | 33.60 | 0.47 |
| 220 | 2.2 | 0.22 | 49.2 | 16.24 | 33.36 | 0.49 |
| 240 | 2.4 | 0.24 | 50.4 | 16.63 | 33.12 | 0.50 |
| 260 | 2.6 | 0.26 | 51.2 | 16.90 | 32.88 | 0.51 |
| 280 | 2.8 | 0.28 | 52.2 | 17.23 | 32.64 | 0.53 |
| 300 | 3 | 0.3 | 53 | 17.49 | 32.40 | 0.54 |
| 320 | 3.2 | 0.32 | 53.8 | 17.75 | 32.16 | 0.55 |
| 340 | 3.4 | 0.34 | 54.6 | 18.02 | 31.92 | 0.56 |
| 360 | 3.6 | 0.36 | 55.2 | 18.22 | 31.68 | 0.58 |
| 380 | 3.8 | 0.38 | 55.9 | 18.45 | 31.44 | 0.59 |
| 400 | 4 | 0.4 | 56.4 | 18.61 | 31.20 | 0.60 |
| 420 | 4.2 | 0.42 | 56.8 | 18.74 | 30.96 | 0.61 |
| 440 | 4.4 | 0.44 | 57 | 18.81 | 30.72 | 0.61 |
| 460 | 4.6 | 0.46 | 57.4 | 18.94 | 30.48 | 0.62 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 480 | 4.8 | 0.48 | 57.6 | 19.01 | 30.24 | 0.63 |
| 500 | 5 | 0.5 | 57.8 | 19.07 | 30.00 | 0.64 |
| 520 | 5.2 | 0.52 | 58 | 19.14 | 29.76 | 0.64 |
| 540 | 5.4 | 0.54 | 58 | 19.14 | 29.52 | 0.65 |
| 560 | 5.6 | 0.56 | 58.1 | 19.17 | 29.28 | 0.65 |
| 580 | 5.8 | 0.58 | 58.2 | 19.21 | 29.04 | 0.66 |
| 600 | 6 | 0.6 | 58 | 19.14 | 28.80 | 0.66 |
| 620 | 6.2 | 0.62 | 58.3 | 19.24 | 28.56 | 0.67 |
| 640 | 6.4 | 0.64 | 58.4 | 19.27 | 28.32 | 0.68 |
| 660 | 6.6 | 0.66 | 58.4 | 19.27 | 28.08 | 0.69 |
| 680 | 6.8 | 0.68 | 58.5 | 19.31 | 27.84 | 0.69 |
| 700 | 7 | 0.7 | 58.5 | 19.31 | 27.60 | 0.70 |
| 720 | 7.2 | 0.72 | 58.5 | 19.31 | 27.36 | 0.71 |
| 740 | 7.4 | 0.74 | 58.5 | 19.31 | 27.12 | 0.71 |
| 760 | 7.6 | 0.76 | 58.5 | 19.31 | 26.88 | 0.72 |
| 780 | 7.8 | 0.78 | 58.2 | 19.21 | 26.64 | 0.72 |
| 800 | 8 | 0.8 | 58.2 | 19.21 | 26.40 | 0.73 |
| 820 | 8.2 | 0.82 | 58.2 | 19.21 | 26.16 | 0.73 |
| 840 | 8.4 | 0.84 | 58 | 19.14 | 25.92 | 0.74 |
| 860 | 8.6 | 0.86 | 58 | 19.14 | 25.68 | 0.75 |
| 880 | 8.8 | 0.88 | 58 | 19.14 | 25.44 | 0.75 |
| 900 | 9 | 0.9 | 58 | 19.14 | 25.20 | 0.76 |
| 920 | 9.2 | 0.92 | 58 | 19.14 | 24.96 | 0.77 |
| 940 | 9.4 | 0.94 | 58 | 19.14 | 24.72 | 0.77 |
| 960 | 9.6 | 0.96 | 58 | 19.14 | 24.48 | 0.78 |
| 980 | 9.8 | 0.98 | 57.8 | 19.07 | 24.24 | 0.79 |
| 1000 | 10 | 1 | 57.8 | 19.07 | 24.00 | 0.79 |
| 1020 | 10.2 | 1.02 | 57.8 | 19.07 | 23.76 | 0.80 |
| 1040 | 10.4 | 1.04 | 57.8 | 19.07 | 23.52 | 0.81 |
| 1060 | 10.6 | 1.06 | 57.6 | 19.01 | 23.28 | 0.82 |
| 1080 | 10.8 | 1.08 | 57.4 | 18.94 | 23.04 | 0.82 |
| 1100 | 11 | 1.1 | 57.1 | 18.84 | 22.80 | 0.83 |
| 1120 | 11.2 | 1.12 | 57 | 18.81 | 22.56 | 0.83 |
| 1140 | 11.4 | 1.14 | 57 | 18.81 | 22.32 | 0.84 |
| 1160 | 11.6 | 1.16 | 56.8 | 18.74 | 22.08 | 0.85 |
| 1180 | 11.8 | 1.18 | 56.8 | 18.74 | 21.84 | 0.86 |
| 1200 | 12 | 1.2 | 56.8 | 18.74 | 21.60 | 0.87 |
| 1220 | 12.2 | 1.22 | 56.8 | 18.74 | 21.36 | 0.88 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 1240 | 12.4 | 1.24 | 56.8 | 18.74 | 21.12 | 0.89 |

**Table:B13**Direct Shear Test Readings for ( Soil +1% cement + 1.5 $kg/m^3$ ZB) at 0.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 4 | 1.32 | 35.76 | 0.04 |
| 40 | 0.4 | 0.04 | 8.3 | 2.74 | 35.52 | 0.08 |
| 60 | 0.6 | 0.06 | 12 | 3.96 | 35.28 | 0.11 |
| 80 | 0.8 | 0.08 | 13.2 | 4.36 | 35.04 | 0.12 |
| 100 | 1 | 0.1 | 14.2 | 4.69 | 34.80 | 0.13 |
| 120 | 1.2 | 0.12 | 15.6 | 5.15 | 34.56 | 0.15 |
| 140 | 1.4 | 0.14 | 16.8 | 5.54 | 34.32 | 0.16 |
| 160 | 1.6 | 0.16 | 17.4 | 5.74 | 34.08 | 0.17 |
| 180 | 1.8 | 0.18 | 18 | 5.94 | 33.84 | 0.18 |
| 200 | 2 | 0.2 | 18.6 | 6.14 | 33.60 | 0.18 |
| 220 | 2.2 | 0.22 | 19 | 6.27 | 33.36 | 0.19 |
| 240 | 2.4 | 0.24 | 19.4 | 6.40 | 33.12 | 0.19 |
| 260 | 2.6 | 0.26 | 19.8 | 6.53 | 32.88 | 0.20 |
| 280 | 2.8 | 0.28 | 20 | 6.60 | 32.64 | 0.20 |
| 300 | 3 | 0.3 | 20.2 | 6.67 | 32.40 | 0.21 |
| 320 | 3.2 | 0.32 | 20.5 | 6.77 | 32.16 | 0.21 |
| 340 | 3.4 | 0.34 | 20.6 | 6.80 | 31.92 | 0.21 |
| 360 | 3.6 | 0.36 | 20.8 | 6.86 | 31.68 | 0.22 |
| 380 | 3.8 | 0.38 | 21 | 6.93 | 31.44 | 0.22 |
| 400 | 4 | 0.4 | 21.2 | 7.00 | 31.20 | 0.22 |
| 420 | 4.2 | 0.42 | 21.4 | 7.06 | 30.96 | 0.23 |
| 440 | 4.4 | 0.44 | 21.4 | 7.06 | 30.72 | 0.23 |
| 460 | 4.6 | 0.46 | 21.4 | 7.06 | 30.48 | 0.23 |
| 480 | 4.8 | 0.48 | 21.2 | 7.00 | 30.24 | 0.23 |
| 500 | 5 | 0.5 | 21.4 | 7.06 | 30.00 | 0.24 |
| 520 | 5.2 | 0.52 | 21.5 | 7.10 | 29.76 | 0.24 |
| 540 | 5.4 | 0.54 | 21.5 | 7.10 | 29.52 | 0.24 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 560 | 5.6 | 0.56 | 21.5 | 7.10 | 29.28 | 0.24 |
| 580 | 5.8 | 0.58 | 21.2 | 7.00 | 29.04 | 0.24 |
| 600 | 6 | 0.6 | 21.3 | 7.03 | 28.80 | 0.24 |
| 620 | 6.2 | 0.62 | 21.3 | 7.03 | 28.56 | 0.25 |
| 640 | 6.4 | 0.64 | 21.2 | 7.00 | 28.32 | 0.25 |
| 660 | 6.6 | 0.66 | 21.1 | 6.96 | 28.08 | 0.25 |
| 680 | 6.8 | 0.68 | 21.2 | 7.00 | 27.84 | 0.25 |
| 700 | 7 | 0.7 | 21.2 | 7.00 | 27.60 | 0.25 |
| 720 | 7.2 | 0.72 | 21.2 | 7.00 | 27.36 | 0.26 |
| 740 | 7.4 | 0.74 | 21.1 | 6.96 | 27.12 | 0.26 |
| 760 | 7.6 | 0.76 | 21.2 | 7.00 | 26.88 | 0.26 |
| 780 | 7.8 | 0.78 | 21.2 | 7.00 | 26.64 | 0.26 |
| 800 | 8 | 0.8 | 21.2 | 7.00 | 26.40 | 0.27 |
| 820 | 8.2 | 0.82 | 21.2 | 7.00 | 26.16 | 0.27 |
| 840 | 8.4 | 0.84 | 21.1 | 6.96 | 25.92 | 0.27 |
| 860 | 8.6 | 0.86 | 21 | 6.93 | 25.68 | 0.27 |
| 880 | 8.8 | 0.88 | 21 | 6.93 | 25.44 | 0.27 |
| 900 | 9 | 0.9 | 21 | 6.93 | 25.20 | 0.28 |
| 920 | 9.2 | 0.92 | 21 | 6.93 | 24.96 | 0.28 |
| 940 | 9.4 | 0.94 | 21 | 6.93 | 24.72 | 0.28 |
| 960 | 9.6 | 0.96 | 21 | 6.93 | 24.48 | 0.28 |
| 980 | 9.8 | 0.98 | 21 | 6.93 | 24.24 | 0.29 |
| 1000 | 10 | 1 | 20.6 | 6.80 | 24.00 | 0.28 |
| 1020 | 10.2 | 1.02 | 20.6 | 6.80 | 23.76 | 0.29 |
| 1040 | 10.4 | 1.04 | 20.6 | 6.80 | 23.52 | 0.29 |
| 1060 | 10.6 | 1.06 | 20.4 | 6.73 | 23.28 | 0.29 |
| 1080 | 10.8 | 1.08 | 20.4 | 6.73 | 23.04 | 0.29 |
| 1100 | 11 | 1.1 | 20.4 | 6.73 | 22.80 | 0.30 |
| 1120 | 11.2 | 1.12 | 20.2 | 6.67 | 22.56 | 0.30 |
| 1140 | 11.4 | 1.14 | 20.2 | 6.67 | 22.32 | 0.30 |
| 1160 | 11.6 | 1.16 | 20 | 6.60 | 22.08 | 0.30 |
| 1180 | 11.8 | 1.18 | 20 | 6.60 | 21.84 | 0.30 |
| 1200 | 12 | 1.2 | 19.6 | 6.47 | 21.60 | 0.30 |
| 1220 | 12.2 | 1.22 | 19.6 | 6.47 | 21.36 | 0.30 |

**Table:B14**Direct Shear Test Readings for ( Soil +1% cement + 1.5 kg/$m^3$ ZB) at 1.0 kg/$cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 10 | 3.30 | 35.76 | 0.09 |
| 40 | 0.4 | 0.04 | 13 | 4.29 | 35.52 | 0.12 |
| 60 | 0.6 | 0.06 | 18 | 5.94 | 35.28 | 0.17 |
| 80 | 0.8 | 0.08 | 22 | 7.26 | 35.04 | 0.21 |
| 100 | 1 | 0.1 | 23.6 | 7.79 | 34.80 | 0.22 |
| 120 | 1.2 | 0.12 | 24.8 | 8.18 | 34.56 | 0.24 |
| 140 | 1.4 | 0.14 | 26.2 | 8.65 | 34.32 | 0.25 |
| 160 | 1.6 | 0.16 | 28 | 9.24 | 34.08 | 0.27 |
| 180 | 1.8 | 0.18 | 29.4 | 9.70 | 33.84 | 0.29 |
| 200 | 2 | 0.2 | 30.8 | 10.16 | 33.60 | 0.30 |
| 220 | 2.2 | 0.22 | 31.7 | 10.46 | 33.36 | 0.31 |
| 240 | 2.4 | 0.24 | 32.4 | 10.69 | 33.12 | 0.32 |
| 260 | 2.6 | 0.26 | 33.2 | 10.96 | 32.88 | 0.33 |
| 280 | 2.8 | 0.28 | 34 | 11.22 | 32.64 | 0.34 |
| 300 | 3 | 0.3 | 34.6 | 11.42 | 32.40 | 0.35 |
| 320 | 3.2 | 0.32 | 35.2 | 11.62 | 32.16 | 0.36 |
| 340 | 3.4 | 0.34 | 35.8 | 11.81 | 31.92 | 0.37 |
| 360 | 3.6 | 0.36 | 36.4 | 12.01 | 31.68 | 0.38 |
| 380 | 3.8 | 0.38 | 36.8 | 12.14 | 31.44 | 0.39 |
| 400 | 4 | 0.4 | 37 | 12.21 | 31.20 | 0.39 |
| 420 | 4.2 | 0.42 | 37.4 | 12.34 | 30.96 | 0.40 |
| 440 | 4.4 | 0.44 | 37.8 | 12.47 | 30.72 | 0.41 |
| 460 | 4.6 | 0.46 | 38 | 12.54 | 30.48 | 0.41 |
| 480 | 4.8 | 0.48 | 38 | 12.54 | 30.24 | 0.41 |
| 500 | 5 | 0.5 | 38.2 | 12.61 | 30.00 | 0.42 |
| 520 | 5.2 | 0.52 | 38.2 | 12.61 | 29.76 | 0.42 |
| 540 | 5.4 | 0.54 | 38.4 | 12.67 | 29.52 | 0.43 |
| 560 | 5.6 | 0.56 | 38.4 | 12.67 | 29.28 | 0.43 |
| 580 | 5.8 | 0.58 | 38.4 | 12.67 | 29.04 | 0.44 |
| 600 | 6 | 0.6 | 38.4 | 12.67 | 28.80 | 0.44 |
| 620 | 6.2 | 0.62 | 38.2 | 12.61 | 28.56 | 0.44 |
| 640 | 6.4 | 0.64 | 38.2 | 12.61 | 28.32 | 0.45 |
| 660 | 6.6 | 0.66 | 38.2 | 12.61 | 28.08 | 0.45 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 680 | 6.8 | 0.68 | 38.2 | 12.61 | 27.84 | 0.45 |
| 700 | 7 | 0.7 | 38.2 | 12.61 | 27.60 | 0.46 |
| 720 | 7.2 | 0.72 | 38.2 | 12.61 | 27.36 | 0.46 |
| 740 | 7.4 | 0.74 | 37.8 | 12.47 | 27.12 | 0.46 |
| 760 | 7.6 | 0.76 | 37.6 | 12.41 | 26.88 | 0.46 |
| 780 | 7.8 | 0.78 | 37.6 | 12.41 | 26.64 | 0.47 |
| 800 | 8 | 0.8 | 37.6 | 12.41 | 26.40 | 0.47 |
| 820 | 8.2 | 0.82 | 37.6 | 12.41 | 26.16 | 0.47 |
| 840 | 8.4 | 0.84 | 37.5 | 12.38 | 25.92 | 0.48 |
| 860 | 8.6 | 0.86 | 37.4 | 12.34 | 25.68 | 0.48 |
| 880 | 8.8 | 0.88 | 37.4 | 12.34 | 25.44 | 0.49 |
| 900 | 9 | 0.9 | 37.4 | 12.34 | 25.20 | 0.49 |
| 920 | 9.2 | 0.92 | 37.4 | 12.34 | 24.96 | 0.49 |
| 940 | 9.4 | 0.94 | 37.4 | 12.34 | 24.72 | 0.50 |
| 960 | 9.6 | 0.96 | 37.4 | 12.34 | 24.48 | 0.50 |
| 980 | 9.8 | 0.98 | 37.4 | 12.34 | 24.24 | 0.51 |
| 1000 | 10 | 1 | 37.4 | 12.34 | 24.00 | 0.51 |
| 1020 | 10.2 | 1.02 | 37.4 | 12.34 | 23.76 | 0.52 |
| 1040 | 10.4 | 1.04 | 37.4 | 12.34 | 23.52 | 0.52 |
| 1060 | 10.6 | 1.06 | 37.1 | 12.24 | 23.28 | 0.53 |
| 1080 | 10.8 | 1.08 | 37.1 | 12.24 | 23.04 | 0.53 |
| 1100 | 11 | 1.1 | 37.1 | 12.24 | 22.80 | 0.54 |
| 1120 | 11.2 | 1.12 | 37.1 | 12.24 | 22.56 | 0.54 |
| 1140 | 11.4 | 1.14 | 37.1 | 12.24 | 22.32 | 0.55 |
| 1160 | 11.6 | 1.16 | 37.1 | 12.24 | 22.08 | 0.55 |
| 1180 | 11.8 | 1.18 | 37.1 | 12.24 | 21.84 | 0.56 |
| 1200 | 12 | 1.2 | 36.8 | 12.14 | 21.60 | 0.56 |
| 1220 | 12.2 | 1.22 | 36.8 | 12.14 | 21.36 | 0.57 |

**Table:B15**Direct Shear Test Readings for ( Soil +1% cement + 1.5 kg/m$^3$ZB) at 1.5 kg/cm$^2$

| **Dial Gauge Reading (D) (div)** | **Horizontal Displacement (0.01 mm/div*D)** | | **Stress Dial Reading (div)** | **Shear Force (0.33*stress dial reading) (kg)** | **Corrected Area (cm$^2$)** | **Shear Stress (kg/cm$^2$)** |
|---|---|---|---|---|---|---|
| | **mm** | **cm** | | | | |
| 0 | 0 | 0 | 0.0 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 10.0 | 3.30 | 35.76 | 0.09 |
| 40 | 0.4 | 0.04 | 16.2 | 5.35 | 35.52 | 0.15 |
| 60 | 0.6 | 0.06 | 25.6 | 8.45 | 35.28 | 0.24 |
| 80 | 0.8 | 0.08 | 36.0 | 11.88 | 35.04 | 0.34 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 100 | 1 | 0.1 | 40.4 | 13.33 | 34.80 | 0.38 |
| 120 | 1.2 | 0.12 | 43.8 | 14.45 | 34.56 | 0.42 |
| 140 | 1.4 | 0.14 | 46.4 | 15.31 | 34.32 | 0.45 |
| 160 | 1.6 | 0.16 | 48.6 | 16.04 | 34.08 | 0.47 |
| 180 | 1.8 | 0.18 | 51.2 | 16.90 | 33.84 | 0.50 |
| 200 | 2 | 0.2 | 52.0 | 17.16 | 33.60 | 0.51 |
| 220 | 2.2 | 0.22 | 53.0 | 17.49 | 33.36 | 0.52 |
| 240 | 2.4 | 0.24 | 54.0 | 17.82 | 33.12 | 0.54 |
| 260 | 2.6 | 0.26 | 54.8 | 18.08 | 32.88 | 0.55 |
| 280 | 2.8 | 0.28 | 55.8 | 18.41 | 32.64 | 0.56 |
| 300 | 3 | 0.3 | 56.4 | 18.61 | 32.40 | 0.57 |
| 320 | 3.2 | 0.32 | 57.2 | 18.88 | 32.16 | 0.59 |
| 340 | 3.4 | 0.34 | 57.8 | 19.07 | 31.92 | 0.60 |
| 360 | 3.6 | 0.36 | 58.2 | 19.21 | 31.68 | 0.61 |
| 380 | 3.8 | 0.38 | 58.4 | 19.27 | 31.44 | 0.61 |
| 400 | 4 | 0.4 | 58.8 | 19.40 | 31.20 | 0.62 |
| 420 | 4.2 | 0.42 | 59.0 | 19.47 | 30.96 | 0.63 |
| 440 | 4.4 | 0.44 | 59.0 | 19.47 | 30.72 | 0.63 |
| 460 | 4.6 | 0.46 | 59.1 | 19.50 | 30.48 | 0.64 |
| 480 | 4.8 | 0.48 | 59.3 | 19.57 | 30.24 | 0.65 |
| 500 | 5 | 0.5 | 59.4 | 19.60 | 30.00 | 0.65 |
| 520 | 5.2 | 0.52 | 59.3 | 19.57 | 29.76 | 0.66 |
| 540 | 5.4 | 0.54 | 59.4 | 19.60 | 29.52 | 0.66 |
| 560 | 5.6 | 0.56 | 59.4 | 19.60 | 29.28 | 0.67 |
| 580 | 5.8 | 0.58 | 59.4 | 19.60 | 29.04 | 0.68 |
| 600 | 6 | 0.6 | 59.4 | 19.60 | 28.80 | 0.68 |
| 620 | 6.2 | 0.62 | 59.2 | 19.54 | 28.56 | 0.68 |
| 640 | 6.4 | 0.64 | 59.2 | 19.54 | 28.32 | 0.69 |
| 660 | 6.6 | 0.66 | 59.3 | 19.57 | 28.08 | 0.70 |
| 680 | 6.8 | 0.68 | 59.9 | 19.77 | 27.84 | 0.71 |
| 700 | 7 | 0.7 | 60.0 | 19.80 | 27.60 | 0.72 |
| 720 | 7.2 | 0.72 | 60.1 | 19.83 | 27.36 | 0.72 |
| 740 | 7.4 | 0.74 | 60.0 | 19.80 | 27.12 | 0.73 |
| 760 | 7.6 | 0.76 | 59.8 | 19.73 | 26.88 | 0.73 |
| 780 | 7.8 | 0.78 | 59.8 | 19.73 | 26.64 | 0.74 |
| 800 | 8 | 0.8 | 59.8 | 19.73 | 26.40 | 0.75 |
| 820 | 8.2 | 0.82 | 59.6 | 19.67 | 26.16 | 0.75 |
| 840 | 8.4 | 0.84 | 59.5 | 19.64 | 25.92 | 0.76 |
| 860 | 8.6 | 0.86 | 59.3 | 19.57 | 25.68 | 0.76 |
| 880 | 8.8 | 0.88 | 59.3 | 19.57 | 25.44 | 0.77 |
| 900 | 9 | 0.9 | 59.2 | 19.54 | 25.20 | 0.78 |
| 920 | 9.2 | 0.92 | 59.0 | 19.47 | 24.96 | 0.78 |
| 940 | 9.4 | 0.94 | 59.0 | 19.47 | 24.72 | 0.79 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 960 | 9.6 | 0.96 | 58.8 | 19.40 | 24.48 | 0.79 |
| 980 | 9.8 | 0.98 | 58.8 | 19.40 | 24.24 | 0.80 |
| 1000 | 10 | 1 | 58.6 | 19.34 | 24.00 | 0.81 |
| 1020 | 10.2 | 1.02 | 58.2 | 19.21 | 23.76 | 0.81 |
| 1040 | 10.4 | 1.04 | 58.0 | 19.14 | 23.52 | 0.81 |
| 1060 | 10.6 | 1.06 | 58.0 | 19.14 | 23.28 | 0.82 |
| 1080 | 10.8 | 1.08 | 57.8 | 19.07 | 23.04 | 0.83 |
| 1100 | 11 | 1.1 | 57.4 | 18.94 | 22.80 | 0.83 |
| 1120 | 11.2 | 1.12 | 57.2 | 18.88 | 22.56 | 0.84 |
| 1140 | 11.4 | 1.14 | 57.0 | 18.81 | 22.32 | 0.84 |
| 1160 | 11.6 | 1.16 | 56.6 | 18.68 | 22.08 | 0.85 |
| 1180 | 11.8 | 1.18 | 56.4 | 18.61 | 21.84 | 0.85 |
| 1200 | 12 | 1.2 | 56.2 | 18.55 | 21.60 | 0.86 |
| 1220 | 12.2 | 1.22 | 56.0 | 18.48 | 21.36 | 0.87 |



## Appendix C

**Table:C1** Direct Shear Test Readings for ( Soil +2 % cement + 0.5 kg/$m^3$ ZB) at 0.5

$kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0.0 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 3.4 | 1.12 | 35.76 | 0.03 |
| 40 | 0.4 | 0.04 | 6.4 | 2.11 | 35.52 | 0.06 |
| 60 | 0.6 | 0.06 | 10.2 | 3.37 | 35.28 | 0.10 |
| 80 | 0.8 | 0.08 | 10.8 | 3.56 | 35.04 | 0.10 |
| 100 | 1 | 0.1 | 12.0 | 3.96 | 34.80 | 0.11 |
| 120 | 1.2 | 0.12 | 12.8 | 4.22 | 34.56 | 0.12 |
| 140 | 1.4 | 0.14 | 13.6 | 4.49 | 34.32 | 0.13 |
| 160 | 1.6 | 0.16 | 14.0 | 4.62 | 34.08 | 0.14 |
| 180 | 1.8 | 0.18 | 14.6 | 4.82 | 33.84 | 0.14 |
| 200 | 2 | 0.2 | 15.2 | 5.02 | 33.60 | 0.15 |
| 220 | 2.2 | 0.22 | 15.4 | 5.08 | 33.36 | 0.15 |
| 240 | 2.4 | 0.24 | 16.0 | 5.28 | 33.12 | 0.16 |
| 260 | 2.6 | 0.26 | 16.4 | 5.41 | 32.88 | 0.16 |
| 280 | 2.8 | 0.28 | 16.6 | 5.48 | 32.64 | 0.17 |
| 300 | 3 | 0.3 | 17.0 | 5.61 | 32.40 | 0.17 |
| 320 | 3.2 | 0.32 | 17.4 | 5.74 | 32.16 | 0.18 |
| 340 | 3.4 | 0.34 | 17.6 | 5.81 | 31.92 | 0.18 |
| 360 | 3.6 | 0.36 | 18.0 | 5.94 | 31.68 | 0.19 |
| 380 | 3.8 | 0.38 | 18.2 | 6.01 | 31.44 | 0.19 |
| 400 | 4 | 0.4 | 18.4 | 6.07 | 31.20 | 0.19 |
| 420 | 4.2 | 0.42 | 18.6 | 6.14 | 30.96 | 0.20 |
| 440 | 4.4 | 0.44 | 18.8 | 6.20 | 30.72 | 0.20 |
| 460 | 4.6 | 0.46 | 18.8 | 6.20 | 30.48 | 0.20 |
| 480 | 4.8 | 0.48 | 19.0 | 6.27 | 30.24 | 0.21 |
| 500 | 5 | 0.5 | 19.0 | 6.27 | 30.00 | 0.21 |
| 520 | 5.2 | 0.52 | 19.0 | 6.27 | 29.76 | 0.21 |
| 540 | 5.4 | 0.54 | 18.8 | 6.20 | 29.52 | 0.21 |
| 560 | 5.6 | 0.56 | 18.8 | 6.20 | 29.28 | 0.21 |
| 580 | 5.8 | 0.58 | 18.8 | 6.20 | 29.04 | 0.21 |
| 600 | 6 | 0.6 | 18.6 | 6.14 | 28.80 | 0.21 |
| 620 | 6.2 | 0.62 | 18.6 | 6.14 | 28.56 | 0.21 |
| 640 | 6.4 | 0.64 | 18.6 | 6.14 | 28.32 | 0.22 |
| 660 | 6.6 | 0.66 | 18.6 | 6.14 | 28.08 | 0.22 |
| 680 | 6.8 | 0.68 | 18.4 | 6.07 | 27.84 | 0.22 |
| 700 | 7 | 0.7 | 18.4 | 6.07 | 27.60 | 0.22 |
| 720 | 7.2 | 0.72 | 18.4 | 6.07 | 27.36 | 0.22 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 740 | 7.4 | 0.74 | 18.4 | 6.07 | 27.12 | 0.22 |
| 760 | 7.6 | 0.76 | 18.4 | 6.07 | 26.88 | 0.23 |
| 780 | 7.8 | 0.78 | 18.4 | 6.07 | 26.64 | 0.23 |
| 800 | 8 | 0.8 | 18.3 | 6.04 | 26.40 | 0.23 |
| 820 | 8.2 | 0.82 | 18.4 | 6.07 | 26.16 | 0.23 |
| 840 | 8.4 | 0.84 | 18.4 | 6.07 | 25.92 | 0.23 |
| 860 | 8.6 | 0.86 | 18.4 | 6.07 | 25.68 | 0.24 |
| 880 | 8.8 | 0.88 | 18.4 | 6.07 | 25.44 | 0.24 |
| 900 | 9 | 0.9 | 18.4 | 6.07 | 25.20 | 0.24 |
| 920 | 9.2 | 0.92 | 18.4 | 6.07 | 24.96 | 0.24 |
| 940 | 9.4 | 0.94 | 18.4 | 6.07 | 24.72 | 0.25 |
| 960 | 9.6 | 0.96 | 18.4 | 6.07 | 24.48 | 0.25 |
| 980 | 9.8 | 0.98 | 18.2 | 6.01 | 24.24 | 0.25 |
| 1000 | 10 | 1 | 18.2 | 6.01 | 24.00 | 0.25 |
| 1020 | 10.2 | 1.02 | 18.2 | 6.01 | 23.76 | 0.25 |
| 1040 | 10.4 | 1.04 | 18.2 | 6.01 | 23.52 | 0.26 |
| 1060 | 10.6 | 1.06 | 18.2 | 6.01 | 23.28 | 0.26 |
| 1080 | 10.8 | 1.08 | 18.2 | 6.01 | 23.04 | 0.26 |
| 1100 | 11 | 1.1 | 18.0 | 5.94 | 22.80 | 0.26 |
| 1120 | 11.2 | 1.12 | 18.0 | 5.94 | 22.56 | 0.26 |
| 1140 | 11.4 | 1.14 | 18.0 | 5.94 | 22.32 | 0.27 |
| 1160 | 11.6 | 1.16 | 18.0 | 5.94 | 22.08 | 0.27 |
| 1180 | 11.8 | 1.18 | 18.0 | 5.94 | 21.84 | 0.27 |
| 1200 | 12 | 1.2 | 18.0 | 5.94 | 21.60 | 0.28 |
| 1220 | 12.2 | 1.22 | 18.0 | 5.94 | 21.36 | 0.28 |

**Table:C2** Direct Shear Test Readings for ( Soil +2 % cement + 0.5 $kg/m^3$ ZB) at 1.0 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 6 | 1.98 | 35.76 | 0.06 |
| 40 | 0.4 | 0.04 | 9.4 | 3.10 | 35.52 | 0.09 |
| 60 | 0.6 | 0.06 | 12.8 | 4.22 | 35.28 | 0.12 |
| 80 | 0.8 | 0.08 | 17.2 | 5.68 | 35.04 | 0.16 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 100 | 1 | 0.1 | 20.2 | 6.67 | 34.80 | 0.19 |
| 120 | 1.2 | 0.12 | 22.6 | 7.46 | 34.56 | 0.22 |
| 140 | 1.4 | 0.14 | 23.6 | 7.79 | 34.32 | 0.23 |
| 160 | 1.6 | 0.16 | 24.6 | 8.12 | 34.08 | 0.24 |
| 180 | 1.8 | 0.18 | 26.4 | 8.71 | 33.84 | 0.26 |
| 200 | 2 | 0.2 | 27.8 | 9.17 | 33.60 | 0.27 |
| 220 | 2.2 | 0.22 | 28.6 | 9.44 | 33.36 | 0.28 |
| 240 | 2.4 | 0.24 | 29.4 | 9.70 | 33.12 | 0.29 |
| 260 | 2.6 | 0.26 | 30.3 | 10.00 | 32.88 | 0.30 |
| 280 | 2.8 | 0.28 | 31 | 10.23 | 32.64 | 0.31 |
| 300 | 3 | 0.3 | 31.6 | 10.43 | 32.40 | 0.32 |
| 320 | 3.2 | 0.32 | 32.4 | 10.69 | 32.16 | 0.33 |
| 340 | 3.4 | 0.34 | 32.8 | 10.82 | 31.92 | 0.34 |
| 360 | 3.6 | 0.36 | 33.6 | 11.09 | 31.68 | 0.35 |
| 380 | 3.8 | 0.38 | 34 | 11.22 | 31.44 | 0.36 |
| 400 | 4 | 0.4 | 34.6 | 11.42 | 31.20 | 0.37 |
| 420 | 4.2 | 0.42 | 35.2 | 11.62 | 30.96 | 0.38 |
| 440 | 4.4 | 0.44 | 36 | 11.88 | 30.72 | 0.39 |
| 460 | 4.6 | 0.46 | 36.2 | 11.95 | 30.48 | 0.39 |
| 480 | 4.8 | 0.48 | 37 | 12.21 | 30.24 | 0.40 |
| 500 | 5 | 0.5 | 37.2 | 12.28 | 30.00 | 0.41 |
| 520 | 5.2 | 0.52 | 37.6 | 12.41 | 29.76 | 0.42 |
| 540 | 5.4 | 0.54 | 37.8 | 12.47 | 29.52 | 0.42 |
| 560 | 5.6 | 0.56 | 38 | 12.54 | 29.28 | 0.43 |
| 580 | 5.8 | 0.58 | 38.2 | 12.61 | 29.04 | 0.43 |
| 600 | 6 | 0.6 | 38.4 | 12.67 | 28.80 | 0.44 |
| 620 | 6.2 | 0.62 | 38.6 | 12.74 | 28.56 | 0.45 |
| 640 | 6.4 | 0.64 | 39 | 12.87 | 28.32 | 0.45 |
| 660 | 6.6 | 0.66 | 38.8 | 12.80 | 28.08 | 0.46 |
| 680 | 6.8 | 0.68 | 38.9 | 12.84 | 27.84 | 0.46 |
| 700 | 7 | 0.7 | 38.9 | 12.84 | 27.60 | 0.47 |
| 720 | 7.2 | 0.72 | 38.9 | 12.84 | 27.36 | 0.47 |
| 740 | 7.4 | 0.74 | 38.8 | 12.80 | 27.12 | 0.47 |
| 760 | 7.6 | 0.76 | 38.6 | 12.74 | 26.88 | 0.47 |
| 780 | 7.8 | 0.78 | 38.6 | 12.74 | 26.64 | 0.48 |
| 800 | 8 | 0.8 | 38.4 | 12.67 | 26.40 | 0.48 |
| 820 | 8.2 | 0.82 | 38.2 | 12.61 | 26.16 | 0.48 |
| 840 | 8.4 | 0.84 | 38.2 | 12.61 | 25.92 | 0.49 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 860 | 8.6 | 0.86 | 37.8 | 12.47 | 25.68 | 0.49 |
| 880 | 8.8 | 0.88 | 37.8 | 12.47 | 25.44 | 0.49 |
| 900 | 9 | 0.9 | 37.8 | 12.47 | 25.20 | 0.50 |
| 920 | 9.2 | 0.92 | 37.8 | 12.47 | 24.96 | 0.50 |
| 940 | 9.4 | 0.94 | 37.6 | 12.41 | 24.72 | 0.50 |
| 960 | 9.6 | 0.96 | 37.6 | 12.41 | 24.48 | 0.51 |
| 980 | 9.8 | 0.98 | 37.6 | 12.41 | 24.24 | 0.51 |
| 1000 | 10 | 1 | 37.6 | 12.41 | 24.00 | 0.52 |
| 1020 | 10.2 | 1.02 | 37.6 | 12.41 | 23.76 | 0.52 |
| 1040 | 10.4 | 1.04 | 37.6 | 12.41 | 23.52 | 0.53 |
| 1060 | 10.6 | 1.06 | 37.6 | 12.41 | 23.28 | 0.53 |
| 1080 | 10.8 | 1.08 | 37.6 | 12.41 | 23.04 | 0.54 |
| 1100 | 11 | 1.1 | 37.4 | 12.34 | 22.80 | 0.54 |
| 1120 | 11.2 | 1.12 | 37.2 | 12.28 | 22.56 | 0.54 |
| 1140 | 11.4 | 1.14 | 37.2 | 12.28 | 22.32 | 0.55 |
| 1160 | 11.6 | 1.16 | 37.1 | 12.23 | 22.08 | 0.55 |
| 1180 | 11.8 | 1.18 | 37.0 | 12.20 | 21.84 | 0.56 |
| 1200 | 12 | 1.2 | 36.9 | 12.17 | 21.60 | 0.56 |
| 1220 | 12.2 | 1.22 | 36.8 | 12.13 | 21.36 | 0.57 |

**Table: C3** Direct Shear Test Readings for ( Soil +2 % cement + 0.5 $kg/m^3$ ZB) at 1.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 14 | 4.62 | 35.76 | 0.13 |
| 40 | 0.4 | 0.04 | 21 | 6.93 | 35.52 | 0.20 |
| 60 | 0.6 | 0.06 | 27.2 | 8.98 | 35.28 | 0.25 |
| 80 | 0.8 | 0.08 | 32.8 | 10.82 | 35.04 | 0.31 |
| 100 | 1 | 0.1 | 36.2 | 11.95 | 34.80 | 0.34 |
| 120 | 1.2 | 0.12 | 37 | 12.21 | 34.56 | 0.35 |
| 140 | 1.4 | 0.14 | 38.8 | 12.80 | 34.32 | 0.37 |
| 160 | 1.6 | 0.16 | 40.8 | 13.46 | 34.08 | 0.40 |
| 180 | 1.8 | 0.18 | 42 | 13.86 | 33.84 | 0.41 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 200 | 2 | 0.2 | 44 | 14.52 | 33.60 | 0.43 |
| 220 | 2.2 | 0.22 | 45 | 14.85 | 33.36 | 0.45 |
| 240 | 2.4 | 0.24 | 46.4 | 15.31 | 33.12 | 0.46 |
| 260 | 2.6 | 0.26 | 47.6 | 15.71 | 32.88 | 0.48 |
| 280 | 2.8 | 0.28 | 49 | 16.17 | 32.64 | 0.50 |
| 300 | 3 | 0.3 | 50 | 16.50 | 32.40 | 0.51 |
| 320 | 3.2 | 0.32 | 51.6 | 17.03 | 32.16 | 0.53 |
| 340 | 3.4 | 0.34 | 52.6 | 17.36 | 31.92 | 0.54 |
| 360 | 3.6 | 0.36 | 53.5 | 17.66 | 31.68 | 0.56 |
| 380 | 3.8 | 0.38 | 54.4 | 17.95 | 31.44 | 0.57 |
| 400 | 4 | 0.4 | 55.2 | 18.22 | 31.20 | 0.58 |
| 420 | 4.2 | 0.42 | 56 | 18.48 | 30.96 | 0.60 |
| 440 | 4.4 | 0.44 | 56.4 | 18.61 | 30.72 | 0.61 |
| 460 | 4.6 | 0.46 | 57 | 18.81 | 30.48 | 0.62 |
| 480 | 4.8 | 0.48 | 57.8 | 19.07 | 30.24 | 0.63 |
| 500 | 5 | 0.5 | 58 | 19.14 | 30.00 | 0.64 |
| 520 | 5.2 | 0.52 | 58.2 | 19.21 | 29.76 | 0.65 |
| 540 | 5.4 | 0.54 | 58.4 | 19.27 | 29.52 | 0.65 |
| 560 | 5.6 | 0.56 | 58.8 | 19.40 | 29.28 | 0.66 |
| 580 | 5.8 | 0.58 | 59 | 19.47 | 29.04 | 0.67 |
| 600 | 6 | 0.6 | 58.9 | 19.44 | 28.80 | 0.67 |
| 620 | 6.2 | 0.62 | 59 | 19.47 | 28.56 | 0.68 |
| 640 | 6.4 | 0.64 | 59 | 19.47 | 28.32 | 0.69 |
| 660 | 6.6 | 0.66 | 58.8 | 19.40 | 28.08 | 0.69 |
| 680 | 6.8 | 0.68 | 58.8 | 19.40 | 27.84 | 0.70 |
| 700 | 7 | 0.7 | 58.8 | 19.40 | 27.60 | 0.70 |
| 720 | 7.2 | 0.72 | 58.8 | 19.40 | 27.36 | 0.71 |
| 740 | 7.4 | 0.74 | 58.6 | 19.34 | 27.12 | 0.71 |
| 760 | 7.6 | 0.76 | 58.6 | 19.34 | 26.88 | 0.72 |
| 780 | 7.8 | 0.78 | 58.6 | 19.34 | 26.64 | 0.73 |
| 800 | 8 | 0.8 | 58.4 | 19.27 | 26.40 | 0.73 |
| 820 | 8.2 | 0.82 | 58 | 19.14 | 26.16 | 0.73 |
| 840 | 8.4 | 0.84 | 58 | 19.14 | 25.92 | 0.74 |
| 860 | 8.6 | 0.86 | 57.6 | 19.01 | 25.68 | 0.74 |
| 880 | 8.8 | 0.88 | 57.6 | 19.01 | 25.44 | 0.75 |
| 900 | 9 | 0.9 | 57.2 | 18.88 | 25.20 | 0.75 |
| 920 | 9.2 | 0.92 | 57.2 | 18.88 | 24.96 | 0.76 |
| 940 | 9.4 | 0.94 | 57 | 18.81 | 24.72 | 0.76 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 960 | 9.6 | 0.96 | 56.8 | 18.74 | 24.48 | 0.77 |
| 980 | 9.8 | 0.98 | 57 | 18.81 | 24.24 | 0.78 |
| 1000 | 10 | 1 | 57.2 | 18.88 | 24.00 | 0.79 |
| 1020 | 10.2 | 1.02 | 57 | 18.81 | 23.76 | 0.79 |
| 1040 | 10.4 | 1.04 | 57 | 18.81 | 23.52 | 0.80 |
| 1060 | 10.6 | 1.06 | 57 | 18.81 | 23.28 | 0.81 |
| 1080 | 10.8 | 1.08 | 56.8 | 18.74 | 23.04 | 0.81 |
| 1100 | 11 | 1.1 | 56.8 | 18.74 | 22.80 | 0.82 |
| 1120 | 11.2 | 1.12 | 56.8 | 18.74 | 22.56 | 0.83 |
| 1140 | 11.4 | 1.14 | 56.8 | 18.74 | 22.32 | 0.84 |
| 1160 | 11.6 | 1.16 | 56.8 | 18.74 | 22.08 | 0.85 |
| 1180 | 11.8 | 1.18 | 56.8 | 18.74 | 21.84 | 0.86 |
| 1200 | 12 | 1.2 | 56.8 | 18.74 | 21.60 | 0.87 |
| 1220 | 12.2 | 1.22 | 56.8 | 18.74 | 21.36 | 0.88 |

**Table:C4** Direct Shear Test Readings for ( Soil +2 % cement + 0.75 $kg/m^3$ ZB) at 0.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 5 | 1.65 | 35.76 | 0.05 |
| 40 | 0.4 | 0.04 | 9 | 2.97 | 35.52 | 0.08 |
| 60 | 0.6 | 0.06 | 11.4 | 3.76 | 35.28 | 0.11 |
| 80 | 0.8 | 0.08 | 14.8 | 4.88 | 35.04 | 0.14 |
| 100 | 1 | 0.1 | 16 | 5.28 | 34.80 | 0.15 |
| 120 | 1.2 | 0.12 | 16.6 | 5.48 | 34.56 | 0.16 |
| 140 | 1.4 | 0.14 | 17.2 | 5.68 | 34.32 | 0.17 |
| 160 | 1.6 | 0.16 | 17.8 | 5.87 | 34.08 | 0.17 |
| 180 | 1.8 | 0.18 | 18.1 | 5.97 | 33.84 | 0.18 |
| 200 | 2 | 0.2 | 18.4 | 6.07 | 33.60 | 0.18 |
| 220 | 2.2 | 0.22 | 18.6 | 6.14 | 33.36 | 0.18 |
| 240 | 2.4 | 0.24 | 18.8 | 6.20 | 33.12 | 0.19 |
| 260 | 2.6 | 0.26 | 19 | 6.27 | 32.88 | 0.19 |
| 280 | 2.8 | 0.28 | 19.4 | 6.40 | 32.64 | 0.20 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 300 | 3 | 0.3 | 19.8 | 6.53 | 32.40 | 0.20 |
| 320 | 3.2 | 0.32 | 20 | 6.60 | 32.16 | 0.21 |
| 340 | 3.4 | 0.34 | 20.1 | 6.63 | 31.92 | 0.21 |
| 360 | 3.6 | 0.36 | 20.4 | 6.73 | 31.68 | 0.21 |
| 380 | 3.8 | 0.38 | 20.6 | 6.80 | 31.44 | 0.22 |
| 400 | 4 | 0.4 | 20.8 | 6.86 | 31.20 | 0.22 |
| 420 | 4.2 | 0.42 | 20.9 | 6.90 | 30.96 | 0.22 |
| 440 | 4.4 | 0.44 | 21 | 6.93 | 30.72 | 0.23 |
| 460 | 4.6 | 0.46 | 21.1 | 6.96 | 30.48 | 0.23 |
| 480 | 4.8 | 0.48 | 21.2 | 7.00 | 30.24 | 0.23 |
| 500 | 5 | 0.5 | 21.4 | 7.06 | 30.00 | 0.24 |
| 520 | 5.2 | 0.52 | 21.6 | 7.13 | 29.76 | 0.24 |
| 540 | 5.4 | 0.54 | 21.6 | 7.13 | 29.52 | 0.24 |
| 560 | 5.6 | 0.56 | 21.8 | 7.19 | 29.28 | 0.25 |
| 580 | 5.8 | 0.58 | 21.8 | 7.19 | 29.04 | 0.25 |
| 600 | 6 | 0.6 | 21.9 | 7.23 | 28.80 | 0.25 |
| 620 | 6.2 | 0.62 | 21.9 | 7.23 | 28.56 | 0.25 |
| 640 | 6.4 | 0.64 | 22 | 7.26 | 28.32 | 0.26 |
| 660 | 6.6 | 0.66 | 22 | 7.26 | 28.08 | 0.26 |
| 680 | 6.8 | 0.68 | 22.1 | 7.29 | 27.84 | 0.26 |
| 700 | 7 | 0.7 | 22 | 7.26 | 27.60 | 0.26 |
| 720 | 7.2 | 0.72 | 22 | 7.26 | 27.36 | 0.27 |
| 740 | 7.4 | 0.74 | 22 | 7.26 | 27.12 | 0.27 |
| 760 | 7.6 | 0.76 | 22 | 7.26 | 26.88 | 0.27 |
| 780 | 7.8 | 0.78 | 22 | 7.26 | 26.64 | 0.27 |
| 800 | 8 | 0.8 | 22 | 7.26 | 26.40 | 0.28 |
| 820 | 8.2 | 0.82 | 21.9 | 7.23 | 26.16 | 0.28 |
| 840 | 8.4 | 0.84 | 21.8 | 7.19 | 25.92 | 0.28 |
| 860 | 8.6 | 0.86 | 21.8 | 7.19 | 25.68 | 0.28 |
| 880 | 8.8 | 0.88 | 21.8 | 7.19 | 25.44 | 0.28 |
| 900 | 9 | 0.9 | 21.8 | 7.19 | 25.20 | 0.29 |
| 920 | 9.2 | 0.92 | 21.8 | 7.19 | 24.96 | 0.29 |
| 940 | 9.4 | 0.94 | 21.8 | 7.19 | 24.72 | 0.29 |
| 960 | 9.6 | 0.96 | 21.8 | 7.19 | 24.48 | 0.29 |
| 980 | 9.8 | 0.98 | 21.8 | 7.19 | 24.24 | 0.30 |
| 1000 | 10 | 1 | 21.8 | 7.19 | 24.00 | 0.30 |
| 1020 | 10.2 | 1.02 | 21.6 | 7.13 | 23.76 | 0.30 |
| 1040 | 10.4 | 1.04 | 21.6 | 7.13 | 23.52 | 0.30 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 1060 | 10.6 | 1.06 | 21.4 | 7.06 | 23.28 | 0.30 |
| 1080 | 10.8 | 1.08 | 21.4 | 7.06 | 23.04 | 0.31 |
| 1100 | 11 | 1.1 | 21.4 | 7.06 | 22.80 | 0.31 |
| 1120 | 11.2 | 1.12 | 21.4 | 7.06 | 22.56 | 0.31 |
| 1140 | 11.4 | 1.14 | 21.4 | 7.06 | 22.32 | 0.32 |
| 1160 | 11.6 | 1.16 | 21.2 | 7.00 | 22.08 | 0.32 |
| 1180 | 11.8 | 1.18 | 21.2 | 7.00 | 21.84 | 0.32 |
| 1200 | 12 | 1.2 | 21.2 | 7.00 | 21.60 | 0.32 |

**Table:C5** Direct Shear Test Readings for ( Soil +2 % cement + 0.75 $kg/m^3$ ZB) at 1.0 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 10.00 | 3.30 | 35.76 | 0.09 |
| 40 | 0.4 | 0.04 | 14.00 | 4.62 | 35.52 | 0.13 |
| 60 | 0.6 | 0.06 | 24.40 | 8.05 | 35.28 | 0.23 |
| 80 | 0.8 | 0.08 | 27.00 | 8.91 | 35.04 | 0.25 |
| 100 | 1 | 0.1 | 28.60 | 9.44 | 34.80 | 0.27 |
| 120 | 1.2 | 0.12 | 29.80 | 9.83 | 34.56 | 0.28 |
| 140 | 1.4 | 0.14 | 30.40 | 10.03 | 34.32 | 0.29 |
| 160 | 1.6 | 0.16 | 31.20 | 10.30 | 34.08 | 0.30 |
| 180 | 1.8 | 0.18 | 32.00 | 10.56 | 33.84 | 0.31 |
| 200 | 2 | 0.2 | 32.80 | 10.82 | 33.60 | 0.32 |
| 220 | 2.2 | 0.22 | 33.80 | 11.15 | 33.36 | 0.33 |
| 240 | 2.4 | 0.24 | 34.30 | 11.32 | 33.12 | 0.34 |
| 260 | 2.6 | 0.26 | 35.20 | 11.62 | 32.88 | 0.35 |
| 280 | 2.8 | 0.28 | 35.80 | 11.81 | 32.64 | 0.36 |
| 300 | 3 | 0.3 | 36.60 | 12.08 | 32.40 | 0.37 |
| 320 | 3.2 | 0.32 | 37.40 | 12.34 | 32.16 | 0.38 |
| 340 | 3.4 | 0.34 | 38.00 | 12.54 | 31.92 | 0.39 |
| 360 | 3.6 | 0.36 | 38.80 | 12.80 | 31.68 | 0.40 |
| 380 | 3.8 | 0.38 | 39.40 | 13.00 | 31.44 | 0.41 |
| 400 | 4 | 0.4 | 39.80 | 13.13 | 31.20 | 0.42 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 420 | 4.2 | 0.42 | 39.80 | 13.13 | 30.96 | 0.42 |
| 440 | 4.4 | 0.44 | 39.80 | 13.13 | 30.72 | 0.43 |
| 460 | 4.6 | 0.46 | 40.00 | 13.20 | 30.48 | 0.43 |
| 480 | 4.8 | 0.48 | 40.20 | 13.27 | 30.24 | 0.44 |
| 500 | 5 | 0.5 | 40.30 | 13.30 | 30.00 | 0.44 |
| 520 | 5.2 | 0.52 | 40.00 | 13.20 | 29.76 | 0.44 |
| 540 | 5.4 | 0.54 | 40.00 | 13.20 | 29.52 | 0.45 |
| 560 | 5.6 | 0.56 | 39.80 | 13.13 | 29.28 | 0.45 |
| 580 | 5.8 | 0.58 | 39.60 | 13.07 | 29.04 | 0.45 |
| 600 | 6 | 0.6 | 39.40 | 13.00 | 28.80 | 0.45 |
| 620 | 6.2 | 0.62 | 39.40 | 13.00 | 28.56 | 0.46 |
| 640 | 6.4 | 0.64 | 39.20 | 12.94 | 28.32 | 0.46 |
| 660 | 6.6 | 0.66 | 39.00 | 12.87 | 28.08 | 0.46 |
| 680 | 6.8 | 0.68 | 38.80 | 12.80 | 27.84 | 0.46 |
| 700 | 7 | 0.7 | 38.80 | 12.80 | 27.60 | 0.46 |
| 720 | 7.2 | 0.72 | 38.60 | 12.74 | 27.36 | 0.47 |
| 740 | 7.4 | 0.74 | 38.40 | 12.67 | 27.12 | 0.47 |
| 760 | 7.6 | 0.76 | 38.40 | 12.67 | 26.88 | 0.47 |
| 780 | 7.8 | 0.78 | 38.40 | 12.67 | 26.64 | 0.48 |
| 800 | 8 | 0.8 | 38.30 | 12.64 | 26.40 | 0.48 |
| 820 | 8.2 | 0.82 | 38.20 | 12.61 | 26.16 | 0.48 |
| 840 | 8.4 | 0.84 | 38.20 | 12.61 | 25.92 | 0.49 |
| 860 | 8.6 | 0.86 | 38.20 | 12.61 | 25.68 | 0.49 |
| 880 | 8.8 | 0.88 | 38.10 | 12.57 | 25.44 | 0.49 |
| 900 | 9 | 0.9 | 38.10 | 12.57 | 25.20 | 0.50 |
| 920 | 9.2 | 0.92 | 38.00 | 12.54 | 24.96 | 0.50 |
| 940 | 9.4 | 0.94 | 38.00 | 12.54 | 24.72 | 0.51 |
| 960 | 9.6 | 0.96 | 38.20 | 12.61 | 24.48 | 0.51 |
| 980 | 9.8 | 0.98 | 38.00 | 12.54 | 24.24 | 0.52 |
| 1000 | 10 | 1 | 38.00 | 12.54 | 24.00 | 0.52 |
| 1020 | 10.2 | 1.02 | 38.00 | 12.54 | 23.76 | 0.53 |
| 1040 | 10.4 | 1.04 | 38.00 | 12.54 | 23.52 | 0.53 |
| 1060 | 10.6 | 1.06 | 38.00 | 12.54 | 23.28 | 0.54 |
| 1080 | 10.8 | 1.08 | 38.00 | 12.54 | 23.04 | 0.54 |
| 1100 | 11 | 1.1 | 38.00 | 12.54 | 22.80 | 0.55 |
| 1120 | 11.2 | 1.12 | 38.00 | 12.54 | 22.56 | 0.56 |
| 1140 | 11.4 | 1.14 | 38.00 | 12.54 | 22.32 | 0.56 |
| 1160 | 11.6 | 1.16 | 38.00 | 12.54 | 22.08 | 0.57 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 1180 | 11.8 | 1.18 | 38.00 | 12.54 | 21.84 | 0.57 |
| 1200 | 12 | 1.2 | 38.00 | 12.54 | 21.60 | 0.58 |

**Table:C6** Direct Shear Test Readings for ( Soil +2 % cement + 0.75 $kg/m^3$ ZB) at 1.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | Mm | cm | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 11.30 | 3.73 | 35.76 | 0.10 |
| 40 | 0.4 | 0.04 | 16.20 | 5.35 | 35.52 | 0.15 |
| 60 | 0.6 | 0.06 | 22.40 | 7.39 | 35.28 | 0.21 |
| 80 | 0.8 | 0.08 | 35.80 | 11.81 | 35.04 | 0.34 |
| 100 | 1 | 0.1 | 40.00 | 13.20 | 34.80 | 0.38 |
| 120 | 1.2 | 0.12 | 43.20 | 14.26 | 34.56 | 0.41 |
| 140 | 1.4 | 0.14 | 45.20 | 14.92 | 34.32 | 0.43 |
| 160 | 1.6 | 0.16 | 46.80 | 15.44 | 34.08 | 0.45 |
| 180 | 1.8 | 0.18 | 48.20 | 15.91 | 33.84 | 0.47 |
| 200 | 2 | 0.2 | 49.80 | 16.43 | 33.60 | 0.49 |
| 220 | 2.2 | 0.22 | 51.00 | 16.83 | 33.36 | 0.50 |
| 240 | 2.4 | 0.24 | 51.80 | 17.09 | 33.12 | 0.52 |
| 260 | 2.6 | 0.26 | 52.80 | 17.42 | 32.88 | 0.53 |
| 280 | 2.8 | 0.28 | 54.00 | 17.82 | 32.64 | 0.55 |
| 300 | 3 | 0.3 | 55.00 | 18.15 | 32.40 | 0.56 |
| 320 | 3.2 | 0.32 | 55.60 | 18.35 | 32.16 | 0.57 |
| 340 | 3.4 | 0.34 | 56.40 | 18.61 | 31.92 | 0.58 |
| 360 | 3.6 | 0.36 | 57.40 | 18.94 | 31.68 | 0.60 |
| 380 | 3.8 | 0.38 | 58.00 | 19.14 | 31.44 | 0.61 |
| 400 | 4 | 0.4 | 58.60 | 19.34 | 31.20 | 0.62 |
| 420 | 4.2 | 0.42 | 59.00 | 19.47 | 30.96 | 0.63 |
| 440 | 4.4 | 0.44 | 59.40 | 19.60 | 30.72 | 0.64 |
| 460 | 4.6 | 0.46 | 59.80 | 19.73 | 30.48 | 0.65 |
| 480 | 4.8 | 0.48 | 60.00 | 19.80 | 30.24 | 0.65 |
| 500 | 5 | 0.5 | 60.00 | 19.80 | 30.00 | 0.66 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | Mm | cm | | | | |
| 520 | 5.2 | 0.52 | 59.80 | 19.73 | 29.76 | 0.66 |
| 540 | 5.4 | 0.54 | 59.80 | 19.73 | 29.52 | 0.67 |
| 560 | 5.6 | 0.56 | 59.80 | 19.73 | 29.28 | 0.67 |
| 580 | 5.8 | 0.58 | 59.80 | 19.73 | 29.04 | 0.68 |
| 600 | 6 | 0.6 | 59.60 | 19.67 | 28.80 | 0.68 |
| 620 | 6.2 | 0.62 | 59.60 | 19.67 | 28.56 | 0.69 |
| 640 | 6.4 | 0.64 | 59.40 | 19.60 | 28.32 | 0.69 |
| 660 | 6.6 | 0.66 | 59.20 | 19.54 | 28.08 | 0.70 |
| 680 | 6.8 | 0.68 | 59.00 | 19.47 | 27.84 | 0.70 |
| 700 | 7 | 0.7 | 58.80 | 19.40 | 27.60 | 0.70 |
| 720 | 7.2 | 0.72 | 58.80 | 19.40 | 27.36 | 0.71 |
| 740 | 7.4 | 0.74 | 58.60 | 19.34 | 27.12 | 0.71 |
| 760 | 7.6 | 0.76 | 58.40 | 19.27 | 26.88 | 0.72 |
| 780 | 7.8 | 0.78 | 58.20 | 19.21 | 26.64 | 0.72 |
| 800 | 8 | 0.8 | 58.20 | 19.21 | 26.40 | 0.73 |
| 820 | 8.2 | 0.82 | 58.00 | 19.14 | 26.16 | 0.73 |
| 840 | 8.4 | 0.84 | 58.00 | 19.14 | 25.92 | 0.74 |
| 860 | 8.6 | 0.86 | 58.00 | 19.14 | 25.68 | 0.75 |
| 880 | 8.8 | 0.88 | 57.80 | 19.07 | 25.44 | 0.75 |
| 900 | 9 | 0.9 | 57.80 | 19.07 | 25.20 | 0.76 |
| 920 | 9.2 | 0.92 | 57.80 | 19.07 | 24.96 | 0.76 |
| 940 | 9.4 | 0.94 | 57.80 | 19.07 | 24.72 | 0.77 |
| 960 | 9.6 | 0.96 | 57.80 | 19.07 | 24.48 | 0.78 |
| 980 | 9.8 | 0.98 | 57.80 | 19.07 | 24.24 | 0.79 |
| 1000 | 10 | 1 | 57.40 | 18.94 | 24.00 | 0.79 |
| 1020 | 10.2 | 1.02 | 57.40 | 18.94 | 23.76 | 0.80 |
| 1040 | 10.4 | 1.04 | 56.80 | 18.74 | 23.52 | 0.80 |
| 1060 | 10.6 | 1.06 | 56.60 | 18.68 | 23.28 | 0.80 |
| 1080 | 10.8 | 1.08 | 56.40 | 18.61 | 23.04 | 0.81 |
| 1100 | 11 | 1.1 | 56.20 | 18.55 | 22.80 | 0.81 |
| 1120 | 11.2 | 1.12 | 56.00 | 18.48 | 22.56 | 0.82 |
| 1140 | 11.4 | 1.14 | 55.80 | 18.41 | 22.32 | 0.83 |
| 1160 | 11.6 | 1.16 | 55.60 | 18.35 | 22.08 | 0.83 |
| 1180 | 11.8 | 1.18 | 55.40 | 18.28 | 21.84 | 0.84 |
| 1200 | 12 | 1.2 | 55.20 | 18.22 | 21.60 | 0.84 |
| 1220 | 12.2 | 1.22 | 55.00 | 18.15 | 21.36 | 0.85 |

**Table:C7** Direct Shear Test Readings for ( Soil +2 % cement + 1.0 kg/$m^3$ ZB) at 0.5 kg/$cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| | | | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 4.00 | 1.32 | 35.76 | 0.04 |
| 40 | 0.4 | 0.04 | 6.80 | 2.24 | 35.52 | 0.06 |
| 60 | 0.6 | 0.06 | 12.80 | 4.22 | 35.28 | 0.12 |
| 80 | 0.8 | 0.08 | 13.40 | 4.42 | 35.04 | 0.13 |
| 100 | 1 | 0.1 | 15.20 | 5.02 | 34.80 | 0.14 |
| 120 | 1.2 | 0.12 | 16.20 | 5.35 | 34.56 | 0.15 |
| 140 | 1.4 | 0.14 | 17.00 | 5.61 | 34.32 | 0.16 |
| 160 | 1.6 | 0.16 | 17.60 | 5.81 | 34.08 | 0.17 |
| 180 | 1.8 | 0.18 | 18.10 | 5.97 | 33.84 | 0.18 |
| 200 | 2 | 0.2 | 18.80 | 6.20 | 33.60 | 0.18 |
| 220 | 2.2 | 0.22 | 19.20 | 6.34 | 33.36 | 0.19 |
| 240 | 2.4 | 0.24 | 19.60 | 6.47 | 33.12 | 0.20 |
| 260 | 2.6 | 0.26 | 20.00 | 6.60 | 32.88 | 0.20 |
| 280 | 2.8 | 0.28 | 20.20 | 6.67 | 32.64 | 0.20 |
| 300 | 3 | 0.3 | 20.40 | 6.73 | 32.40 | 0.21 |
| 320 | 3.2 | 0.32 | 20.60 | 6.80 | 32.16 | 0.21 |
| 340 | 3.4 | 0.34 | 20.60 | 6.80 | 31.92 | 0.21 |
| 360 | 3.6 | 0.36 | 20.80 | 6.86 | 31.68 | 0.22 |
| 380 | 3.8 | 0.38 | 20.80 | 6.86 | 31.44 | 0.22 |
| 400 | 4 | 0.4 | 20.90 | 6.90 | 31.20 | 0.22 |
| 420 | 4.2 | 0.42 | 20.90 | 6.90 | 30.96 | 0.22 |
| 440 | 4.4 | 0.44 | 21.00 | 6.93 | 30.72 | 0.23 |
| 460 | 4.6 | 0.46 | 21.00 | 6.93 | 30.48 | 0.23 |
| 480 | 4.8 | 0.48 | 21.00 | 6.93 | 30.24 | 0.23 |
| 500 | 5 | 0.5 | 20.80 | 6.86 | 30.00 | 0.23 |
| 520 | 5.2 | 0.52 | 20.80 | 6.86 | 29.76 | 0.23 |
| 540 | 5.4 | 0.54 | 20.60 | 6.80 | 29.52 | 0.23 |
| 560 | 5.6 | 0.56 | 20.60 | 6.80 | 29.28 | 0.23 |
| 580 | 5.8 | 0.58 | 20.40 | 6.73 | 29.04 | 0.23 |
| 600 | 6 | 0.6 | 20.40 | 6.73 | 28.80 | 0.23 |
| 620 | 6.2 | 0.62 | 20.30 | 6.70 | 28.56 | 0.23 |
| 640 | 6.4 | 0.64 | 20.30 | 6.70 | 28.32 | 0.24 |
| 660 | 6.6 | 0.66 | 20.30 | 6.70 | 28.08 | 0.24 |
| 680 | 6.8 | 0.68 | 20.20 | 6.67 | 27.84 | 0.24 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 700 | 7 | 0.7 | 20.20 | 6.67 | 27.60 | 0.24 |
| 720 | 7.2 | 0.72 | 20.20 | 6.67 | 27.36 | 0.24 |
| 740 | 7.4 | 0.74 | 20.20 | 6.67 | 27.12 | 0.25 |
| 760 | 7.6 | 0.76 | 20.20 | 6.67 | 26.88 | 0.25 |
| 780 | 7.8 | 0.78 | 20.30 | 6.70 | 26.64 | 0.25 |
| 800 | 8 | 0.8 | 20.20 | 6.67 | 26.40 | 0.25 |
| 820 | 8.2 | 0.82 | 20.20 | 6.67 | 26.16 | 0.25 |
| 840 | 8.4 | 0.84 | 20.20 | 6.67 | 25.92 | 0.26 |
| 860 | 8.6 | 0.86 | 20.00 | 6.60 | 25.68 | 0.26 |
| 880 | 8.8 | 0.88 | 20.00 | 6.60 | 25.44 | 0.26 |
| 900 | 9 | 0.9 | 20.00 | 6.60 | 25.20 | 0.26 |
| 920 | 9.2 | 0.92 | 20.00 | 6.60 | 24.96 | 0.26 |
| 940 | 9.4 | 0.94 | 20.00 | 6.60 | 24.72 | 0.27 |
| 960 | 9.6 | 0.96 | 20.00 | 6.60 | 24.48 | 0.27 |
| 980 | 9.8 | 0.98 | 20.00 | 6.60 | 24.24 | 0.27 |
| 1000 | 10 | 1 | 19.80 | 6.53 | 24.00 | 0.27 |
| 1020 | 10.2 | 1.02 | 19.80 | 6.53 | 23.76 | 0.28 |
| 1040 | 10.4 | 1.04 | 19.80 | 6.53 | 23.52 | 0.28 |
| 1060 | 10.6 | 1.06 | 19.60 | 6.47 | 23.28 | 0.28 |
| 1080 | 10.8 | 1.08 | 19.60 | 6.47 | 23.04 | 0.28 |
| 1100 | 11 | 1.1 | 19.60 | 6.47 | 22.80 | 0.28 |
| 1120 | 11.2 | 1.12 | 19.40 | 6.40 | 22.56 | 0.28 |
| 1140 | 11.4 | 1.14 | 19.40 | 6.40 | 22.32 | 0.29 |
| 1160 | 11.6 | 1.16 | 19.40 | 6.40 | 22.08 | 0.29 |
| 1180 | 11.8 | 1.18 | 19.40 | 6.40 | 21.84 | 0.29 |
| 1200 | 12 | 1.2 | 19.40 | 6.40 | 21.60 | 0.30 |
| 1220 | 12.2 | 1.22 | 19.40 | 6.40 | 21.36 | 0.30 |

**Table:C8** Direct Shear Test Readings for ( Soil +2 % cement + 1.0 $kg/m^3$ ZB) at 1.0 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 10.00 | 3.30 | 35.76 | 0.09 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 40 | 0.4 | 0.04 | 15.20 | 5.02 | 35.52 | 0.14 |
| 60 | 0.6 | 0.06 | 21.00 | 6.93 | 35.28 | 0.20 |
| 80 | 0.8 | 0.08 | 26.00 | 8.58 | 35.04 | 0.24 |
| 100 | 1 | 0.1 | 28.80 | 9.50 | 34.80 | 0.27 |
| 120 | 1.2 | 0.12 | 30.40 | 10.03 | 34.56 | 0.29 |
| 140 | 1.4 | 0.14 | 31.80 | 10.49 | 34.32 | 0.31 |
| 160 | 1.6 | 0.16 | 33.00 | 10.89 | 34.08 | 0.32 |
| 180 | 1.8 | 0.18 | 34.00 | 11.22 | 33.84 | 0.33 |
| 200 | 2 | 0.2 | 35.00 | 11.55 | 33.60 | 0.34 |
| 220 | 2.2 | 0.22 | 35.40 | 11.68 | 33.36 | 0.35 |
| 240 | 2.4 | 0.24 | 36.40 | 12.01 | 33.12 | 0.36 |
| 260 | 2.6 | 0.26 | 37.20 | 12.28 | 32.88 | 0.37 |
| 280 | 2.8 | 0.28 | 37.80 | 12.47 | 32.64 | 0.38 |
| 300 | 3 | 0.3 | 38.40 | 12.67 | 32.40 | 0.39 |
| 320 | 3.2 | 0.32 | 38.80 | 12.80 | 32.16 | 0.40 |
| 340 | 3.4 | 0.34 | 39.20 | 12.94 | 31.92 | 0.41 |
| 360 | 3.6 | 0.36 | 39.40 | 13.00 | 31.68 | 0.41 |
| 380 | 3.8 | 0.38 | 39.80 | 13.13 | 31.44 | 0.42 |
| 400 | 4 | 0.4 | 40.20 | 13.27 | 31.20 | 0.43 |
| 420 | 4.2 | 0.42 | 40.80 | 13.46 | 30.96 | 0.43 |
| 440 | 4.4 | 0.44 | 41.00 | 13.53 | 30.72 | 0.44 |
| 460 | 4.6 | 0.46 | 41.20 | 13.60 | 30.48 | 0.45 |
| 480 | 4.8 | 0.48 | 41.30 | 13.63 | 30.24 | 0.45 |
| 500 | 5 | 0.5 | 41.40 | 13.66 | 30.00 | 0.46 |
| 520 | 5.2 | 0.52 | 41.40 | 13.66 | 29.76 | 0.46 |
| 540 | 5.4 | 0.54 | 41.20 | 13.60 | 29.52 | 0.46 |
| 560 | 5.6 | 0.56 | 41.00 | 13.53 | 29.28 | 0.46 |
| 580 | 5.8 | 0.58 | 40.90 | 13.50 | 29.04 | 0.46 |
| 600 | 6 | 0.6 | 40.80 | 13.46 | 28.80 | 0.47 |
| 620 | 6.2 | 0.62 | 40.60 | 13.40 | 28.56 | 0.47 |
| 640 | 6.4 | 0.64 | 40.40 | 13.33 | 28.32 | 0.47 |
| 660 | 6.6 | 0.66 | 40.00 | 13.20 | 28.08 | 0.47 |
| 680 | 6.8 | 0.68 | 40.00 | 13.20 | 27.84 | 0.47 |
| 700 | 7 | 0.7 | 40.00 | 13.20 | 27.60 | 0.48 |
| 720 | 7.2 | 0.72 | 39.90 | 13.17 | 27.36 | 0.48 |
| 740 | 7.4 | 0.74 | 39.80 | 13.13 | 27.12 | 0.48 |
| 760 | 7.6 | 0.76 | 39.80 | 13.13 | 26.88 | 0.49 |
| 780 | 7.8 | 0.78 | 39.60 | 13.07 | 26.64 | 0.49 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 800 | 8 | 0.8 | 39.60 | 13.07 | 26.40 | 0.50 |
| 820 | 8.2 | 0.82 | 39.70 | 13.10 | 26.16 | 0.50 |
| 840 | 8.4 | 0.84 | 39.60 | 13.07 | 25.92 | 0.50 |
| 860 | 8.6 | 0.86 | 39.60 | 13.07 | 25.68 | 0.51 |
| 880 | 8.8 | 0.88 | 39.60 | 13.07 | 25.44 | 0.51 |
| 900 | 9 | 0.9 | 39.60 | 13.07 | 25.20 | 0.52 |
| 920 | 9.2 | 0.92 | 39.50 | 13.04 | 24.96 | 0.52 |
| 940 | 9.4 | 0.94 | 39.40 | 13.00 | 24.72 | 0.53 |
| 960 | 9.6 | 0.96 | 39.30 | 12.97 | 24.48 | 0.53 |
| 980 | 9.8 | 0.98 | 39.20 | 12.94 | 24.24 | 0.53 |
| 1000 | 10 | 1 | 39.10 | 12.90 | 24.00 | 0.54 |
| 1020 | 10.2 | 1.02 | 39.00 | 12.87 | 23.76 | 0.54 |
| 1040 | 10.4 | 1.04 | 38.80 | 12.80 | 23.52 | 0.54 |
| 1060 | 10.6 | 1.06 | 38.80 | 12.80 | 23.28 | 0.55 |
| 1080 | 10.8 | 1.08 | 38.60 | 12.74 | 23.04 | 0.55 |
| 1100 | 11 | 1.1 | 38.40 | 12.67 | 22.80 | 0.56 |
| 1120 | 11.2 | 1.12 | 38.10 | 12.57 | 22.56 | 0.56 |
| 1140 | 11.4 | 1.14 | 38.10 | 12.57 | 22.32 | 0.56 |
| 1160 | 11.6 | 1.16 | 38.10 | 12.57 | 22.08 | 0.57 |
| 1180 | 11.8 | 1.18 | 38.10 | 12.57 | 21.84 | 0.58 |
| 1200 | 12 | 1.2 | 38.10 | 12.57 | 21.60 | 0.58 |

**Table:C9** Direct Shear Test Readings for ( Soil +2 % cement + 1.0 $kg/m^3$ ZB) at 1.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 15.00 | 4.95 | 35.76 | 0.14 |
| 40 | 0.4 | 0.04 | 25.00 | 8.25 | 35.52 | 0.23 |
| 60 | 0.6 | 0.06 | 29.80 | 9.83 | 35.28 | 0.28 |
| 80 | 0.8 | 0.08 | 35.60 | 11.75 | 35.04 | 0.34 |
| 100 | 1 | 0.1 | 38.00 | 12.54 | 34.80 | 0.36 |
| 120 | 1.2 | 0.12 | 41.00 | 13.53 | 34.56 | 0.39 |
| 140 | 1.4 | 0.14 | 43.40 | 14.32 | 34.32 | 0.42 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 160 | 1.6 | 0.16 | 46.00 | 15.18 | 34.08 | 0.45 |
| 180 | 1.8 | 0.18 | 48.20 | 15.91 | 33.84 | 0.47 |
| 200 | 2 | 0.2 | 50.00 | 16.50 | 33.60 | 0.49 |
| 220 | 2.2 | 0.22 | 51.60 | 17.03 | 33.36 | 0.51 |
| 240 | 2.4 | 0.24 | 53.20 | 17.56 | 33.12 | 0.53 |
| 260 | 2.6 | 0.26 | 54.60 | 18.02 | 32.88 | 0.55 |
| 280 | 2.8 | 0.28 | 55.40 | 18.28 | 32.64 | 0.56 |
| 300 | 3 | 0.3 | 56.40 | 18.61 | 32.40 | 0.57 |
| 320 | 3.2 | 0.32 | 57.40 | 18.94 | 32.16 | 0.59 |
| 340 | 3.4 | 0.34 | 58.10 | 19.17 | 31.92 | 0.60 |
| 360 | 3.6 | 0.36 | 58.80 | 19.40 | 31.68 | 0.61 |
| 380 | 3.8 | 0.38 | 59.00 | 19.47 | 31.44 | 0.62 |
| 400 | 4 | 0.4 | 59.80 | 19.73 | 31.20 | 0.63 |
| 420 | 4.2 | 0.42 | 60.20 | 19.87 | 30.96 | 0.64 |
| 440 | 4.4 | 0.44 | 60.40 | 19.93 | 30.72 | 0.65 |
| 460 | 4.6 | 0.46 | 60.80 | 20.06 | 30.48 | 0.66 |
| 480 | 4.8 | 0.48 | 61.00 | 20.13 | 30.24 | 0.67 |
| 500 | 5 | 0.5 | 60.80 | 20.06 | 30.00 | 0.67 |
| 520 | 5.2 | 0.52 | 60.80 | 20.06 | 29.76 | 0.67 |
| 540 | 5.4 | 0.54 | 60.80 | 20.06 | 29.52 | 0.68 |
| 560 | 5.6 | 0.56 | 60.60 | 20.00 | 29.28 | 0.68 |
| 580 | 5.8 | 0.58 | 60.50 | 19.97 | 29.04 | 0.69 |
| 600 | 6 | 0.6 | 60.40 | 19.93 | 28.80 | 0.69 |
| 620 | 6.2 | 0.62 | 60.20 | 19.87 | 28.56 | 0.70 |
| 640 | 6.4 | 0.64 | 60.20 | 19.87 | 28.32 | 0.70 |
| 660 | 6.6 | 0.66 | 60.20 | 19.87 | 28.08 | 0.71 |
| 680 | 6.8 | 0.68 | 60.00 | 19.80 | 27.84 | 0.71 |
| 700 | 7 | 0.7 | 59.80 | 19.73 | 27.60 | 0.72 |
| 720 | 7.2 | 0.72 | 59.60 | 19.67 | 27.36 | 0.72 |
| 740 | 7.4 | 0.74 | 59.40 | 19.60 | 27.12 | 0.72 |
| 760 | 7.6 | 0.76 | 59.20 | 19.54 | 26.88 | 0.73 |
| 780 | 7.8 | 0.78 | 59.00 | 19.47 | 26.64 | 0.73 |
| 800 | 8 | 0.8 | 59.00 | 19.47 | 26.40 | 0.74 |
| 820 | 8.2 | 0.82 | 58.80 | 19.40 | 26.16 | 0.74 |
| 840 | 8.4 | 0.84 | 58.80 | 19.40 | 25.92 | 0.75 |
| 860 | 8.6 | 0.86 | 58.80 | 19.40 | 25.68 | 0.76 |
| 880 | 8.8 | 0.88 | 58.80 | 19.40 | 25.44 | 0.76 |
| 900 | 9 | 0.9 | 58.80 | 19.40 | 25.20 | 0.77 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 920 | 9.2 | 0.92 | 58.60 | 19.34 | 24.96 | 0.77 |
| 940 | 9.4 | 0.94 | 58.40 | 19.27 | 24.72 | 0.78 |
| 960 | 9.6 | 0.96 | 58.40 | 19.27 | 24.48 | 0.79 |
| 980 | 9.8 | 0.98 | 58.40 | 19.27 | 24.24 | 0.80 |
| 1000 | 10 | 1 | 58.40 | 19.27 | 24.00 | 0.80 |
| 1020 | 10.2 | 1.02 | 58.00 | 19.14 | 23.76 | 0.81 |
| 1040 | 10.4 | 1.04 | 58.00 | 19.14 | 23.52 | 0.81 |
| 1060 | 10.6 | 1.06 | 58.00 | 19.14 | 23.28 | 0.82 |
| 1080 | 10.8 | 1.08 | 58.00 | 19.14 | 23.04 | 0.83 |
| 1100 | 11 | 1.1 | 57.60 | 19.01 | 22.80 | 0.83 |
| 1120 | 11.2 | 1.12 | 57.60 | 19.01 | 22.56 | 0.84 |
| 1140 | 11.4 | 1.14 | 57.60 | 19.01 | 22.32 | 0.85 |
| 1160 | 11.6 | 1.16 | 57.60 | 19.01 | 22.08 | 0.86 |
| 1180 | 11.8 | 1.18 | 57.60 | 19.01 | 21.84 | 0.87 |
| 1200 | 12 | 1.2 | 57.60 | 19.01 | 21.60 | 0.88 |
| 1220 | 12.2 | 1.22 | 57.60 | 19.01 | 21.36 | 0.89 |

**Table:C10** Direct Shear Test Readings for ( Soil +2 % cement + 1.25 $kg/m^3$ ZB) at 0.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 3.20 | 1.06 | 35.76 | 0.03 |
| 40 | 0.4 | 0.04 | 9.80 | 3.23 | 35.52 | 0.09 |
| 60 | 0.6 | 0.06 | 12.50 | 4.13 | 35.28 | 0.12 |
| 80 | 0.8 | 0.08 | 15.20 | 5.02 | 35.04 | 0.14 |
| 100 | 1 | 0.1 | 16.80 | 5.54 | 34.80 | 0.16 |
| 120 | 1.2 | 0.12 | 18.00 | 5.94 | 34.56 | 0.17 |
| 140 | 1.4 | 0.14 | 18.80 | 6.20 | 34.32 | 0.18 |
| 160 | 1.6 | 0.16 | 19.40 | 6.40 | 34.08 | 0.19 |
| 180 | 1.8 | 0.18 | 20.20 | 6.67 | 33.84 | 0.20 |
| 200 | 2 | 0.2 | 20.80 | 6.86 | 33.60 | 0.20 |
| 220 | 2.2 | 0.22 | 21.40 | 7.06 | 33.36 | 0.21 |
| 240 | 2.4 | 0.24 | 22.00 | 7.26 | 33.12 | 0.22 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 260 | 2.6 | 0.26 | 22.40 | 7.39 | 32.88 | 0.22 |
| 280 | 2.8 | 0.28 | 22.80 | 7.52 | 32.64 | 0.23 |
| 300 | 3 | 0.3 | 23.20 | 7.66 | 32.40 | 0.24 |
| 320 | 3.2 | 0.32 | 23.60 | 7.79 | 32.16 | 0.24 |
| 340 | 3.4 | 0.34 | 24.00 | 7.92 | 31.92 | 0.25 |
| 360 | 3.6 | 0.36 | 24.00 | 7.92 | 31.68 | 0.25 |
| 380 | 3.8 | 0.38 | 24.00 | 7.92 | 31.44 | 0.25 |
| 400 | 4 | 0.4 | 24.00 | 7.92 | 31.20 | 0.25 |
| 420 | 4.2 | 0.42 | 23.90 | 7.89 | 30.96 | 0.25 |
| 440 | 4.4 | 0.44 | 23.80 | 7.85 | 30.72 | 0.26 |
| 460 | 4.6 | 0.46 | 23.60 | 7.79 | 30.48 | 0.26 |
| 480 | 4.8 | 0.48 | 23.60 | 7.79 | 30.24 | 0.26 |
| 500 | 5 | 0.5 | 23.40 | 7.72 | 30.00 | 0.26 |
| 520 | 5.2 | 0.52 | 23.20 | 7.66 | 29.76 | 0.26 |
| 540 | 5.4 | 0.54 | 23.20 | 7.66 | 29.52 | 0.26 |
| 560 | 5.6 | 0.56 | 23.00 | 7.59 | 29.28 | 0.26 |
| 580 | 5.8 | 0.58 | 22.80 | 7.52 | 29.04 | 0.26 |
| 600 | 6 | 0.6 | 22.80 | 7.52 | 28.80 | 0.26 |
| 620 | 6.2 | 0.62 | 22.80 | 7.52 | 28.56 | 0.26 |
| 640 | 6.4 | 0.64 | 22.60 | 7.46 | 28.32 | 0.26 |
| 660 | 6.6 | 0.66 | 22.40 | 7.39 | 28.08 | 0.26 |
| 680 | 6.8 | 0.68 | 22.30 | 7.36 | 27.84 | 0.26 |
| 700 | 7 | 0.7 | 22.30 | 7.36 | 27.60 | 0.27 |
| 720 | 7.2 | 0.72 | 22.40 | 7.39 | 27.36 | 0.27 |
| 740 | 7.4 | 0.74 | 22.60 | 7.46 | 27.12 | 0.28 |
| 760 | 7.6 | 0.76 | 22.60 | 7.46 | 26.88 | 0.28 |
| 780 | 7.8 | 0.78 | 22.40 | 7.39 | 26.64 | 0.28 |
| 800 | 8 | 0.8 | 22.40 | 7.39 | 26.40 | 0.28 |
| 820 | 8.2 | 0.82 | 22.40 | 7.39 | 26.16 | 0.28 |
| 840 | 8.4 | 0.84 | 22.40 | 7.39 | 25.92 | 0.29 |
| 860 | 8.6 | 0.86 | 22.40 | 7.39 | 25.68 | 0.29 |
| 880 | 8.8 | 0.88 | 22.20 | 7.33 | 25.44 | 0.29 |
| 900 | 9 | 0.9 | 22.10 | 7.29 | 25.20 | 0.29 |
| 920 | 9.2 | 0.92 | 22.00 | 7.26 | 24.96 | 0.29 |
| 940 | 9.4 | 0.94 | 22.00 | 7.26 | 24.72 | 0.29 |
| 960 | 9.6 | 0.96 | 21.80 | 7.19 | 24.48 | 0.29 |
| 980 | 9.8 | 0.98 | 21.60 | 7.13 | 24.24 | 0.29 |
| 1000 | 10 | 1 | 21.60 | 7.13 | 24.00 | 0.30 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 1020 | 10.2 | 1.02 | 21.60 | 7.13 | 23.76 | 0.30 |
| 1040 | 10.4 | 1.04 | 21.40 | 7.06 | 23.52 | 0.30 |
| 1060 | 10.6 | 1.06 | 21.20 | 7.00 | 23.28 | 0.30 |
| 1080 | 10.8 | 1.08 | 21.20 | 7.00 | 23.04 | 0.30 |
| 1100 | 11 | 1.1 | 21.20 | 7.00 | 22.80 | 0.31 |
| 1120 | 11.2 | 1.12 | 21.10 | 6.96 | 22.56 | 0.31 |
| 1140 | 11.4 | 1.14 | 21.10 | 6.96 | 22.32 | 0.31 |
| 1160 | 11.6 | 1.16 | 21.00 | 6.93 | 22.08 | 0.31 |
| 1180 | 11.8 | 1.18 | 21.00 | 6.93 | 21.84 | 0.32 |
| 1200 | 12 | 1.2 | 21.00 | 6.93 | 21.60 | 0.32 |
| 1220 | 12.2 | 1.22 | 20.80 | 6.86 | 21.36 | 0.32 |

**Table:C11** Direct Shear Test Readings for ( Soil +2 % cement + 1.25 $kg/m^3$ ZB) at 1.0 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 9.00 | 2.97 | 35.76 | 0.08 |
| 40 | 0.4 | 0.04 | 13.20 | 4.36 | 35.52 | 0.12 |
| 60 | 0.6 | 0.06 | 18.90 | 6.24 | 35.28 | 0.18 |
| 80 | 0.8 | 0.08 | 21.80 | 7.19 | 35.04 | 0.21 |
| 100 | 1 | 0.1 | 23.80 | 7.85 | 34.80 | 0.23 |
| 120 | 1.2 | 0.12 | 25.00 | 8.25 | 34.56 | 0.24 |
| 140 | 1.4 | 0.14 | 27.40 | 9.04 | 34.32 | 0.26 |
| 160 | 1.6 | 0.16 | 29.20 | 9.64 | 34.08 | 0.28 |
| 180 | 1.8 | 0.18 | 30.60 | 10.10 | 33.84 | 0.30 |
| 200 | 2 | 0.2 | 31.40 | 10.36 | 33.60 | 0.31 |
| 220 | 2.2 | 0.22 | 32.80 | 10.82 | 33.36 | 0.32 |
| 240 | 2.4 | 0.24 | 33.60 | 11.09 | 33.12 | 0.33 |
| 260 | 2.6 | 0.26 | 34.60 | 11.42 | 32.88 | 0.35 |
| 280 | 2.8 | 0.28 | 35.40 | 11.68 | 32.64 | 0.36 |
| 300 | 3 | 0.3 | 36.20 | 11.95 | 32.40 | 0.37 |
| 320 | 3.2 | 0.32 | 37.20 | 12.28 | 32.16 | 0.38 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 340 | 3.4 | 0.34 | 37.40 | 12.34 | 31.92 | 0.39 |
| 360 | 3.6 | 0.36 | 38.00 | 12.54 | 31.68 | 0.40 |
| 380 | 3.8 | 0.38 | 38.90 | 12.84 | 31.44 | 0.41 |
| 400 | 4 | 0.4 | 39.40 | 13.00 | 31.20 | 0.42 |
| 420 | 4.2 | 0.42 | 39.80 | 13.13 | 30.96 | 0.42 |
| 440 | 4.4 | 0.44 | 40.00 | 13.20 | 30.72 | 0.43 |
| 460 | 4.6 | 0.46 | 40.00 | 13.20 | 30.48 | 0.43 |
| 480 | 4.8 | 0.48 | 40.00 | 13.20 | 30.24 | 0.44 |
| 500 | 5 | 0.5 | 40.20 | 13.27 | 30.00 | 0.44 |
| 520 | 5.2 | 0.52 | 40.20 | 13.27 | 29.76 | 0.45 |
| 540 | 5.4 | 0.54 | 40.40 | 13.33 | 29.52 | 0.45 |
| 560 | 5.6 | 0.56 | 40.40 | 13.33 | 29.28 | 0.46 |
| 580 | 5.8 | 0.58 | 40.50 | 13.37 | 29.04 | 0.46 |
| 600 | 6 | 0.6 | 40.40 | 13.33 | 28.80 | 0.46 |
| 620 | 6.2 | 0.62 | 40.40 | 13.33 | 28.56 | 0.47 |
| 640 | 6.4 | 0.64 | 40.30 | 13.30 | 28.32 | 0.47 |
| 660 | 6.6 | 0.66 | 40.50 | 13.37 | 28.08 | 0.48 |
| 680 | 6.8 | 0.68 | 40.60 | 13.40 | 27.84 | 0.48 |
| 700 | 7 | 0.7 | 40.60 | 13.40 | 27.60 | 0.49 |
| 720 | 7.2 | 0.72 | 40.60 | 13.40 | 27.36 | 0.49 |
| 740 | 7.4 | 0.74 | 40.60 | 13.40 | 27.12 | 0.49 |
| 760 | 7.6 | 0.76 | 40.60 | 13.40 | 26.88 | 0.50 |
| 780 | 7.8 | 0.78 | 40.50 | 13.37 | 26.64 | 0.50 |
| 800 | 8 | 0.8 | 40.50 | 13.37 | 26.40 | 0.51 |
| 820 | 8.2 | 0.82 | 40.40 | 13.33 | 26.16 | 0.51 |
| 840 | 8.4 | 0.84 | 40.40 | 13.33 | 25.92 | 0.51 |
| 860 | 8.6 | 0.86 | 40.40 | 13.33 | 25.68 | 0.52 |
| 880 | 8.8 | 0.88 | 40.40 | 13.33 | 25.44 | 0.52 |
| 900 | 9 | 0.9 | 40.00 | 13.20 | 25.20 | 0.52 |
| 920 | 9.2 | 0.92 | 40.00 | 13.20 | 24.96 | 0.53 |
| 940 | 9.4 | 0.94 | 40.00 | 13.20 | 24.72 | 0.53 |
| 960 | 9.6 | 0.96 | 40.00 | 13.20 | 24.48 | 0.54 |
| 980 | 9.8 | 0.98 | 40.00 | 13.20 | 24.24 | 0.54 |
| 1000 | 10 | 1 | 40.00 | 13.20 | 24.00 | 0.55 |
| 1020 | 10.2 | 1.02 | 39.80 | 13.13 | 23.76 | 0.55 |
| 1040 | 10.4 | 1.04 | 39.60 | 13.07 | 23.52 | 0.56 |
| 1060 | 10.6 | 1.06 | 39.60 | 13.07 | 23.28 | 0.56 |
| 1080 | 10.8 | 1.08 | 39.40 | 13.00 | 23.04 | 0.56 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 1100 | 11 | 1.1 | 39.40 | 13.00 | 22.80 | 0.57 |
| 1120 | 11.2 | 1.12 | 39.40 | 13.00 | 22.56 | 0.58 |
| 1140 | 11.4 | 1.14 | 39.40 | 13.00 | 22.32 | 0.58 |
| 1160 | 11.6 | 1.16 | 39.40 | 13.00 | 22.08 | 0.59 |
| 1180 | 11.8 | 1.18 | 39.40 | 13.00 | 21.84 | 0.60 |
| 1200 | 12 | 1.2 | 39.40 | 13.00 | 21.60 | 0.60 |

**Table:C12** Direct Shear Test Readings for ( Soil +2 % cement + 1.25 $kg/m^3$ ZB) at 1.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| | | | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 12.00 | 3.96 | 35.76 | 0.11 |
| 40 | 0.4 | 0.04 | 19.20 | 6.34 | 35.52 | 0.18 |
| 60 | 0.6 | 0.06 | 26.40 | 8.71 | 35.28 | 0.25 |
| 80 | 0.8 | 0.08 | 32.00 | 10.56 | 35.04 | 0.30 |
| 100 | 1 | 0.1 | 41.00 | 13.53 | 34.80 | 0.39 |
| 120 | 1.2 | 0.12 | 43.40 | 14.32 | 34.56 | 0.41 |
| 140 | 1.4 | 0.14 | 48.20 | 15.91 | 34.32 | 0.46 |
| 160 | 1.6 | 0.16 | 52.00 | 17.16 | 34.08 | 0.50 |
| 180 | 1.8 | 0.18 | 55.00 | 18.15 | 33.84 | 0.54 |
| 200 | 2 | 0.2 | 57.00 | 18.81 | 33.60 | 0.56 |
| 220 | 2.2 | 0.22 | 59.40 | 19.60 | 33.36 | 0.59 |
| 240 | 2.4 | 0.24 | 60.00 | 19.80 | 33.12 | 0.60 |
| 260 | 2.6 | 0.26 | 61.00 | 20.13 | 32.88 | 0.61 |
| 280 | 2.8 | 0.28 | 62.40 | 20.59 | 32.64 | 0.63 |
| 300 | 3 | 0.3 | 63.80 | 21.05 | 32.40 | 0.65 |
| 320 | 3.2 | 0.32 | 65.20 | 21.52 | 32.16 | 0.67 |
| 340 | 3.4 | 0.34 | 66.20 | 21.85 | 31.92 | 0.68 |
| 360 | 3.6 | 0.36 | 67.60 | 22.31 | 31.68 | 0.70 |
| 380 | 3.8 | 0.38 | 68.60 | 22.64 | 31.44 | 0.72 |
| 400 | 4 | 0.4 | 69.40 | 22.90 | 31.20 | 0.73 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 420 | 4.2 | 0.42 | 70.00 | 23.10 | 30.96 | 0.75 |
| 440 | 4.4 | 0.44 | 70.40 | 23.23 | 30.72 | 0.76 |
| 460 | 4.6 | 0.46 | 70.60 | 23.30 | 30.48 | 0.76 |
| 480 | 4.8 | 0.48 | 70.60 | 23.30 | 30.24 | 0.77 |
| 500 | 5 | 0.5 | 70.40 | 23.23 | 30.00 | 0.77 |
| 520 | 5.2 | 0.52 | 70.30 | 23.20 | 29.76 | 0.78 |
| 540 | 5.4 | 0.54 | 69.80 | 23.03 | 29.52 | 0.78 |
| 560 | 5.6 | 0.56 | 69.00 | 22.77 | 29.28 | 0.78 |
| 580 | 5.8 | 0.58 | 67.80 | 22.37 | 29.04 | 0.77 |
| 600 | 6 | 0.6 | 66.60 | 21.98 | 28.80 | 0.76 |
| 620 | 6.2 | 0.62 | 65.40 | 21.58 | 28.56 | 0.76 |
| 640 | 6.4 | 0.64 | 65.00 | 21.45 | 28.32 | 0.76 |
| 660 | 6.6 | 0.66 | 64.00 | 21.12 | 28.08 | 0.75 |
| 680 | 6.8 | 0.68 | 63.80 | 21.05 | 27.84 | 0.76 |
| 700 | 7 | 0.7 | 63.80 | 21.05 | 27.60 | 0.76 |
| 720 | 7.2 | 0.72 | 63.20 | 20.86 | 27.36 | 0.76 |
| 740 | 7.4 | 0.74 | 63.20 | 20.86 | 27.12 | 0.77 |
| 760 | 7.6 | 0.76 | 63.00 | 20.79 | 26.88 | 0.77 |
| 780 | 7.8 | 0.78 | 63.00 | 20.79 | 26.64 | 0.78 |
| 800 | 8 | 0.8 | 62.80 | 20.72 | 26.40 | 0.79 |
| 820 | 8.2 | 0.82 | 62.80 | 20.72 | 26.16 | 0.79 |
| 840 | 8.4 | 0.84 | 62.67 | 20.68 | 25.92 | 0.80 |
| 860 | 8.6 | 0.86 | 62.67 | 20.68 | 25.68 | 0.81 |
| 880 | 8.8 | 0.88 | 62.47 | 20.61 | 25.44 | 0.81 |
| 900 | 9 | 0.9 | 62.37 | 20.58 | 25.20 | 0.82 |
| 920 | 9.2 | 0.92 | 62.27 | 20.55 | 24.96 | 0.82 |
| 940 | 9.4 | 0.94 | 62.17 | 20.52 | 24.72 | 0.83 |
| 960 | 9.6 | 0.96 | 62.17 | 20.52 | 24.48 | 0.84 |
| 980 | 9.8 | 0.98 | 61.97 | 20.45 | 24.24 | 0.84 |
| 1000 | 10 | 1 | 61.87 | 20.42 | 24.00 | 0.85 |
| 1020 | 10.2 | 1.02 | 61.77 | 20.38 | 23.76 | 0.86 |
| 1040 | 10.4 | 1.04 | 61.77 | 20.38 | 23.52 | 0.87 |
| 1060 | 10.6 | 1.06 | 61.77 | 20.38 | 23.28 | 0.88 |
| 1080 | 10.8 | 1.08 | 61.47 | 20.28 | 23.04 | 0.88 |
| 1100 | 11 | 1.1 | 61.37 | 20.25 | 22.80 | 0.89 |
| 1120 | 11.2 | 1.12 | 61.20 | 20.20 | 22.56 | 0.90 |
| 1140 | 11.4 | 1.14 | 61.00 | 20.13 | 22.32 | 0.90 |
| 1160 | 11.6 | 1.16 | 61.07 | 20.15 | 22.08 | 0.91 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 1180 | 11.8 | 1.18 | 61.07 | 20.15 | 21.84 | 0.92 |
| 1200 | 12 | 1.2 | 61.07 | 20.15 | 21.60 | 0.93 |
| 1220 | 12.2 | 1.22 | 61.07 | 20.15 | 21.36 | 0.94 |

**Table:C13** Direct Shear Test Readings for ( Soil +2 % cement + 1.5 $kg/m^3$ ZB) at 0.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| | | | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 2.60 | 0.86 | 35.76 | 0.02 |
| 40 | 0.4 | 0.04 | 5.20 | 1.72 | 35.52 | 0.05 |
| 60 | 0.6 | 0.06 | 8.80 | 2.90 | 35.28 | 0.08 |
| 80 | 0.8 | 0.08 | 13.10 | 4.32 | 35.04 | 0.12 |
| 100 | 1 | 0.1 | 14.00 | 4.62 | 34.80 | 0.13 |
| 120 | 1.2 | 0.12 | 16.40 | 5.41 | 34.56 | 0.16 |
| 140 | 1.4 | 0.14 | 17.20 | 5.68 | 34.32 | 0.17 |
| 160 | 1.6 | 0.16 | 18.00 | 5.94 | 34.08 | 0.17 |
| 180 | 1.8 | 0.18 | 18.40 | 6.07 | 33.84 | 0.18 |
| 200 | 2 | 0.2 | 19.00 | 6.27 | 33.60 | 0.19 |
| 220 | 2.2 | 0.22 | 19.20 | 6.34 | 33.36 | 0.19 |
| 240 | 2.4 | 0.24 | 19.60 | 6.47 | 33.12 | 0.20 |
| 260 | 2.6 | 0.26 | 20.00 | 6.60 | 32.88 | 0.20 |
| 280 | 2.8 | 0.28 | 20.20 | 6.67 | 32.64 | 0.20 |
| 300 | 3 | 0.3 | 20.40 | 6.73 | 32.40 | 0.21 |
| 320 | 3.2 | 0.32 | 20.50 | 6.77 | 32.16 | 0.21 |
| 340 | 3.4 | 0.34 | 20.60 | 6.80 | 31.92 | 0.21 |
| 360 | 3.6 | 0.36 | 20.60 | 6.80 | 31.68 | 0.21 |
| 380 | 3.8 | 0.38 | 20.60 | 6.80 | 31.44 | 0.22 |
| 400 | 4 | 0.4 | 20.60 | 6.80 | 31.20 | 0.22 |
| 420 | 4.2 | 0.42 | 20.60 | 6.80 | 30.96 | 0.22 |
| 440 | 4.4 | 0.44 | 20.60 | 6.80 | 30.72 | 0.22 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 460 | 4.6 | 0.46 | 20.60 | 6.80 | 30.48 | 0.22 |
| 480 | 4.8 | 0.48 | 20.60 | 6.80 | 30.24 | 0.22 |
| 500 | 5 | 0.5 | 20.40 | 6.73 | 30.00 | 0.22 |
| 520 | 5.2 | 0.52 | 20.40 | 6.73 | 29.76 | 0.23 |
| 540 | 5.4 | 0.54 | 20.40 | 6.73 | 29.52 | 0.23 |
| 560 | 5.6 | 0.56 | 20.40 | 6.73 | 29.28 | 0.23 |
| 580 | 5.8 | 0.58 | 20.30 | 6.70 | 29.04 | 0.23 |
| 600 | 6 | 0.6 | 20.20 | 6.67 | 28.80 | 0.23 |
| 620 | 6.2 | 0.62 | 20.20 | 6.67 | 28.56 | 0.23 |
| 640 | 6.4 | 0.64 | 20.20 | 6.67 | 28.32 | 0.24 |
| 660 | 6.6 | 0.66 | 20.00 | 6.60 | 28.08 | 0.24 |
| 680 | 6.8 | 0.68 | 20.00 | 6.60 | 27.84 | 0.24 |
| 700 | 7 | 0.7 | 20.00 | 6.60 | 27.60 | 0.24 |
| 720 | 7.2 | 0.72 | 20.00 | 6.60 | 27.36 | 0.24 |
| 740 | 7.4 | 0.74 | 19.80 | 6.53 | 27.12 | 0.24 |
| 760 | 7.6 | 0.76 | 19.90 | 6.57 | 26.88 | 0.24 |
| 780 | 7.8 | 0.78 | 19.80 | 6.53 | 26.64 | 0.25 |
| 800 | 8 | 0.8 | 19.70 | 6.50 | 26.40 | 0.25 |
| 820 | 8.2 | 0.82 | 19.70 | 6.50 | 26.16 | 0.25 |
| 840 | 8.4 | 0.84 | 19.60 | 6.47 | 25.92 | 0.25 |
| 860 | 8.6 | 0.86 | 19.60 | 6.47 | 25.68 | 0.25 |
| 880 | 8.8 | 0.88 | 19.40 | 6.40 | 25.44 | 0.25 |
| 900 | 9 | 0.9 | 19.40 | 6.40 | 25.20 | 0.25 |
| 920 | 9.2 | 0.92 | 19.20 | 6.34 | 24.96 | 0.25 |
| 940 | 9.4 | 0.94 | 19.20 | 6.34 | 24.72 | 0.26 |
| 960 | 9.6 | 0.96 | 19.20 | 6.34 | 24.48 | 0.26 |
| 980 | 9.8 | 0.98 | 19.20 | 6.34 | 24.24 | 0.26 |
| 1000 | 10 | 1 | 19.00 | 6.27 | 24.00 | 0.26 |
| 1020 | 10.2 | 1.02 | 19.00 | 6.27 | 23.76 | 0.26 |
| 1040 | 10.4 | 1.04 | 19.00 | 6.27 | 23.52 | 0.27 |
| 1060 | 10.6 | 1.06 | 19.00 | 6.27 | 23.28 | 0.27 |
| 1080 | 10.8 | 1.08 | 19.00 | 6.27 | 23.04 | 0.27 |
| 1100 | 11 | 1.1 | 19.00 | 6.27 | 22.80 | 0.28 |
| 1120 | 11.2 | 1.12 | 18.90 | 6.24 | 22.56 | 0.28 |
| 1140 | 11.4 | 1.14 | 18.90 | 6.24 | 22.32 | 0.28 |
| 1160 | 11.6 | 1.16 | 18.90 | 6.24 | 22.08 | 0.28 |
| 1180 | 11.8 | 1.18 | 18.90 | 6.24 | 21.84 | 0.29 |
| 1200 | 12 | 1.2 | 18.90 | 6.24 | 21.60 | 0.29 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 1220 | 12.2 | 1.22 | 18.90 | 6.24 | 21.36 | 0.29 |

**Table:C14** Direct Shear Test Readings for ( Soil +2 % cement + 1.5 $kg/m^3$ ZB) at 1.0 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| | | | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 11.00 | 3.63 | 35.76 | 0.10 |
| 40 | 0.4 | 0.04 | 15.60 | 5.15 | 35.52 | 0.14 |
| 60 | 0.6 | 0.06 | 20.80 | 6.86 | 35.28 | 0.19 |
| 80 | 0.8 | 0.08 | 22.40 | 7.39 | 35.04 | 0.21 |
| 100 | 1 | 0.1 | 24.80 | 8.18 | 34.80 | 0.24 |
| 120 | 1.2 | 0.12 | 26.20 | 8.65 | 34.56 | 0.25 |
| 140 | 1.4 | 0.14 | 27.60 | 9.11 | 34.32 | 0.27 |
| 160 | 1.6 | 0.16 | 28.80 | 9.50 | 34.08 | 0.28 |
| 180 | 1.8 | 0.18 | 30.00 | 9.90 | 33.84 | 0.29 |
| 200 | 2 | 0.2 | 31.00 | 10.23 | 33.60 | 0.30 |
| 220 | 2.2 | 0.22 | 32.00 | 10.56 | 33.36 | 0.32 |
| 240 | 2.4 | 0.24 | 32.60 | 10.76 | 33.12 | 0.32 |
| 260 | 2.6 | 0.26 | 33.40 | 11.02 | 32.88 | 0.34 |
| 280 | 2.8 | 0.28 | 34.20 | 11.29 | 32.64 | 0.35 |
| 300 | 3 | 0.3 | 35.00 | 11.55 | 32.40 | 0.36 |
| 320 | 3.2 | 0.32 | 35.60 | 11.75 | 32.16 | 0.37 |
| 340 | 3.4 | 0.34 | 36.00 | 11.88 | 31.92 | 0.37 |
| 360 | 3.6 | 0.36 | 36.40 | 12.01 | 31.68 | 0.38 |
| 380 | 3.8 | 0.38 | 36.80 | 12.14 | 31.44 | 0.39 |
| 400 | 4 | 0.4 | 37.20 | 12.28 | 31.20 | 0.39 |
| 420 | 4.2 | 0.42 | 37.40 | 12.34 | 30.96 | 0.40 |
| 440 | 4.4 | 0.44 | 37.80 | 12.47 | 30.72 | 0.41 |
| 460 | 4.6 | 0.46 | 38.40 | 12.67 | 30.48 | 0.42 |
| 480 | 4.8 | 0.48 | 38.50 | 12.71 | 30.24 | 0.42 |
| 500 | 5 | 0.5 | 38.60 | 12.74 | 30.00 | 0.42 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 520 | 5.2 | 0.52 | 38.80 | 12.80 | 29.76 | 0.43 |
| 540 | 5.4 | 0.54 | 38.80 | 12.80 | 29.52 | 0.43 |
| 560 | 5.6 | 0.56 | 38.90 | 12.84 | 29.28 | 0.44 |
| 580 | 5.8 | 0.58 | 38.90 | 12.84 | 29.04 | 0.44 |
| 600 | 6 | 0.6 | 38.80 | 12.80 | 28.80 | 0.44 |
| 620 | 6.2 | 0.62 | 38.80 | 12.80 | 28.56 | 0.45 |
| 640 | 6.4 | 0.64 | 38.60 | 12.74 | 28.32 | 0.45 |
| 660 | 6.6 | 0.66 | 38.60 | 12.74 | 28.08 | 0.45 |
| 680 | 6.8 | 0.68 | 38.60 | 12.74 | 27.84 | 0.46 |
| 700 | 7 | 0.7 | 38.60 | 12.74 | 27.60 | 0.46 |
| 720 | 7.2 | 0.72 | 38.60 | 12.74 | 27.36 | 0.47 |
| 740 | 7.4 | 0.74 | 38.40 | 12.67 | 27.12 | 0.47 |
| 760 | 7.6 | 0.76 | 38.50 | 12.71 | 26.88 | 0.47 |
| 780 | 7.8 | 0.78 | 38.20 | 12.61 | 26.64 | 0.47 |
| 800 | 8 | 0.8 | 38.30 | 12.64 | 26.40 | 0.48 |
| 820 | 8.2 | 0.82 | 38.20 | 12.61 | 26.16 | 0.48 |
| 840 | 8.4 | 0.84 | 38.20 | 12.61 | 25.92 | 0.49 |
| 860 | 8.6 | 0.86 | 38.20 | 12.61 | 25.68 | 0.49 |
| 880 | 8.8 | 0.88 | 38.00 | 12.54 | 25.44 | 0.49 |
| 900 | 9 | 0.9 | 38.00 | 12.54 | 25.20 | 0.50 |
| 920 | 9.2 | 0.92 | 38.00 | 12.54 | 24.96 | 0.50 |
| 940 | 9.4 | 0.94 | 38.10 | 12.57 | 24.72 | 0.51 |
| 960 | 9.6 | 0.96 | 38.00 | 12.54 | 24.48 | 0.51 |
| 980 | 9.8 | 0.98 | 37.90 | 12.51 | 24.24 | 0.52 |
| 1000 | 10 | 1 | 37.80 | 12.47 | 24.00 | 0.52 |
| 1020 | 10.2 | 1.02 | 37.80 | 12.47 | 23.76 | 0.53 |
| 1040 | 10.4 | 1.04 | 37.80 | 12.47 | 23.52 | 0.53 |
| 1060 | 10.6 | 1.06 | 37.80 | 12.47 | 23.28 | 0.54 |
| 1080 | 10.8 | 1.08 | 37.80 | 12.47 | 23.04 | 0.54 |
| 1100 | 11 | 1.1 | 37.80 | 12.47 | 22.80 | 0.55 |
| 1120 | 11.2 | 1.12 | 37.40 | 12.34 | 22.56 | 0.55 |
| 1140 | 11.4 | 1.14 | 37.40 | 12.34 | 22.32 | 0.55 |
| 1160 | 11.6 | 1.16 | 37.40 | 12.34 | 22.08 | 0.56 |
| 1180 | 11.8 | 1.18 | 37.40 | 12.34 | 21.84 | 0.57 |
| 1200 | 12 | 1.2 | 37.40 | 12.34 | 21.60 | 0.57 |
| 1220 | 12.2 | 1.22 | 37.40 | 12.34 | 21.36 | 0.58 |

**Table:C15** Direct Shear Test Readings for ( Soil +2 % cement + 1.5 kg/$m^3$ ZB) at 1.5 kg/$cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| | | | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 12.40 | 4.09 | 35.76 | 0.11 |
| 40 | 0.4 | 0.04 | 22.20 | 7.33 | 35.52 | 0.21 |
| 60 | 0.6 | 0.06 | 29.80 | 9.83 | 35.28 | 0.28 |
| 80 | 0.8 | 0.08 | 41.00 | 13.53 | 35.04 | 0.39 |
| 100 | 1 | 0.1 | 45.40 | 14.98 | 34.80 | 0.43 |
| 120 | 1.2 | 0.12 | 47.00 | 15.51 | 34.56 | 0.45 |
| 140 | 1.4 | 0.14 | 51.20 | 16.90 | 34.32 | 0.49 |
| 160 | 1.6 | 0.16 | 53.00 | 17.49 | 34.08 | 0.51 |
| 180 | 1.8 | 0.18 | 56.00 | 18.48 | 33.84 | 0.55 |
| 200 | 2 | 0.2 | 58.00 | 19.14 | 33.60 | 0.57 |
| 220 | 2.2 | 0.22 | 59.00 | 19.47 | 33.36 | 0.58 |
| 240 | 2.4 | 0.24 | 60.00 | 19.80 | 33.12 | 0.60 |
| 260 | 2.6 | 0.26 | 61.00 | 20.13 | 32.88 | 0.61 |
| 280 | 2.8 | 0.28 | 62.00 | 20.46 | 32.64 | 0.63 |
| 300 | 3 | 0.3 | 62.40 | 20.59 | 32.40 | 0.64 |
| 320 | 3.2 | 0.32 | 62.80 | 20.72 | 32.16 | 0.64 |
| 340 | 3.4 | 0.34 | 62.80 | 20.72 | 31.92 | 0.65 |
| 360 | 3.6 | 0.36 | 62.80 | 20.72 | 31.68 | 0.65 |
| 380 | 3.8 | 0.38 | 62.60 | 20.66 | 31.44 | 0.66 |
| 400 | 4 | 0.4 | 62.00 | 20.46 | 31.20 | 0.66 |
| 420 | 4.2 | 0.42 | 61.40 | 20.26 | 30.96 | 0.65 |
| 440 | 4.4 | 0.44 | 61.00 | 20.13 | 30.72 | 0.66 |
| 460 | 4.6 | 0.46 | 60.80 | 20.06 | 30.48 | 0.66 |
| 480 | 4.8 | 0.48 | 60.00 | 19.80 | 30.24 | 0.65 |
| 500 | 5 | 0.5 | 60.00 | 19.80 | 30.00 | 0.66 |
| 520 | 5.2 | 0.52 | 59.80 | 19.73 | 29.76 | 0.66 |
| 540 | 5.4 | 0.54 | 59.60 | 19.67 | 29.52 | 0.67 |
| 560 | 5.6 | 0.56 | 59.40 | 19.60 | 29.28 | 0.67 |
| 580 | 5.8 | 0.58 | 59.20 | 19.54 | 29.04 | 0.67 |
| 600 | 6 | 0.6 | 59.20 | 19.54 | 28.80 | 0.68 |
| 620 | 6.2 | 0.62 | 59.20 | 19.54 | 28.56 | 0.68 |
| 640 | 6.4 | 0.64 | 59.20 | 19.54 | 28.32 | 0.69 |
| 660 | 6.6 | 0.66 | 59.20 | 19.54 | 28.08 | 0.70 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 680 | 6.8 | 0.68 | 59.40 | 19.60 | 27.84 | 0.70 |
| 700 | 7 | 0.7 | 59.40 | 19.60 | 27.60 | 0.71 |
| 720 | 7.2 | 0.72 | 59.40 | 19.60 | 27.36 | 0.72 |
| 740 | 7.4 | 0.74 | 59.40 | 19.60 | 27.12 | 0.72 |
| 760 | 7.6 | 0.76 | 59.40 | 19.60 | 26.88 | 0.73 |
| 780 | 7.8 | 0.78 | 59.20 | 19.54 | 26.64 | 0.73 |
| 800 | 8 | 0.8 | 59.20 | 19.54 | 26.40 | 0.74 |
| 820 | 8.2 | 0.82 | 59.20 | 19.54 | 26.16 | 0.75 |
| 840 | 8.4 | 0.84 | 59.20 | 19.54 | 25.92 | 0.75 |
| 860 | 8.6 | 0.86 | 59.20 | 19.54 | 25.68 | 0.76 |
| 880 | 8.8 | 0.88 | 59.20 | 19.54 | 25.44 | 0.77 |
| 900 | 9 | 0.9 | 59.00 | 19.47 | 25.20 | 0.77 |
| 920 | 9.2 | 0.92 | 59.00 | 19.47 | 24.96 | 0.78 |
| 940 | 9.4 | 0.94 | 58.80 | 19.40 | 24.72 | 0.78 |
| 960 | 9.6 | 0.96 | 58.80 | 19.40 | 24.48 | 0.79 |
| 980 | 9.8 | 0.98 | 58.60 | 19.34 | 24.24 | 0.80 |
| 1000 | 10 | 1 | 58.50 | 19.31 | 24.00 | 0.80 |
| 1020 | 10.2 | 1.02 | 58.60 | 19.34 | 23.76 | 0.81 |
| 1040 | 10.4 | 1.04 | 58.60 | 19.34 | 23.52 | 0.82 |
| 1060 | 10.6 | 1.06 | 58.50 | 19.31 | 23.28 | 0.83 |
| 1080 | 10.8 | 1.08 | 58.50 | 19.31 | 23.04 | 0.84 |
| 1100 | 11 | 1.1 | 58.40 | 19.27 | 22.80 | 0.85 |
| 1120 | 11.2 | 1.12 | 58.40 | 19.27 | 22.56 | 0.85 |
| 1140 | 11.4 | 1.14 | 58.20 | 19.21 | 22.32 | 0.86 |
| 1160 | 11.6 | 1.16 | 58.20 | 19.21 | 22.08 | 0.87 |
| 1180 | 11.8 | 1.18 | 58.20 | 19.21 | 21.84 | 0.88 |
| 1200 | 12 | 1.2 | 58.00 | 19.14 | 21.60 | 0.89 |
| 1220 | 12.2 | 1.22 | 58.00 | 19.14 | 21.36 | 0.90 |

## Appendix D

**Table:D1** Direct Shear Test Readings for ( Soil +3 % cement + 0.5 $kg/m^3$ ZB) at 0.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| | | | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 2.60 | 0.86 | 35.76 | 0.02 |
| 40 | 0.4 | 0.04 | 6.40 | 2.11 | 35.52 | 0.06 |
| 60 | 0.6 | 0.06 | 10.00 | 3.30 | 35.28 | 0.09 |
| 80 | 0.8 | 0.08 | 12.60 | 4.16 | 35.04 | 0.12 |
| 100 | 1 | 0.1 | 14.00 | 4.62 | 34.80 | 0.13 |
| 120 | 1.2 | 0.12 | 14.80 | 4.88 | 34.56 | 0.14 |
| 140 | 1.4 | 0.14 | 15.00 | 4.95 | 34.32 | 0.14 |
| 160 | 1.6 | 0.16 | 15.60 | 5.15 | 34.08 | 0.15 |
| 180 | 1.8 | 0.18 | 16.20 | 5.35 | 33.84 | 0.16 |
| 200 | 2 | 0.2 | 16.60 | 5.48 | 33.60 | 0.16 |
| 220 | 2.2 | 0.22 | 16.80 | 5.54 | 33.36 | 0.17 |
| 240 | 2.4 | 0.24 | 17.20 | 5.68 | 33.12 | 0.17 |
| 260 | 2.6 | 0.26 | 17.40 | 5.74 | 32.88 | 0.17 |
| 280 | 2.8 | 0.28 | 17.80 | 5.87 | 32.64 | 0.18 |
| 300 | 3 | 0.3 | 18.00 | 5.94 | 32.40 | 0.18 |
| 320 | 3.2 | 0.32 | 18.20 | 6.01 | 32.16 | 0.19 |
| 340 | 3.4 | 0.34 | 18.20 | 6.01 | 31.92 | 0.19 |
| 360 | 3.6 | 0.36 | 18.00 | 5.94 | 31.68 | 0.19 |
| 380 | 3.8 | 0.38 | 17.80 | 5.87 | 31.44 | 0.19 |
| 400 | 4 | 0.4 | 17.80 | 5.87 | 31.20 | 0.19 |
| 420 | 4.2 | 0.42 | 17.70 | 5.84 | 30.96 | 0.19 |
| 440 | 4.4 | 0.44 | 17.60 | 5.81 | 30.72 | 0.19 |
| 460 | 4.6 | 0.46 | 17.60 | 5.81 | 30.48 | 0.19 |
| 480 | 4.8 | 0.48 | 17.60 | 5.81 | 30.24 | 0.19 |
| 500 | 5 | 0.5 | 17.60 | 5.81 | 30.00 | 0.19 |
| 520 | 5.2 | 0.52 | 17.60 | 5.81 | 29.76 | 0.20 |
| 540 | 5.4 | 0.54 | 17.40 | 5.74 | 29.52 | 0.19 |
| 560 | 5.6 | 0.56 | 17.40 | 5.74 | 29.28 | 0.20 |
| 580 | 5.8 | 0.58 | 17.40 | 5.74 | 29.04 | 0.20 |
| 600 | 6 | 0.6 | 17.40 | 5.74 | 28.80 | 0.20 |
| 620 | 6.2 | 0.62 | 17.30 | 5.71 | 28.56 | 0.20 |
| 640 | 6.4 | 0.64 | 17.30 | 5.71 | 28.32 | 0.20 |
| 660 | 6.6 | 0.66 | 17.20 | 5.68 | 28.08 | 0.20 |
| 680 | 6.8 | 0.68 | 17.20 | 5.68 | 27.84 | 0.20 |
| 700 | 7 | 0.7 | 17.10 | 5.64 | 27.60 | 0.20 |
| 720 | 7.2 | 0.72 | 17.00 | 5.61 | 27.36 | 0.21 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 740 | 7.4 | 0.74 | 16.80 | 5.54 | 27.12 | 0.20 |
| 760 | 7.6 | 0.76 | 16.80 | 5.54 | 26.88 | 0.21 |
| 780 | 7.8 | 0.78 | 16.80 | 5.54 | 26.64 | 0.21 |
| 800 | 8 | 0.8 | 16.60 | 5.48 | 26.40 | 0.21 |
| 820 | 8.2 | 0.82 | 16.60 | 5.48 | 26.16 | 0.21 |
| 840 | 8.4 | 0.84 | 16.50 | 5.45 | 25.92 | 0.21 |
| 860 | 8.6 | 0.86 | 16.40 | 5.41 | 25.68 | 0.21 |
| 880 | 8.8 | 0.88 | 16.40 | 5.41 | 25.44 | 0.21 |
| 900 | 9 | 0.9 | 16.30 | 5.38 | 25.20 | 0.21 |
| 920 | 9.2 | 0.92 | 16.20 | 5.35 | 24.96 | 0.21 |
| 940 | 9.4 | 0.94 | 16.10 | 5.31 | 24.72 | 0.21 |
| 960 | 9.6 | 0.96 | 16.00 | 5.28 | 24.48 | 0.22 |
| 980 | 9.8 | 0.98 | 16.00 | 5.28 | 24.24 | 0.22 |
| 1000 | 10 | 1 | 15.90 | 5.25 | 24.00 | 0.22 |
| 1020 | 10.2 | 1.02 | 15.83 | 5.22 | 23.76 | 0.22 |
| 1040 | 10.4 | 1.04 | 15.76 | 5.20 | 23.52 | 0.22 |
| 1060 | 10.6 | 1.06 | 15.69 | 5.18 | 23.28 | 0.22 |
| 1080 | 10.8 | 1.08 | 15.62 | 5.15 | 23.04 | 0.22 |
| 1100 | 11 | 1.1 | 15.55 | 5.13 | 22.80 | 0.23 |
| 1120 | 11.2 | 1.12 | 15.48 | 5.11 | 22.56 | 0.23 |
| 1140 | 11.4 | 1.14 | 15.41 | 5.09 | 22.32 | 0.23 |
| 1160 | 11.6 | 1.16 | 15.34 | 5.06 | 22.08 | 0.23 |
| 1180 | 11.8 | 1.18 | 15.27 | 5.04 | 21.84 | 0.23 |
| 1200 | 12 | 1.2 | 15.20 | 5.02 | 21.60 | 0.23 |
| 1220 | 12.2 | 1.22 | 15.13 | 4.99 | 21.36 | 0.24 |
| 1240 | 12.4 | 1.24 | 15.06 | 4.97 | 21.12 | 0.24 |

**Table:D2** Direct Shear Test Readings for ( Soil +3 % cement + 0.5 $kg/m^3$ ZB) at 1.0 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| | | | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 10.20 | 3.37 | 35.76 | 0.09 |
| 40 | 0.4 | 0.04 | 15.40 | 5.08 | 35.52 | 0.14 |
| 60 | 0.6 | 0.06 | 19.20 | 6.34 | 35.28 | 0.18 |
| 80 | 0.8 | 0.08 | 21.60 | 7.13 | 35.04 | 0.20 |
| 100 | 1 | 0.1 | 23.80 | 7.85 | 34.80 | 0.23 |
| 120 | 1.2 | 0.12 | 24.20 | 7.99 | 34.56 | 0.23 |
| 140 | 1.4 | 0.14 | 24.80 | 8.18 | 34.32 | 0.24 |
| 160 | 1.6 | 0.16 | 26.40 | 8.71 | 34.08 | 0.26 |
| 180 | 1.8 | 0.18 | 27.20 | 8.98 | 33.84 | 0.27 |
| 200 | 2 | 0.2 | 28.40 | 9.37 | 33.60 | 0.28 |
| 220 | 2.2 | 0.22 | 29.40 | 9.70 | 33.36 | 0.29 |
| 240 | 2.4 | 0.24 | 30.20 | 9.97 | 33.12 | 0.30 |
| 260 | 2.6 | 0.26 | 30.80 | 10.16 | 32.88 | 0.31 |
| 280 | 2.8 | 0.28 | 31.30 | 10.33 | 32.64 | 0.32 |
| 300 | 3 | 0.3 | 31.80 | 10.49 | 32.40 | 0.32 |
| 320 | 3.2 | 0.32 | 32.20 | 10.63 | 32.16 | 0.33 |
| 340 | 3.4 | 0.34 | 32.60 | 10.76 | 31.92 | 0.34 |
| 360 | 3.6 | 0.36 | 32.90 | 10.86 | 31.68 | 0.34 |
| 380 | 3.8 | 0.38 | 33.20 | 10.96 | 31.44 | 0.35 |
| 400 | 4 | 0.4 | 33.40 | 11.02 | 31.20 | 0.35 |
| 420 | 4.2 | 0.42 | 33.40 | 11.02 | 30.96 | 0.36 |
| 440 | 4.4 | 0.44 | 33.00 | 10.89 | 30.72 | 0.35 |
| 460 | 4.6 | 0.46 | 33.20 | 10.96 | 30.48 | 0.36 |
| 480 | 4.8 | 0.48 | 33.60 | 11.09 | 30.24 | 0.37 |
| 500 | 5 | 0.5 | 33.60 | 11.09 | 30.00 | 0.37 |
| 520 | 5.2 | 0.52 | 33.80 | 11.15 | 29.76 | 0.37 |
| 540 | 5.4 | 0.54 | 33.90 | 11.19 | 29.52 | 0.38 |
| 560 | 5.6 | 0.56 | 34.00 | 11.22 | 29.28 | 0.38 |
| 580 | 5.8 | 0.58 | 34.00 | 11.22 | 29.04 | 0.39 |
| 600 | 6 | 0.6 | 34.20 | 11.29 | 28.80 | 0.39 |
| 620 | 6.2 | 0.62 | 34.20 | 11.29 | 28.56 | 0.40 |
| 640 | 6.4 | 0.64 | 34.40 | 11.35 | 28.32 | 0.40 |
| 660 | 6.6 | 0.66 | 34.60 | 11.42 | 28.08 | 0.41 |
| 680 | 6.8 | 0.68 | 34.60 | 11.42 | 27.84 | 0.41 |
| 700 | 7 | 0.7 | 34.60 | 11.42 | 27.60 | 0.41 |
| 720 | 7.2 | 0.72 | 34.70 | 11.45 | 27.36 | 0.42 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 740 | 7.4 | 0.74 | 34.70 | 11.45 | 27.12 | 0.42 |
| 760 | 7.6 | 0.76 | 34.70 | 11.45 | 26.88 | 0.43 |
| 780 | 7.8 | 0.78 | 34.80 | 11.48 | 26.64 | 0.43 |
| 800 | 8 | 0.8 | 35.00 | 11.55 | 26.40 | 0.44 |
| 820 | 8.2 | 0.82 | 35.00 | 11.55 | 26.16 | 0.44 |
| 840 | 8.4 | 0.84 | 35.00 | 11.55 | 25.92 | 0.45 |
| 860 | 8.6 | 0.86 | 35.00 | 11.55 | 25.68 | 0.45 |
| 880 | 8.8 | 0.88 | 35.00 | 11.55 | 25.44 | 0.45 |
| 900 | 9 | 0.9 | 35.00 | 11.55 | 25.20 | 0.46 |
| 920 | 9.2 | 0.92 | 34.80 | 11.48 | 24.96 | 0.46 |
| 940 | 9.4 | 0.94 | 34.70 | 11.45 | 24.72 | 0.46 |
| 960 | 9.6 | 0.96 | 34.80 | 11.48 | 24.48 | 0.47 |
| 980 | 9.8 | 0.98 | 34.60 | 11.42 | 24.24 | 0.47 |
| 1000 | 10 | 1 | 34.50 | 11.39 | 24.00 | 0.47 |
| 1020 | 10.2 | 1.02 | 34.50 | 11.39 | 23.76 | 0.48 |
| 1040 | 10.4 | 1.04 | 34.60 | 11.42 | 23.52 | 0.49 |
| 1060 | 10.6 | 1.06 | 34.50 | 11.39 | 23.28 | 0.49 |
| 1080 | 10.8 | 1.08 | 34.50 | 11.39 | 23.04 | 0.49 |
| 1100 | 11 | 1.1 | 34.40 | 11.35 | 22.80 | 0.50 |
| 1120 | 11.2 | 1.12 | 34.20 | 11.29 | 22.56 | 0.50 |
| 1140 | 11.4 | 1.14 | 34.20 | 11.29 | 22.32 | 0.51 |
| 1160 | 11.6 | 1.16 | 34.20 | 11.29 | 22.08 | 0.51 |
| 1180 | 11.8 | 1.18 | 34.00 | 11.22 | 21.84 | 0.51 |
| 1200 | 12 | 1.2 | 34.00 | 11.22 | 21.60 | 0.52 |
| 1220 | 12.2 | 1.22 | 34.00 | 11.22 | 21.36 | 0.53 |
| 1240 | 12.4 | 1.24 | 34.00 | 11.22 | 21.12 | 0.54 |
| 1260 | 12.6 | 1.26 | 34.00 | 11.22 | 20.88 | 0.54 |

**Table:D3** Direct Shear Test Readings for ( Soil +3% cement + 0.5 $kg/m^3$ ZB) at 1.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| | | | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 10.00 | 3.30 | 35.76 | 0.09 |
| 40 | 0.4 | 0.04 | 15.60 | 5.15 | 35.52 | 0.14 |
| 60 | 0.6 | 0.06 | 24.20 | 7.99 | 35.28 | 0.23 |
| 80 | 0.8 | 0.08 | 31.20 | 10.30 | 35.04 | 0.29 |
| 100 | 1 | 0.1 | 35.20 | 11.62 | 34.80 | 0.33 |
| 120 | 1.2 | 0.12 | 38.20 | 12.61 | 34.56 | 0.36 |
| 140 | 1.4 | 0.14 | 40.20 | 13.27 | 34.32 | 0.39 |
| 160 | 1.6 | 0.16 | 41.00 | 13.53 | 34.08 | 0.40 |
| 180 | 1.8 | 0.18 | 41.60 | 13.73 | 33.84 | 0.41 |
| 200 | 2 | 0.2 | 42.40 | 13.99 | 33.60 | 0.42 |
| 220 | 2.2 | 0.22 | 43.60 | 14.39 | 33.36 | 0.43 |
| 240 | 2.4 | 0.24 | 44.40 | 14.65 | 33.12 | 0.44 |
| 260 | 2.6 | 0.26 | 45.20 | 14.92 | 32.88 | 0.45 |
| 280 | 2.8 | 0.28 | 46.20 | 15.25 | 32.64 | 0.47 |
| 300 | 3 | 0.3 | 47.00 | 15.51 | 32.40 | 0.48 |
| 320 | 3.2 | 0.32 | 47.80 | 15.77 | 32.16 | 0.49 |
| 340 | 3.4 | 0.34 | 48.20 | 15.91 | 31.92 | 0.50 |
| 360 | 3.6 | 0.36 | 49.00 | 16.17 | 31.68 | 0.51 |
| 380 | 3.8 | 0.38 | 49.60 | 16.37 | 31.44 | 0.52 |
| 400 | 4 | 0.4 | 50.00 | 16.50 | 31.20 | 0.53 |
| 420 | 4.2 | 0.42 | 50.60 | 16.70 | 30.96 | 0.54 |
| 440 | 4.4 | 0.44 | 51.20 | 16.90 | 30.72 | 0.55 |
| 460 | 4.6 | 0.46 | 51.60 | 17.03 | 30.48 | 0.56 |
| 480 | 4.8 | 0.48 | 52.20 | 17.23 | 30.24 | 0.57 |
| 500 | 5 | 0.5 | 52.60 | 17.36 | 30.00 | 0.58 |
| 520 | 5.2 | 0.52 | 52.80 | 17.42 | 29.76 | 0.59 |
| 540 | 5.4 | 0.54 | 53.30 | 17.59 | 29.52 | 0.60 |
| 560 | 5.6 | 0.56 | 53.60 | 17.69 | 29.28 | 0.60 |
| 580 | 5.8 | 0.58 | 54.00 | 17.82 | 29.04 | 0.61 |
| 600 | 6 | 0.6 | 54.20 | 17.89 | 28.80 | 0.62 |
| 620 | 6.2 | 0.62 | 54.60 | 18.02 | 28.56 | 0.63 |
| 640 | 6.4 | 0.64 | 54.80 | 18.08 | 28.32 | 0.64 |
| 660 | 6.6 | 0.66 | 55.00 | 18.15 | 28.08 | 0.65 |
| 680 | 6.8 | 0.68 | 55.20 | 18.22 | 27.84 | 0.65 |
| 700 | 7 | 0.7 | 55.40 | 18.28 | 27.60 | 0.66 |
| 720 | 7.2 | 0.72 | 55.40 | 18.28 | 27.36 | 0.67 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 740 | 7.4 | 0.74 | 55.60 | 18.35 | 27.12 | 0.68 |
| 760 | 7.6 | 0.76 | 55.80 | 18.41 | 26.88 | 0.69 |
| 780 | 7.8 | 0.78 | 56.20 | 18.55 | 26.64 | 0.70 |
| 800 | 8 | 0.8 | 56.40 | 18.61 | 26.40 | 0.71 |
| 820 | 8.2 | 0.82 | 56.40 | 18.61 | 26.16 | 0.71 |
| 840 | 8.4 | 0.84 | 56.60 | 18.68 | 25.92 | 0.72 |
| 860 | 8.6 | 0.86 | 56.70 | 18.71 | 25.68 | 0.73 |
| 880 | 8.8 | 0.88 | 56.80 | 18.74 | 25.44 | 0.74 |
| 900 | 9 | 0.9 | 57.00 | 18.81 | 25.20 | 0.75 |
| 920 | 9.2 | 0.92 | 57.20 | 18.88 | 24.96 | 0.76 |
| 940 | 9.4 | 0.94 | 57.20 | 18.88 | 24.72 | 0.76 |
| 960 | 9.6 | 0.96 | 57.40 | 18.94 | 24.48 | 0.77 |
| 980 | 9.8 | 0.98 | 57.60 | 19.01 | 24.24 | 0.78 |
| 1000 | 10 | 1 | 57.50 | 18.98 | 24.00 | 0.79 |
| 1020 | 10.2 | 1.02 | 57.70 | 19.04 | 23.76 | 0.80 |
| 1040 | 10.4 | 1.04 | 57.70 | 19.04 | 23.52 | 0.81 |
| 1060 | 10.6 | 1.06 | 58.00 | 19.14 | 23.28 | 0.82 |
| 1080 | 10.8 | 1.08 | 58.00 | 19.14 | 23.04 | 0.83 |
| 1100 | 11 | 1.1 | 58.00 | 19.14 | 22.80 | 0.84 |
| 1120 | 11.2 | 1.12 | 58.00 | 19.14 | 22.56 | 0.85 |
| 1140 | 11.4 | 1.14 | 58.00 | 19.14 | 22.32 | 0.86 |
| 1160 | 11.6 | 1.16 | 58.00 | 19.14 | 22.08 | 0.87 |
| 1180 | 11.8 | 1.18 | 57.80 | 19.07 | 21.84 | 0.87 |
| 1200 | 12 | 1.2 | 57.80 | 19.07 | 21.60 | 0.88 |
| 1220 | 12.2 | 1.22 | 57.60 | 19.01 | 21.36 | 0.89 |
| 1240 | 12.4 | 1.24 | 57.40 | 18.94 | 21.12 | 0.89 |

**Table:D4** Direct Shear Test Readings for ( Soil +3 % cement + 0.75 $kg/m^3$ ZB) at0.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 6.00 | 1.43 | 35.76 | 0.04 |
| 40 | 0.4 | 0.04 | 10.00 | 2.39 | 35.52 | 0.07 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 60 | 0.6 | 0.06 | 15.00 | 3.59 | 35.28 | 0.10 |
| 80 | 0.8 | 0.08 | 19.20 | 4.59 | 35.04 | 0.13 |
| 100 | 1 | 0.1 | 22.00 | 5.26 | 34.80 | 0.15 |
| 120 | 1.2 | 0.12 | 24.00 | 5.74 | 34.56 | 0.17 |
| 140 | 1.4 | 0.14 | 24.80 | 5.93 | 34.32 | 0.17 |
| 160 | 1.6 | 0.16 | 25.20 | 6.02 | 34.08 | 0.18 |
| 180 | 1.8 | 0.18 | 26.20 | 6.26 | 33.84 | 0.19 |
| 200 | 2 | 0.2 | 27.00 | 6.45 | 33.60 | 0.19 |
| 220 | 2.2 | 0.22 | 28.20 | 6.74 | 33.36 | 0.20 |
| 240 | 2.4 | 0.24 | 28.70 | 6.86 | 33.12 | 0.21 |
| 260 | 2.6 | 0.26 | 29.00 | 6.93 | 32.88 | 0.21 |
| 280 | 2.8 | 0.28 | 29.20 | 6.98 | 32.64 | 0.21 |
| 300 | 3 | 0.3 | 29.40 | 7.03 | 32.40 | 0.22 |
| 320 | 3.2 | 0.32 | 29.60 | 7.07 | 32.16 | 0.22 |
| 340 | 3.4 | 0.34 | 29.80 | 7.12 | 31.92 | 0.22 |
| 360 | 3.6 | 0.36 | 30.00 | 7.17 | 31.68 | 0.23 |
| 380 | 3.8 | 0.38 | 30.20 | 7.22 | 31.44 | 0.23 |
| 400 | 4 | 0.4 | 30.40 | 7.27 | 31.20 | 0.23 |
| 420 | 4.2 | 0.42 | 30.40 | 7.27 | 30.96 | 0.23 |
| 440 | 4.4 | 0.44 | 30.50 | 7.29 | 30.72 | 0.24 |
| 460 | 4.6 | 0.46 | 30.60 | 7.31 | 30.48 | 0.24 |
| 480 | 4.8 | 0.48 | 30.80 | 7.36 | 30.24 | 0.24 |
| 500 | 5 | 0.5 | 30.80 | 7.36 | 30.00 | 0.25 |
| 520 | 5.2 | 0.52 | 30.80 | 7.36 | 29.76 | 0.25 |
| 540 | 5.4 | 0.54 | 30.80 | 7.36 | 29.52 | 0.25 |
| 560 | 5.6 | 0.56 | 31.00 | 7.41 | 29.28 | 0.25 |
| 580 | 5.8 | 0.58 | 31.00 | 7.41 | 29.04 | 0.26 |
| 600 | 6 | 0.6 | 31.00 | 7.41 | 28.80 | 0.26 |
| 620 | 6.2 | 0.62 | 31.00 | 7.41 | 28.56 | 0.26 |
| 640 | 6.4 | 0.64 | 31.00 | 7.41 | 28.32 | 0.26 |
| 660 | 6.6 | 0.66 | 31.00 | 7.41 | 28.08 | 0.26 |
| 680 | 6.8 | 0.68 | 30.90 | 7.39 | 27.84 | 0.27 |
| 700 | 7 | 0.7 | 30.80 | 7.36 | 27.60 | 0.27 |
| 720 | 7.2 | 0.72 | 30.80 | 7.36 | 27.36 | 0.27 |
| 740 | 7.4 | 0.74 | 30.60 | 7.31 | 27.12 | 0.27 |
| 760 | 7.6 | 0.76 | 30.60 | 7.31 | 26.88 | 0.27 |
| 780 | 7.8 | 0.78 | 30.60 | 7.31 | 26.64 | 0.27 |
| 800 | 8 | 0.8 | 30.60 | 7.31 | 26.40 | 0.28 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 820 | 8.2 | 0.82 | 30.50 | 7.29 | 26.16 | 0.28 |
| 840 | 8.4 | 0.84 | 30.60 | 7.31 | 25.92 | 0.28 |
| 860 | 8.6 | 0.86 | 30.50 | 7.29 | 25.68 | 0.28 |
| 880 | 8.8 | 0.88 | 30.40 | 7.27 | 25.44 | 0.29 |
| 900 | 9 | 0.9 | 30.40 | 7.27 | 25.20 | 0.29 |
| 920 | 9.2 | 0.92 | 30.30 | 7.24 | 24.96 | 0.29 |
| 940 | 9.4 | 0.94 | 30.20 | 7.22 | 24.72 | 0.29 |
| 960 | 9.6 | 0.96 | 30.20 | 7.22 | 24.48 | 0.29 |
| 980 | 9.8 | 0.98 | 30.00 | 7.17 | 24.24 | 0.30 |
| 1000 | 10 | 1 | 29.80 | 7.12 | 24.00 | 0.30 |
| 1020 | 10.2 | 1.02 | 29.90 | 7.15 | 23.76 | 0.30 |
| 1040 | 10.4 | 1.04 | 29.80 | 7.12 | 23.52 | 0.30 |
| 1060 | 10.6 | 1.06 | 29.60 | 7.07 | 23.28 | 0.30 |
| 1080 | 10.8 | 1.08 | 29.40 | 7.03 | 23.04 | 0.30 |
| 1100 | 11 | 1.1 | 29.20 | 6.98 | 22.80 | 0.31 |
| 1120 | 11.2 | 1.12 | 29.20 | 6.98 | 22.56 | 0.31 |
| 1140 | 11.4 | 1.14 | 29.10 | 6.95 | 22.32 | 0.31 |
| 1160 | 11.6 | 1.16 | 29.00 | 6.93 | 22.08 | 0.31 |
| 1180 | 11.8 | 1.18 | 28.80 | 6.88 | 21.84 | 0.32 |
| 1200 | 12 | 1.2 | 28.60 | 6.84 | 21.60 | 0.32 |
| 1220 | 12.2 | 1.22 | 28.20 | 6.74 | 21.36 | 0.32 |

**Table:D5** Direct Shear Test Readings for ( Soil +3 % cement + 0.75 $kg/m^3$ ZB) at 1.0 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| | | | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 9.20 | 3.04 | 35.76 | 0.08 |
| 40 | 0.4 | 0.04 | 11.20 | 3.70 | 35.52 | 0.10 |
| 60 | 0.6 | 0.06 | 15.40 | 5.08 | 35.28 | 0.14 |
| 80 | 0.8 | 0.08 | 21.60 | 7.13 | 35.04 | 0.20 |
| 100 | 1 | 0.1 | 26.20 | 8.65 | 34.80 | 0.25 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 120 | 1.2 | 0.12 | 28.30 | 9.34 | 34.56 | 0.27 |
| 140 | 1.4 | 0.14 | 30.20 | 9.97 | 34.32 | 0.29 |
| 160 | 1.6 | 0.16 | 31.00 | 10.23 | 34.08 | 0.30 |
| 180 | 1.8 | 0.18 | 32.00 | 10.56 | 33.84 | 0.31 |
| 200 | 2 | 0.2 | 32.60 | 10.76 | 33.60 | 0.32 |
| 220 | 2.2 | 0.22 | 33.10 | 10.92 | 33.36 | 0.33 |
| 240 | 2.4 | 0.24 | 33.40 | 11.02 | 33.12 | 0.33 |
| 260 | 2.6 | 0.26 | 34.00 | 11.22 | 32.88 | 0.34 |
| 280 | 2.8 | 0.28 | 34.20 | 11.29 | 32.64 | 0.35 |
| 300 | 3 | 0.3 | 34.40 | 11.35 | 32.40 | 0.35 |
| 320 | 3.2 | 0.32 | 34.80 | 11.48 | 32.16 | 0.36 |
| 340 | 3.4 | 0.34 | 35.00 | 11.55 | 31.92 | 0.36 |
| 360 | 3.6 | 0.36 | 35.20 | 11.62 | 31.68 | 0.37 |
| 380 | 3.8 | 0.38 | 35.60 | 11.75 | 31.44 | 0.37 |
| 400 | 4 | 0.4 | 35.80 | 11.81 | 31.20 | 0.38 |
| 420 | 4.2 | 0.42 | 36.20 | 11.95 | 30.96 | 0.39 |
| 440 | 4.4 | 0.44 | 36.40 | 12.01 | 30.72 | 0.39 |
| 460 | 4.6 | 0.46 | 36.60 | 12.08 | 30.48 | 0.40 |
| 480 | 4.8 | 0.48 | 36.80 | 12.14 | 30.24 | 0.40 |
| 500 | 5 | 0.5 | 36.90 | 12.18 | 30.00 | 0.41 |
| 520 | 5.2 | 0.52 | 37.00 | 12.21 | 29.76 | 0.41 |
| 540 | 5.4 | 0.54 | 37.20 | 12.28 | 29.52 | 0.42 |
| 560 | 5.6 | 0.56 | 37.40 | 12.34 | 29.28 | 0.42 |
| 580 | 5.8 | 0.58 | 37.60 | 12.41 | 29.04 | 0.43 |
| 600 | 6 | 0.6 | 37.80 | 12.47 | 28.80 | 0.43 |
| 620 | 6.2 | 0.62 | 38.00 | 12.54 | 28.56 | 0.44 |
| 640 | 6.4 | 0.64 | 38.10 | 12.57 | 28.32 | 0.44 |
| 660 | 6.6 | 0.66 | 38.20 | 12.61 | 28.08 | 0.45 |
| 680 | 6.8 | 0.68 | 38.60 | 12.74 | 27.84 | 0.46 |
| 700 | 7 | 0.7 | 38.60 | 12.74 | 27.60 | 0.46 |
| 720 | 7.2 | 0.72 | 38.80 | 12.80 | 27.36 | 0.47 |
| 740 | 7.4 | 0.74 | 38.80 | 12.80 | 27.12 | 0.47 |
| 760 | 7.6 | 0.76 | 39.00 | 12.87 | 26.88 | 0.48 |
| 780 | 7.8 | 0.78 | 39.20 | 12.94 | 26.64 | 0.49 |
| 800 | 8 | 0.8 | 39.40 | 13.00 | 26.40 | 0.49 |
| 820 | 8.2 | 0.82 | 39.40 | 13.00 | 26.16 | 0.50 |
| 840 | 8.4 | 0.84 | 39.40 | 13.00 | 25.92 | 0.50 |
| 860 | 8.6 | 0.86 | 39.60 | 13.07 | 25.68 | 0.51 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 880 | 8.8 | 0.88 | 39.60 | 13.07 | 25.44 | 0.51 |
| 900 | 9 | 0.9 | 39.60 | 13.07 | 25.20 | 0.52 |
| 920 | 9.2 | 0.92 | 39.80 | 13.13 | 24.96 | 0.53 |
| 940 | 9.4 | 0.94 | 39.80 | 13.13 | 24.72 | 0.53 |
| 960 | 9.6 | 0.96 | 39.80 | 13.13 | 24.48 | 0.54 |
| 980 | 9.8 | 0.98 | 39.80 | 13.13 | 24.24 | 0.54 |
| 1000 | 10 | 1 | 40.00 | 13.20 | 24.00 | 0.55 |
| 1020 | 10.2 | 1.02 | 40.00 | 13.20 | 23.76 | 0.56 |
| 1040 | 10.4 | 1.04 | 40.00 | 13.20 | 23.52 | 0.56 |
| 1060 | 10.6 | 1.06 | 40.00 | 13.20 | 23.28 | 0.57 |
| 1080 | 10.8 | 1.08 | 40.00 | 13.20 | 23.04 | 0.57 |
| 1100 | 11 | 1.1 | 39.80 | 13.13 | 22.80 | 0.58 |
| 1120 | 11.2 | 1.12 | 39.80 | 13.13 | 22.56 | 0.58 |
| 1140 | 11.4 | 1.14 | 39.60 | 13.07 | 22.32 | 0.59 |
| 1160 | 11.6 | 1.16 | 39.40 | 13.00 | 22.08 | 0.59 |
| 1180 | 11.8 | 1.18 | 39.30 | 12.97 | 21.84 | 0.59 |
| 1200 | 12 | 1.2 | 39.20 | 12.94 | 21.60 | 0.60 |
| 1220 | 12.2 | 1.22 | 39.00 | 12.87 | 21.36 | 0.60 |

**Table:D6** Direct Shear Test Readings for ( Soil +3 % cement + 0.75 $kg/m^3$ ZB) at 1.5 $kg/cm^{22}$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| | | | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 9.80 | 3.23 | 35.76 | 0.09 |
| 40 | 0.4 | 0.04 | 16.20 | 5.35 | 35.52 | 0.15 |
| 60 | 0.6 | 0.06 | 19.50 | 6.44 | 35.28 | 0.18 |
| 80 | 0.8 | 0.08 | 26.20 | 8.65 | 35.04 | 0.25 |
| 100 | 1 | 0.1 | 32.60 | 10.76 | 34.80 | 0.31 |
| 120 | 1.2 | 0.12 | 42.20 | 13.93 | 34.56 | 0.40 |
| 140 | 1.4 | 0.14 | 45.50 | 15.02 | 34.32 | 0.44 |
| 160 | 1.6 | 0.16 | 49.20 | 16.24 | 34.08 | 0.48 |
| 180 | 1.8 | 0.18 | 50.70 | 16.73 | 33.84 | 0.49 |
| 200 | 2 | 0.2 | 51.60 | 17.03 | 33.60 | 0.51 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 220 | 2.2 | 0.22 | 52.80 | 17.42 | 33.36 | 0.52 |
| 240 | 2.4 | 0.24 | 53.40 | 17.62 | 33.12 | 0.53 |
| 260 | 2.6 | 0.26 | 54.00 | 17.82 | 32.88 | 0.54 |
| 280 | 2.8 | 0.28 | 54.50 | 17.99 | 32.64 | 0.55 |
| 300 | 3 | 0.3 | 54.80 | 18.08 | 32.40 | 0.56 |
| 320 | 3.2 | 0.32 | 55.20 | 18.22 | 32.16 | 0.57 |
| 340 | 3.4 | 0.34 | 55.80 | 18.41 | 31.92 | 0.58 |
| 360 | 3.6 | 0.36 | 56.20 | 18.55 | 31.68 | 0.59 |
| 380 | 3.8 | 0.38 | 56.60 | 18.68 | 31.44 | 0.59 |
| 400 | 4 | 0.4 | 57.00 | 18.81 | 31.20 | 0.60 |
| 420 | 4.2 | 0.42 | 57.20 | 18.88 | 30.96 | 0.61 |
| 440 | 4.4 | 0.44 | 57.60 | 19.01 | 30.72 | 0.62 |
| 460 | 4.6 | 0.46 | 57.80 | 19.07 | 30.48 | 0.63 |
| 480 | 4.8 | 0.48 | 58.00 | 19.14 | 30.24 | 0.63 |
| 500 | 5 | 0.5 | 58.20 | 19.21 | 30.00 | 0.64 |
| 520 | 5.2 | 0.52 | 58.60 | 19.34 | 29.76 | 0.65 |
| 540 | 5.4 | 0.54 | 58.80 | 19.40 | 29.52 | 0.66 |
| 560 | 5.6 | 0.56 | 58.80 | 19.40 | 29.28 | 0.66 |
| 580 | 5.8 | 0.58 | 59.20 | 19.54 | 29.04 | 0.67 |
| 600 | 6 | 0.6 | 59.40 | 19.60 | 28.80 | 0.68 |
| 620 | 6.2 | 0.62 | 59.60 | 19.67 | 28.56 | 0.69 |
| 640 | 6.4 | 0.64 | 59.60 | 19.67 | 28.32 | 0.69 |
| 660 | 6.6 | 0.66 | 59.80 | 19.73 | 28.08 | 0.70 |
| 680 | 6.8 | 0.68 | 60.00 | 19.80 | 27.84 | 0.71 |
| 700 | 7 | 0.7 | 60.20 | 19.87 | 27.60 | 0.72 |
| 720 | 7.2 | 0.72 | 60.40 | 19.93 | 27.36 | 0.73 |
| 740 | 7.4 | 0.74 | 60.40 | 19.93 | 27.12 | 0.73 |
| 760 | 7.6 | 0.76 | 60.60 | 20.00 | 26.88 | 0.74 |
| 780 | 7.8 | 0.78 | 60.60 | 20.00 | 26.64 | 0.75 |
| 800 | 8 | 0.8 | 60.80 | 20.06 | 26.40 | 0.76 |
| 820 | 8.2 | 0.82 | 60.80 | 20.06 | 26.16 | 0.77 |
| 840 | 8.4 | 0.84 | 61.00 | 20.13 | 25.92 | 0.78 |
| 860 | 8.6 | 0.86 | 61.20 | 20.20 | 25.68 | 0.79 |
| 880 | 8.8 | 0.88 | 61.10 | 20.16 | 25.44 | 0.79 |
| 900 | 9 | 0.9 | 61.20 | 20.20 | 25.20 | 0.80 |
| 920 | 9.2 | 0.92 | 61.20 | 20.20 | 24.96 | 0.81 |
| 940 | 9.4 | 0.94 | 61.30 | 20.23 | 24.72 | 0.82 |
| 960 | 9.6 | 0.96 | 61.40 | 20.26 | 24.48 | 0.83 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 980 | 9.8 | 0.98 | 61.40 | 20.26 | 24.24 | 0.84 |
| 1000 | 10 | 1 | 61.40 | 20.26 | 24.00 | 0.84 |
| 1020 | 10.2 | 1.02 | 61.40 | 20.26 | 23.76 | 0.85 |
| 1040 | 10.4 | 1.04 | 61.40 | 20.26 | 23.52 | 0.86 |
| 1060 | 10.6 | 1.06 | 61.40 | 20.26 | 23.28 | 0.87 |
| 1080 | 10.8 | 1.08 | 61.40 | 20.26 | 23.04 | 0.88 |
| 1100 | 11 | 1.1 | 61.20 | 20.20 | 22.80 | 0.89 |
| 1120 | 11.2 | 1.12 | 61.10 | 20.16 | 22.56 | 0.89 |
| 1140 | 11.4 | 1.14 | 61.00 | 20.13 | 22.32 | 0.90 |
| 1160 | 11.6 | 1.16 | 60.80 | 20.06 | 22.08 | 0.91 |
| 1180 | 11.8 | 1.18 | 60.50 | 19.97 | 21.84 | 0.91 |
| 1200 | 12 | 1.2 | 60.20 | 19.87 | 21.60 | 0.92 |
| 1220 | 12.2 | 1.22 | 60.00 | 19.80 | 21.36 | 0.93 |

**Table:D7** Direct Shear Test Readings for ( Soil +3 % cement + 1.0 $kg/m^3$ ZB) at 0.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 3.60 | 1.19 | 35.76 | 0.03 |
| 40 | 0.4 | 0.04 | 8.60 | 2.84 | 35.52 | 0.08 |
| 60 | 0.6 | 0.06 | 10.20 | 3.37 | 35.28 | 0.10 |
| 80 | 0.8 | 0.08 | 12.80 | 4.22 | 35.04 | 0.12 |
| 100 | 1 | 0.1 | 14.60 | 4.82 | 34.80 | 0.14 |
| 120 | 1.2 | 0.12 | 15.20 | 5.02 | 34.56 | 0.15 |
| 140 | 1.4 | 0.14 | 16.80 | 5.54 | 34.32 | 0.16 |
| 160 | 1.6 | 0.16 | 17.40 | 5.74 | 34.08 | 0.17 |
| 180 | 1.8 | 0.18 | 17.80 | 5.87 | 33.84 | 0.17 |
| 200 | 2 | 0.2 | 18.20 | 6.01 | 33.60 | 0.18 |
| 220 | 2.2 | 0.22 | 18.60 | 6.14 | 33.36 | 0.18 |
| 240 | 2.4 | 0.24 | 18.90 | 6.24 | 33.12 | 0.19 |
| 260 | 2.6 | 0.26 | 19.10 | 6.30 | 32.88 | 0.19 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 280 | 2.8 | 0.28 | 19.40 | 6.40 | 32.64 | 0.20 |
| 300 | 3 | 0.3 | 19.60 | 6.47 | 32.40 | 0.20 |
| 320 | 3.2 | 0.32 | 20.00 | 6.60 | 32.16 | 0.21 |
| 340 | 3.4 | 0.34 | 20.20 | 6.67 | 31.92 | 0.21 |
| 360 | 3.6 | 0.36 | 20.40 | 6.73 | 31.68 | 0.21 |
| 380 | 3.8 | 0.38 | 20.60 | 6.80 | 31.44 | 0.22 |
| 400 | 4 | 0.4 | 20.80 | 6.86 | 31.20 | 0.22 |
| 420 | 4.2 | 0.42 | 21.00 | 6.93 | 30.96 | 0.22 |
| 440 | 4.4 | 0.44 | 21.00 | 6.93 | 30.72 | 0.23 |
| 460 | 4.6 | 0.46 | 21.20 | 7.00 | 30.48 | 0.23 |
| 480 | 4.8 | 0.48 | 21.20 | 7.00 | 30.24 | 0.23 |
| 500 | 5 | 0.5 | 21.40 | 7.06 | 30.00 | 0.24 |
| 520 | 5.2 | 0.52 | 21.40 | 7.06 | 29.76 | 0.24 |
| 540 | 5.4 | 0.54 | 21.50 | 7.10 | 29.52 | 0.24 |
| 560 | 5.6 | 0.56 | 21.60 | 7.13 | 29.28 | 0.24 |
| 580 | 5.8 | 0.58 | 21.60 | 7.13 | 29.04 | 0.25 |
| 600 | 6 | 0.6 | 21.70 | 7.16 | 28.80 | 0.25 |
| 620 | 6.2 | 0.62 | 21.70 | 7.16 | 28.56 | 0.25 |
| 640 | 6.4 | 0.64 | 21.80 | 7.19 | 28.32 | 0.25 |
| 660 | 6.6 | 0.66 | 21.80 | 7.19 | 28.08 | 0.26 |
| 680 | 6.8 | 0.68 | 21.80 | 7.19 | 27.84 | 0.26 |
| 700 | 7 | 0.7 | 21.80 | 7.19 | 27.60 | 0.26 |
| 720 | 7.2 | 0.72 | 21.80 | 7.19 | 27.36 | 0.26 |
| 740 | 7.4 | 0.74 | 21.90 | 7.23 | 27.12 | 0.27 |
| 760 | 7.6 | 0.76 | 21.90 | 7.23 | 26.88 | 0.27 |
| 780 | 7.8 | 0.78 | 21.80 | 7.19 | 26.64 | 0.27 |
| 800 | 8 | 0.8 | 21.80 | 7.19 | 26.40 | 0.27 |
| 820 | 8.2 | 0.82 | 21.90 | 7.23 | 26.16 | 0.28 |
| 840 | 8.4 | 0.84 | 21.80 | 7.19 | 25.92 | 0.28 |
| 860 | 8.6 | 0.86 | 21.90 | 7.23 | 25.68 | 0.28 |
| 880 | 8.8 | 0.88 | 21.90 | 7.23 | 25.44 | 0.28 |
| 900 | 9 | 0.9 | 21.90 | 7.23 | 25.20 | 0.29 |
| 920 | 9.2 | 0.92 | 22.00 | 7.26 | 24.96 | 0.29 |
| 940 | 9.4 | 0.94 | 22.00 | 7.26 | 24.72 | 0.29 |
| 960 | 9.6 | 0.96 | 22.00 | 7.26 | 24.48 | 0.30 |
| 980 | 9.8 | 0.98 | 22.20 | 7.33 | 24.24 | 0.30 |
| 1000 | 10 | 1 | 22.20 | 7.33 | 24.00 | 0.31 |
| 1020 | 10.2 | 1.02 | 22.30 | 7.36 | 23.76 | 0.31 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 1040 | 10.4 | 1.04 | 22.40 | 7.39 | 23.52 | 0.31 |
| 1060 | 10.6 | 1.06 | 22.40 | 7.39 | 23.28 | 0.32 |
| 1080 | 10.8 | 1.08 | 22.50 | 7.43 | 23.04 | 0.32 |
| 1100 | 11 | 1.1 | 22.50 | 7.43 | 22.80 | 0.33 |
| 1120 | 11.2 | 1.12 | 22.60 | 7.46 | 22.56 | 0.33 |
| 1140 | 11.4 | 1.14 | 22.80 | 7.52 | 22.32 | 0.34 |
| 1160 | 11.6 | 1.16 | 23.00 | 7.59 | 22.08 | 0.34 |
| 1180 | 11.8 | 1.18 | 23.00 | 7.59 | 21.84 | 0.35 |
| 1200 | 12 | 1.2 | 23.00 | 7.59 | 21.60 | 0.35 |
| 1220 | 12.2 | 1.22 | 23.00 | 7.59 | 21.36 | 0.36 |
| 1240 | 12.4 | 1.24 | 23.00 | 7.59 | 21.12 | 0.36 |

**Table:D8** Direct Shear Test Readings for ( Soil +3 % cement + 1.0 $kg/m^3$ ZB) at 1.0 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| | | | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 6.80 | 2.24 | 35.76 | 0.06 |
| 40 | 0.4 | 0.04 | 12.40 | 4.09 | 35.52 | 0.12 |
| 60 | 0.6 | 0.06 | 16.80 | 5.54 | 35.28 | 0.16 |
| 80 | 0.8 | 0.08 | 21.00 | 6.93 | 35.04 | 0.20 |
| 100 | 1 | 0.1 | 23.20 | 7.66 | 34.80 | 0.22 |
| 120 | 1.2 | 0.12 | 26.60 | 8.78 | 34.56 | 0.25 |
| 140 | 1.4 | 0.14 | 27.80 | 9.17 | 34.32 | 0.27 |
| 160 | 1.6 | 0.16 | 28.80 | 9.50 | 34.08 | 0.28 |
| 180 | 1.8 | 0.18 | 29.80 | 9.83 | 33.84 | 0.29 |
| 200 | 2 | 0.2 | 30.60 | 10.10 | 33.60 | 0.30 |
| 220 | 2.2 | 0.22 | 31.20 | 10.30 | 33.36 | 0.31 |
| 240 | 2.4 | 0.24 | 32.20 | 10.63 | 33.12 | 0.32 |
| 260 | 2.6 | 0.26 | 32.60 | 10.76 | 32.88 | 0.33 |
| 280 | 2.8 | 0.28 | 33.20 | 10.96 | 32.64 | 0.34 |
| 300 | 3 | 0.3 | 34.00 | 11.22 | 32.40 | 0.35 |
| 320 | 3.2 | 0.32 | 34.40 | 11.35 | 32.16 | 0.35 |
| 340 | 3.4 | 0.34 | 35.00 | 11.55 | 31.92 | 0.36 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 360 | 3.6 | 0.36 | 35.40 | 11.68 | 31.68 | 0.37 |
| 380 | 3.8 | 0.38 | 36.00 | 11.88 | 31.44 | 0.38 |
| 400 | 4 | 0.4 | 36.40 | 12.01 | 31.20 | 0.39 |
| 420 | 4.2 | 0.42 | 36.60 | 12.08 | 30.96 | 0.39 |
| 440 | 4.4 | 0.44 | 37.00 | 12.21 | 30.72 | 0.40 |
| 460 | 4.6 | 0.46 | 37.20 | 12.28 | 30.48 | 0.40 |
| 480 | 4.8 | 0.48 | 37.40 | 12.34 | 30.24 | 0.41 |
| 500 | 5 | 0.5 | 37.60 | 12.41 | 30.00 | 0.41 |
| 520 | 5.2 | 0.52 | 37.70 | 12.44 | 29.76 | 0.42 |
| 540 | 5.4 | 0.54 | 37.80 | 12.47 | 29.52 | 0.42 |
| 560 | 5.6 | 0.56 | 37.90 | 12.51 | 29.28 | 0.43 |
| 580 | 5.8 | 0.58 | 38.00 | 12.54 | 29.04 | 0.43 |
| 600 | 6 | 0.6 | 38.10 | 12.57 | 28.80 | 0.44 |
| 620 | 6.2 | 0.62 | 38.20 | 12.61 | 28.56 | 0.44 |
| 640 | 6.4 | 0.64 | 38.30 | 12.64 | 28.32 | 0.45 |
| 660 | 6.6 | 0.66 | 38.40 | 12.67 | 28.08 | 0.45 |
| 680 | 6.8 | 0.68 | 38.40 | 12.67 | 27.84 | 0.46 |
| 700 | 7 | 0.7 | 38.50 | 12.71 | 27.60 | 0.46 |
| 720 | 7.2 | 0.72 | 38.40 | 12.67 | 27.36 | 0.46 |
| 740 | 7.4 | 0.74 | 38.80 | 12.80 | 27.12 | 0.47 |
| 760 | 7.6 | 0.76 | 39.00 | 12.87 | 26.88 | 0.48 |
| 780 | 7.8 | 0.78 | 39.00 | 12.87 | 26.64 | 0.48 |
| 800 | 8 | 0.8 | 39.00 | 12.87 | 26.40 | 0.49 |
| 820 | 8.2 | 0.82 | 39.10 | 12.90 | 26.16 | 0.49 |
| 840 | 8.4 | 0.84 | 39.10 | 12.90 | 25.92 | 0.50 |
| 860 | 8.6 | 0.86 | 39.20 | 12.94 | 25.68 | 0.50 |
| 880 | 8.8 | 0.88 | 39.20 | 12.94 | 25.44 | 0.51 |
| 900 | 9 | 0.9 | 39.10 | 12.90 | 25.20 | 0.51 |
| 920 | 9.2 | 0.92 | 39.20 | 12.94 | 24.96 | 0.52 |
| 940 | 9.4 | 0.94 | 39.10 | 12.90 | 24.72 | 0.52 |
| 960 | 9.6 | 0.96 | 39.10 | 12.90 | 24.48 | 0.53 |
| 980 | 9.8 | 0.98 | 39.00 | 12.87 | 24.24 | 0.53 |
| 1000 | 10 | 1 | 38.90 | 12.84 | 24.00 | 0.53 |
| 1020 | 10.2 | 1.02 | 38.80 | 12.80 | 23.76 | 0.54 |
| 1040 | 10.4 | 1.04 | 38.80 | 12.80 | 23.52 | 0.54 |
| 1060 | 10.6 | 1.06 | 38.80 | 12.80 | 23.28 | 0.55 |
| 1080 | 10.8 | 1.08 | 38.80 | 12.80 | 23.04 | 0.56 |
| 1100 | 11 | 1.1 | 38.80 | 12.80 | 22.80 | 0.56 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 1120 | 11.2 | 1.12 | 38.80 | 12.80 | 22.56 | 0.57 |
| 1140 | 11.4 | 1.14 | 38.80 | 12.80 | 22.32 | 0.57 |
| 1160 | 11.6 | 1.16 | 38.70 | 12.77 | 22.08 | 0.58 |
| 1180 | 11.8 | 1.18 | 38.70 | 12.77 | 21.84 | 0.58 |
| 1200 | 12 | 1.2 | 38.60 | 12.74 | 21.60 | 0.59 |
| 1220 | 12.2 | 1.22 | 38.60 | 12.74 | 21.36 | 0.60 |
| 1240 | 12.4 | 1.24 | 38.60 | 12.74 | 21.12 | 0.60 |

**Table:D9** Direct Shear Test Readings for ( Soil +3 % cement + 1.0 $kg/m^3$ ZB) at 1.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | Cm | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 10.20 | 3.37 | 35.76 | 0.09 |
| 40 | 0.4 | 0.04 | 16.40 | 5.41 | 35.52 | 0.15 |
| 60 | 0.6 | 0.06 | 24.00 | 7.92 | 35.28 | 0.22 |
| 80 | 0.8 | 0.08 | 32.20 | 10.63 | 35.04 | 0.30 |
| 100 | 1 | 0.1 | 39.20 | 12.94 | 34.80 | 0.37 |
| 120 | 1.2 | 0.12 | 42.00 | 13.86 | 34.56 | 0.40 |
| 140 | 1.4 | 0.14 | 44.00 | 14.52 | 34.32 | 0.42 |
| 160 | 1.6 | 0.16 | 46.60 | 15.38 | 34.08 | 0.45 |
| 180 | 1.8 | 0.18 | 47.40 | 15.64 | 33.84 | 0.46 |
| 200 | 2 | 0.2 | 48.80 | 16.10 | 33.60 | 0.48 |
| 220 | 2.2 | 0.22 | 49.20 | 16.24 | 33.36 | 0.49 |
| 240 | 2.4 | 0.24 | 51.20 | 16.90 | 33.12 | 0.51 |
| 260 | 2.6 | 0.26 | 52.20 | 17.23 | 32.88 | 0.52 |
| 280 | 2.8 | 0.28 | 53.20 | 17.56 | 32.64 | 0.54 |
| 300 | 3 | 0.3 | 54.00 | 17.82 | 32.40 | 0.55 |
| 320 | 3.2 | 0.32 | 54.80 | 18.08 | 32.16 | 0.56 |
| 340 | 3.4 | 0.34 | 55.40 | 18.28 | 31.92 | 0.57 |
| 360 | 3.6 | 0.36 | 56.20 | 18.55 | 31.68 | 0.59 |
| 380 | 3.8 | 0.38 | 56.60 | 18.68 | 31.44 | 0.59 |
| 400 | 4 | 0.4 | 57.00 | 18.81 | 31.20 | 0.60 |
| 420 | 4.2 | 0.42 | 57.40 | 18.94 | 30.96 | 0.61 |
| 440 | 4.4 | 0.44 | 57.80 | 19.07 | 30.72 | 0.62 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | Cm | | | | |
| 460 | 4.6 | 0.46 | 58.00 | 19.14 | 30.48 | 0.63 |
| 480 | 4.8 | 0.48 | 58.20 | 19.21 | 30.24 | 0.64 |
| 500 | 5 | 0.5 | 58.40 | 19.27 | 30.00 | 0.64 |
| 520 | 5.2 | 0.52 | 58.60 | 19.34 | 29.76 | 0.65 |
| 540 | 5.4 | 0.54 | 58.70 | 19.37 | 29.52 | 0.66 |
| 560 | 5.6 | 0.56 | 58.80 | 19.40 | 29.28 | 0.66 |
| 580 | 5.8 | 0.58 | 58.90 | 19.44 | 29.04 | 0.67 |
| 600 | 6 | 0.6 | 58.80 | 19.40 | 28.80 | 0.67 |
| 620 | 6.2 | 0.62 | 59.00 | 19.47 | 28.56 | 0.68 |
| 640 | 6.4 | 0.64 | 59.00 | 19.47 | 28.32 | 0.69 |
| 660 | 6.6 | 0.66 | 59.10 | 19.50 | 28.08 | 0.69 |
| 680 | 6.8 | 0.68 | 59.10 | 19.50 | 27.84 | 0.70 |
| 700 | 7 | 0.7 | 59.00 | 19.47 | 27.60 | 0.71 |
| 720 | 7.2 | 0.72 | 59.20 | 19.54 | 27.36 | 0.71 |
| 740 | 7.4 | 0.74 | 59.20 | 19.54 | 27.12 | 0.72 |
| 760 | 7.6 | 0.76 | 59.20 | 19.54 | 26.88 | 0.73 |
| 780 | 7.8 | 0.78 | 59.40 | 19.60 | 26.64 | 0.74 |
| 800 | 8 | 0.8 | 59.40 | 19.60 | 26.40 | 0.74 |
| 820 | 8.2 | 0.82 | 59.40 | 19.60 | 26.16 | 0.75 |
| 840 | 8.4 | 0.84 | 59.20 | 19.54 | 25.92 | 0.75 |
| 860 | 8.6 | 0.86 | 59.40 | 19.60 | 25.68 | 0.76 |
| 880 | 8.8 | 0.88 | 59.00 | 19.47 | 25.44 | 0.77 |
| 900 | 9 | 0.9 | 59.00 | 19.47 | 25.20 | 0.77 |
| 920 | 9.2 | 0.92 | 59.00 | 19.47 | 24.96 | 0.78 |
| 940 | 9.4 | 0.94 | 59.00 | 19.47 | 24.72 | 0.79 |
| 960 | 9.6 | 0.96 | 59.00 | 19.47 | 24.48 | 0.80 |
| 980 | 9.8 | 0.98 | 58.80 | 19.40 | 24.24 | 0.80 |
| 1000 | 10 | 1 | 59.00 | 19.47 | 24.00 | 0.81 |
| 1020 | 10.2 | 1.02 | 59.00 | 19.47 | 23.76 | 0.82 |
| 1040 | 10.4 | 1.04 | 59.20 | 19.54 | 23.52 | 0.83 |
| 1060 | 10.6 | 1.06 | 59.20 | 19.54 | 23.28 | 0.84 |
| 1080 | 10.8 | 1.08 | 59.20 | 19.54 | 23.04 | 0.85 |
| 1100 | 11 | 1.1 | 59.40 | 19.60 | 22.80 | 0.86 |
| 1120 | 11.2 | 1.12 | 59.20 | 19.54 | 22.56 | 0.87 |
| 1140 | 11.4 | 1.14 | 59.20 | 19.54 | 22.32 | 0.88 |
| 1160 | 11.6 | 1.16 | 59.20 | 19.54 | 22.08 | 0.88 |
| 1180 | 11.8 | 1.18 | 59.40 | 19.60 | 21.84 | 0.90 |
| 1200 | 12 | 1.2 | 59.40 | 19.60 | 21.60 | 0.91 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | Cm | | | | |
| 1220 | 12.2 | 1.22 | 59.40 | 19.60 | 21.36 | 0.92 |
| 1240 | 12.4 | 1.24 | 59.40 | 19.60 | 21.12 | 0.93 |

**Table:D10** Direct Shear Test Readings for ( Soil +3 % cement + 1.25 $kg/m^3$ ZB) at 0.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | Cm | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 6.20 | 2.05 | 35.76 | 0.06 |
| 40 | 0.4 | 0.04 | 11.20 | 3.70 | 35.52 | 0.10 |
| 60 | 0.6 | 0.06 | 15.00 | 4.95 | 35.28 | 0.14 |
| 80 | 0.8 | 0.08 | 18.60 | 6.14 | 35.04 | 0.18 |
| 100 | 1 | 0.1 | 20.00 | 6.60 | 34.80 | 0.19 |
| 120 | 1.2 | 0.12 | 21.80 | 7.19 | 34.56 | 0.21 |
| 140 | 1.4 | 0.14 | 22.80 | 7.52 | 34.32 | 0.22 |
| 160 | 1.6 | 0.16 | 23.20 | 7.66 | 34.08 | 0.22 |
| 180 | 1.8 | 0.18 | 23.40 | 7.72 | 33.84 | 0.23 |
| 200 | 2 | 0.2 | 23.80 | 7.85 | 33.60 | 0.23 |
| 220 | 2.2 | 0.22 | 24.00 | 7.92 | 33.36 | 0.24 |
| 240 | 2.4 | 0.24 | 24.20 | 7.99 | 33.12 | 0.24 |
| 260 | 2.6 | 0.26 | 24.40 | 8.05 | 32.88 | 0.24 |
| 280 | 2.8 | 0.28 | 24.80 | 8.18 | 32.64 | 0.25 |
| 300 | 3 | 0.3 | 24.80 | 8.18 | 32.40 | 0.25 |
| 320 | 3.2 | 0.32 | 25.00 | 8.25 | 32.16 | 0.26 |
| 340 | 3.4 | 0.34 | 25.20 | 8.32 | 31.92 | 0.26 |
| 360 | 3.6 | 0.36 | 25.20 | 8.32 | 31.68 | 0.26 |
| 380 | 3.8 | 0.38 | 25.40 | 8.38 | 31.44 | 0.27 |
| 400 | 4 | 0.4 | 25.60 | 8.45 | 31.20 | 0.27 |
| 420 | 4.2 | 0.42 | 25.60 | 8.45 | 30.96 | 0.27 |
| 440 | 4.4 | 0.44 | 25.80 | 8.51 | 30.72 | 0.28 |
| 460 | 4.6 | 0.46 | 25.80 | 8.51 | 30.48 | 0.28 |
| 480 | 4.8 | 0.48 | 25.80 | 8.51 | 30.24 | 0.28 |
| 500 | 5 | 0.5 | 25.90 | 8.55 | 30.00 | 0.28 |
| 520 | 5.2 | 0.52 | 25.90 | 8.55 | 29.76 | 0.29 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | Cm | | | | |
| 540 | 5.4 | 0.54 | 25.90 | 8.55 | 29.52 | 0.29 |
| 560 | 5.6 | 0.56 | 26.00 | 8.58 | 29.28 | 0.29 |
| 580 | 5.8 | 0.58 | 26.00 | 8.58 | 29.04 | 0.30 |
| 600 | 6 | 0.6 | 26.00 | 8.58 | 28.80 | 0.30 |
| 620 | 6.2 | 0.62 | 26.00 | 8.58 | 28.56 | 0.30 |
| 640 | 6.4 | 0.64 | 26.00 | 8.58 | 28.32 | 0.30 |
| 660 | 6.6 | 0.66 | 25.80 | 8.51 | 28.08 | 0.30 |
| 680 | 6.8 | 0.68 | 25.80 | 8.51 | 27.84 | 0.31 |
| 700 | 7 | 0.7 | 25.80 | 8.51 | 27.60 | 0.31 |
| 720 | 7.2 | 0.72 | 25.80 | 8.51 | 27.36 | 0.31 |
| 740 | 7.4 | 0.74 | 25.60 | 8.45 | 27.12 | 0.31 |
| 760 | 7.6 | 0.76 | 25.60 | 8.45 | 26.88 | 0.31 |
| 780 | 7.8 | 0.78 | 25.50 | 8.42 | 26.64 | 0.32 |
| 800 | 8 | 0.8 | 25.40 | 8.38 | 26.40 | 0.32 |
| 820 | 8.2 | 0.82 | 25.20 | 8.32 | 26.16 | 0.32 |
| 840 | 8.4 | 0.84 | 25.20 | 8.32 | 25.92 | 0.32 |
| 860 | 8.6 | 0.86 | 25.10 | 8.28 | 25.68 | 0.32 |
| 880 | 8.8 | 0.88 | 25.00 | 8.25 | 25.44 | 0.32 |
| 900 | 9 | 0.9 | 25.00 | 8.25 | 25.20 | 0.33 |
| 920 | 9.2 | 0.92 | 25.00 | 8.25 | 24.96 | 0.33 |
| 940 | 9.4 | 0.94 | 24.80 | 8.18 | 24.72 | 0.33 |
| 960 | 9.6 | 0.96 | 24.80 | 8.18 | 24.48 | 0.33 |
| 980 | 9.8 | 0.98 | 24.60 | 8.12 | 24.24 | 0.33 |
| 1000 | 10 | 1 | 24.40 | 8.05 | 24.00 | 0.34 |
| 1020 | 10.2 | 1.02 | 24.20 | 7.99 | 23.76 | 0.34 |
| 1040 | 10.4 | 1.04 | 24.20 | 7.99 | 23.52 | 0.34 |
| 1060 | 10.6 | 1.06 | 24.20 | 7.99 | 23.28 | 0.34 |
| 1080 | 10.8 | 1.08 | 24.00 | 7.92 | 23.04 | 0.34 |
| 1100 | 11 | 1.1 | 24.00 | 7.92 | 22.80 | 0.35 |
| 1120 | 11.2 | 1.12 | 23.80 | 7.85 | 22.56 | 0.35 |
| 1140 | 11.4 | 1.14 | 23.80 | 7.85 | 22.32 | 0.35 |
| 1160 | 11.6 | 1.16 | 23.40 | 7.72 | 22.08 | 0.35 |
| 1180 | 11.8 | 1.18 | 23.00 | 7.59 | 21.84 | 0.35 |
| 1200 | 12 | 1.2 | 23.00 | 7.59 | 21.60 | 0.35 |
| 1220 | 12.2 | 1.22 | 23.00 | 7.59 | 21.36 | 0.36 |

**Table:D11** Direct Shear Test Readings for ( Soil +3 % cement + 1.25 kg/$m^3$ ZB) at 1.0 kg/$cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 4.60 | 1.52 | 35.76 | 0.04 |
| 40 | 0.4 | 0.04 | 6.80 | 2.24 | 35.52 | 0.06 |
| 60 | 0.6 | 0.06 | 12.40 | 4.09 | 35.28 | 0.12 |
| 80 | 0.8 | 0.08 | 17.60 | 5.81 | 35.04 | 0.17 |
| 100 | 1 | 0.1 | 22.40 | 7.39 | 34.80 | 0.21 |
| 120 | 1.2 | 0.12 | 26.00 | 8.58 | 34.56 | 0.25 |
| 140 | 1.4 | 0.14 | 28.60 | 9.44 | 34.32 | 0.28 |
| 160 | 1.6 | 0.16 | 31.20 | 10.30 | 34.08 | 0.30 |
| 180 | 1.8 | 0.18 | 33.40 | 11.02 | 33.84 | 0.33 |
| 200 | 2 | 0.2 | 34.20 | 11.29 | 33.60 | 0.34 |
| 220 | 2.2 | 0.22 | 35.00 | 11.55 | 33.36 | 0.35 |
| 240 | 2.4 | 0.24 | 36.00 | 11.88 | 33.12 | 0.36 |
| 260 | 2.6 | 0.26 | 36.80 | 12.14 | 32.88 | 0.37 |
| 280 | 2.8 | 0.28 | 37.60 | 12.41 | 32.64 | 0.38 |
| 300 | 3 | 0.3 | 38.20 | 12.61 | 32.40 | 0.39 |
| 320 | 3.2 | 0.32 | 39.00 | 12.87 | 32.16 | 0.40 |
| 340 | 3.4 | 0.34 | 39.60 | 13.07 | 31.92 | 0.41 |
| 360 | 3.6 | 0.36 | 40.00 | 13.20 | 31.68 | 0.42 |
| 380 | 3.8 | 0.38 | 40.40 | 13.33 | 31.44 | 0.42 |
| 400 | 4 | 0.4 | 40.80 | 13.46 | 31.20 | 0.43 |
| 420 | 4.2 | 0.42 | 41.20 | 13.60 | 30.96 | 0.44 |
| 440 | 4.4 | 0.44 | 41.60 | 13.73 | 30.72 | 0.45 |
| 460 | 4.6 | 0.46 | 42.00 | 13.86 | 30.48 | 0.45 |
| 480 | 4.8 | 0.48 | 42.20 | 13.93 | 30.24 | 0.46 |
| 500 | 5 | 0.5 | 42.40 | 13.99 | 30.00 | 0.47 |
| 520 | 5.2 | 0.52 | 42.60 | 14.06 | 29.76 | 0.47 |
| 540 | 5.4 | 0.54 | 42.80 | 14.12 | 29.52 | 0.48 |
| 560 | 5.6 | 0.56 | 43.00 | 14.19 | 29.28 | 0.48 |
| 580 | 5.8 | 0.58 | 43.00 | 14.19 | 29.04 | 0.49 |
| 600 | 6 | 0.6 | 43.00 | 14.19 | 28.80 | 0.49 |
| 620 | 6.2 | 0.62 | 43.00 | 14.19 | 28.56 | 0.50 |
| 640 | 6.4 | 0.64 | 43.00 | 14.19 | 28.32 | 0.50 |
| 660 | 6.6 | 0.66 | 43.20 | 14.26 | 28.08 | 0.51 |
| 680 | 6.8 | 0.68 | 43.20 | 14.26 | 27.84 | 0.51 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 700 | 7 | 0.7 | 43.20 | 14.26 | 27.60 | 0.52 |
| 720 | 7.2 | 0.72 | 43.20 | 14.26 | 27.36 | 0.52 |
| 740 | 7.4 | 0.74 | 43.10 | 14.22 | 27.12 | 0.52 |
| 760 | 7.6 | 0.76 | 43.20 | 14.26 | 26.88 | 0.53 |
| 780 | 7.8 | 0.78 | 43.10 | 14.22 | 26.64 | 0.53 |
| 800 | 8 | 0.8 | 43.00 | 14.19 | 26.40 | 0.54 |
| 820 | 8.2 | 0.82 | 43.00 | 14.19 | 26.16 | 0.54 |
| 840 | 8.4 | 0.84 | 42.80 | 14.12 | 25.92 | 0.54 |
| 860 | 8.6 | 0.86 | 42.80 | 14.12 | 25.68 | 0.55 |
| 880 | 8.8 | 0.88 | 42.60 | 14.06 | 25.44 | 0.55 |
| 900 | 9 | 0.9 | 42.60 | 14.06 | 25.20 | 0.56 |
| 920 | 9.2 | 0.92 | 42.40 | 13.99 | 24.96 | 0.56 |
| 940 | 9.4 | 0.94 | 42.40 | 13.99 | 24.72 | 0.57 |
| 960 | 9.6 | 0.96 | 42.40 | 13.99 | 24.48 | 0.57 |
| 980 | 9.8 | 0.98 | 42.40 | 13.99 | 24.24 | 0.58 |
| 1000 | 10 | 1 | 42.20 | 13.93 | 24.00 | 0.58 |
| 1020 | 10.2 | 1.02 | 42.00 | 13.86 | 23.76 | 0.58 |
| 1040 | 10.4 | 1.04 | 42.00 | 13.86 | 23.52 | 0.59 |
| 1060 | 10.6 | 1.06 | 41.80 | 13.79 | 23.28 | 0.59 |
| 1080 | 10.8 | 1.08 | 41.90 | 13.83 | 23.04 | 0.60 |
| 1100 | 11 | 1.1 | 41.60 | 13.73 | 22.80 | 0.60 |
| 1120 | 11.2 | 1.12 | 41.60 | 13.73 | 22.56 | 0.61 |
| 1140 | 11.4 | 1.14 | 41.40 | 13.66 | 22.32 | 0.61 |
| 1160 | 11.6 | 1.16 | 41.00 | 13.53 | 22.08 | 0.61 |
| 1180 | 11.8 | 1.18 | 41.00 | 13.53 | 21.84 | 0.62 |
| 1200 | 12 | 1.2 | 41.00 | 13.53 | 21.60 | 0.63 |
| 1220 | 12.2 | 1.22 | 41.00 | 13.53 | 21.36 | 0.63 |

**Table:D12** Direct Shear Test Readings for ( Soil +3 % cement + 1.25 $kg/m^3$ ZB) at 1.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | Cm | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 12.20 | 4.03 | 35.76 | 0.11 |
| 40 | 0.4 | 0.04 | 20.80 | 6.86 | 35.52 | 0.19 |
| 60 | 0.6 | 0.06 | 33.60 | 11.09 | 35.28 | 0.31 |
| 80 | 0.8 | 0.08 | 40.00 | 13.20 | 35.04 | 0.38 |
| 100 | 1 | 0.1 | 46.20 | 15.25 | 34.80 | 0.44 |
| 120 | 1.2 | 0.12 | 50.00 | 16.50 | 34.56 | 0.48 |
| 140 | 1.4 | 0.14 | 52.20 | 17.23 | 34.32 | 0.50 |
| 160 | 1.6 | 0.16 | 54.00 | 17.82 | 34.08 | 0.52 |
| 180 | 1.8 | 0.18 | 55.20 | 18.22 | 33.84 | 0.54 |
| 200 | 2 | 0.2 | 56.60 | 18.68 | 33.60 | 0.56 |
| 220 | 2.2 | 0.22 | 57.80 | 19.07 | 33.36 | 0.57 |
| 240 | 2.4 | 0.24 | 59.00 | 19.47 | 33.12 | 0.59 |
| 260 | 2.6 | 0.26 | 60.00 | 19.80 | 32.88 | 0.60 |
| 280 | 2.8 | 0.28 | 61.20 | 20.20 | 32.64 | 0.62 |
| 300 | 3 | 0.3 | 62.40 | 20.59 | 32.40 | 0.64 |
| 320 | 3.2 | 0.32 | 63.40 | 20.92 | 32.16 | 0.65 |
| 340 | 3.4 | 0.34 | 64.40 | 21.25 | 31.92 | 0.67 |
| 360 | 3.6 | 0.36 | 65.40 | 21.58 | 31.68 | 0.68 |
| 380 | 3.8 | 0.38 | 66.00 | 21.78 | 31.44 | 0.69 |
| 400 | 4 | 0.4 | 67.00 | 22.11 | 31.20 | 0.71 |
| 420 | 4.2 | 0.42 | 67.80 | 22.37 | 30.96 | 0.72 |
| 440 | 4.4 | 0.44 | 68.20 | 22.51 | 30.72 | 0.73 |
| 460 | 4.6 | 0.46 | 69.00 | 22.77 | 30.48 | 0.75 |
| 480 | 4.8 | 0.48 | 69.40 | 22.90 | 30.24 | 0.76 |
| 500 | 5 | 0.5 | 69.80 | 23.03 | 30.00 | 0.77 |
| 520 | 5.2 | 0.52 | 70.20 | 23.17 | 29.76 | 0.78 |
| 540 | 5.4 | 0.54 | 70.60 | 23.30 | 29.52 | 0.79 |
| 560 | 5.6 | 0.56 | 70.80 | 23.36 | 29.28 | 0.80 |
| 580 | 5.8 | 0.58 | 70.90 | 23.40 | 29.04 | 0.81 |
| 600 | 6 | 0.6 | 71.00 | 23.43 | 28.80 | 0.81 |
| 620 | 6.2 | 0.62 | 71.20 | 23.50 | 28.56 | 0.82 |
| 640 | 6.4 | 0.64 | 71.60 | 23.63 | 28.32 | 0.83 |
| 660 | 6.6 | 0.66 | 71.30 | 23.53 | 28.08 | 0.84 |
| 680 | 6.8 | 0.68 | 71.40 | 23.56 | 27.84 | 0.85 |
| 700 | 7 | 0.7 | 71.40 | 23.56 | 27.60 | 0.85 |
| 720 | 7.2 | 0.72 | 71.40 | 23.56 | 27.36 | 0.86 |
| 740 | 7.4 | 0.74 | 71.40 | 23.56 | 27.12 | 0.87 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | Cm | | | | |
| 760 | 7.6 | 0.76 | 71.30 | 23.53 | 26.88 | 0.88 |
| 780 | 7.8 | 0.78 | 71.20 | 23.50 | 26.64 | 0.88 |
| 800 | 8 | 0.8 | 71.20 | 23.50 | 26.40 | 0.89 |
| 820 | 8.2 | 0.82 | 71.00 | 23.43 | 26.16 | 0.90 |
| 840 | 8.4 | 0.84 | 70.80 | 23.36 | 25.92 | 0.90 |
| 860 | 8.6 | 0.86 | 70.80 | 23.36 | 25.68 | 0.91 |
| 880 | 8.8 | 0.88 | 70.70 | 23.33 | 25.44 | 0.92 |
| 900 | 9 | 0.9 | 70.80 | 23.36 | 25.20 | 0.93 |
| 920 | 9.2 | 0.92 | 70.70 | 23.33 | 24.96 | 0.93 |
| 940 | 9.4 | 0.94 | 70.80 | 23.36 | 24.72 | 0.95 |
| 960 | 9.6 | 0.96 | 70.60 | 23.30 | 24.48 | 0.95 |
| 980 | 9.8 | 0.98 | 70.40 | 23.23 | 24.24 | 0.96 |
| 1000 | 10 | 1 | 70.20 | 23.17 | 24.00 | 0.97 |
| 1020 | 10.2 | 1.02 | 70.20 | 23.17 | 23.76 | 0.98 |
| 1040 | 10.4 | 1.04 | 70.10 | 23.13 | 23.52 | 0.98 |
| 1060 | 10.6 | 1.06 | 70.00 | 23.10 | 23.28 | 0.99 |
| 1080 | 10.8 | 1.08 | 69.80 | 23.03 | 23.04 | 1.00 |
| 1100 | 11 | 1.1 | 69.90 | 23.07 | 22.80 | 1.01 |
| 1120 | 11.2 | 1.12 | 69.80 | 23.03 | 22.56 | 1.02 |
| 1140 | 11.4 | 1.14 | 69.60 | 22.97 | 22.32 | 1.03 |
| 1160 | 11.6 | 1.16 | 69.60 | 22.97 | 22.08 | 1.04 |
| 1180 | 11.8 | 1.18 | 69.40 | 22.90 | 21.84 | 1.05 |
| 1200 | 12 | 1.2 | 69.20 | 22.84 | 21.60 | 1.06 |
| 1220 | 12.2 | 1.22 | 68.80 | 22.70 | 21.36 | 1.06 |

**Table:D13** Direct Shear Test Readings for ( Soil +3 % cement + 1.5 $kg/m^3$ ZB) at 0.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 3.50 | 1.16 | 35.76 | 0.03 |
| 40 | 0.4 | 0.04 | 7.80 | 2.57 | 35.52 | 0.07 |
| 60 | 0.6 | 0.06 | 11.20 | 3.70 | 35.28 | 0.10 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 80 | 0.8 | 0.08 | 16.00 | 5.28 | 35.04 | 0.15 |
| 100 | 1 | 0.1 | 19.00 | 6.27 | 34.80 | 0.18 |
| 120 | 1.2 | 0.12 | 20.60 | 6.80 | 34.56 | 0.20 |
| 140 | 1.4 | 0.14 | 21.80 | 7.19 | 34.32 | 0.21 |
| 160 | 1.6 | 0.16 | 22.80 | 7.52 | 34.08 | 0.22 |
| 180 | 1.8 | 0.18 | 23.80 | 7.85 | 33.84 | 0.23 |
| 200 | 2 | 0.2 | 24.40 | 8.05 | 33.60 | 0.24 |
| 220 | 2.2 | 0.22 | 25.00 | 8.25 | 33.36 | 0.25 |
| 240 | 2.4 | 0.24 | 25.60 | 8.45 | 33.12 | 0.26 |
| 260 | 2.6 | 0.26 | 26.20 | 8.65 | 32.88 | 0.26 |
| 280 | 2.8 | 0.28 | 26.60 | 8.78 | 32.64 | 0.27 |
| 300 | 3 | 0.3 | 26.80 | 8.84 | 32.40 | 0.27 |
| 320 | 3.2 | 0.32 | 27.20 | 8.98 | 32.16 | 0.28 |
| 340 | 3.4 | 0.34 | 27.40 | 9.04 | 31.92 | 0.28 |
| 360 | 3.6 | 0.36 | 27.00 | 8.91 | 31.68 | 0.28 |
| 380 | 3.8 | 0.38 | 27.60 | 9.11 | 31.44 | 0.29 |
| 400 | 4 | 0.4 | 27.70 | 9.14 | 31.20 | 0.29 |
| 420 | 4.2 | 0.42 | 27.80 | 9.17 | 30.96 | 0.30 |
| 440 | 4.4 | 0.44 | 27.80 | 9.17 | 30.72 | 0.30 |
| 460 | 4.6 | 0.46 | 27.80 | 9.17 | 30.48 | 0.30 |
| 480 | 4.8 | 0.48 | 27.70 | 9.14 | 30.24 | 0.30 |
| 500 | 5 | 0.5 | 27.70 | 9.14 | 30.00 | 0.30 |
| 520 | 5.2 | 0.52 | 27.70 | 9.14 | 29.76 | 0.31 |
| 540 | 5.4 | 0.54 | 27.50 | 9.08 | 29.52 | 0.31 |
| 560 | 5.6 | 0.56 | 27.50 | 9.08 | 29.28 | 0.31 |
| 580 | 5.8 | 0.58 | 27.40 | 9.04 | 29.04 | 0.31 |
| 600 | 6 | 0.6 | 27.20 | 8.98 | 28.80 | 0.31 |
| 620 | 6.2 | 0.62 | 27.00 | 8.91 | 28.56 | 0.31 |
| 640 | 6.4 | 0.64 | 27.00 | 8.91 | 28.32 | 0.31 |
| 660 | 6.6 | 0.66 | 26.90 | 8.88 | 28.08 | 0.32 |
| 680 | 6.8 | 0.68 | 26.80 | 8.84 | 27.84 | 0.32 |
| 700 | 7 | 0.7 | 26.80 | 8.84 | 27.60 | 0.32 |
| 720 | 7.2 | 0.72 | 26.60 | 8.78 | 27.36 | 0.32 |
| 740 | 7.4 | 0.74 | 26.60 | 8.78 | 27.12 | 0.32 |
| 760 | 7.6 | 0.76 | 26.20 | 8.65 | 26.88 | 0.32 |
| 780 | 7.8 | 0.78 | 26.20 | 8.65 | 26.64 | 0.32 |
| 800 | 8 | 0.8 | 26.20 | 8.65 | 26.40 | 0.33 |
| 820 | 8.2 | 0.82 | 26.10 | 8.61 | 26.16 | 0.33 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 840 | 8.4 | 0.84 | 26.10 | 8.61 | 25.92 | 0.33 |
| 860 | 8.6 | 0.86 | 26.00 | 8.58 | 25.68 | 0.33 |
| 880 | 8.8 | 0.88 | 26.00 | 8.58 | 25.44 | 0.34 |
| 900 | 9 | 0.9 | 25.80 | 8.51 | 25.20 | 0.34 |
| 920 | 9.2 | 0.92 | 25.60 | 8.45 | 24.96 | 0.34 |
| 940 | 9.4 | 0.94 | 25.40 | 8.38 | 24.72 | 0.34 |
| 960 | 9.6 | 0.96 | 25.20 | 8.32 | 24.48 | 0.34 |
| 980 | 9.8 | 0.98 | 25.10 | 8.28 | 24.24 | 0.34 |
| 1000 | 10 | 1 | 25.00 | 8.25 | 24.00 | 0.34 |
| 1020 | 10.2 | 1.02 | 24.80 | 8.18 | 23.76 | 0.34 |
| 1040 | 10.4 | 1.04 | 24.90 | 8.22 | 23.52 | 0.35 |
| 1060 | 10.6 | 1.06 | 24.80 | 8.18 | 23.28 | 0.35 |
| 1080 | 10.8 | 1.08 | 24.40 | 8.05 | 23.04 | 0.35 |
| 1100 | 11 | 1.1 | 24.20 | 7.99 | 22.80 | 0.35 |
| 1120 | 11.2 | 1.12 | 24.00 | 7.92 | 22.56 | 0.35 |
| 1140 | 11.4 | 1.14 | 23.80 | 7.85 | 22.32 | 0.35 |
| 1160 | 11.6 | 1.16 | 23.60 | 7.79 | 22.08 | 0.35 |
| 1180 | 11.8 | 1.18 | 23.60 | 7.79 | 21.84 | 0.36 |
| 1200 | 12 | 1.2 | 23.50 | 7.76 | 21.60 | 0.36 |

**Table:D14** Direct Shear Test Readings for ( Soil +3 % cement + 1.5 $kg/m^3$ ZB) at 1.0 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | Cm | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 9.40 | 3.10 | 35.76 | 0.09 |
| 40 | 0.4 | 0.04 | 13.40 | 4.42 | 35.52 | 0.12 |
| 60 | 0.6 | 0.06 | 19.20 | 6.34 | 35.28 | 0.18 |
| 80 | 0.8 | 0.08 | 25.60 | 8.45 | 35.04 | 0.24 |
| 100 | 1 | 0.1 | 30.20 | 9.97 | 34.80 | 0.29 |
| 120 | 1.2 | 0.12 | 33.00 | 10.89 | 34.56 | 0.32 |
| 140 | 1.4 | 0.14 | 36.00 | 11.88 | 34.32 | 0.35 |
| 160 | 1.6 | 0.16 | 37.20 | 12.28 | 34.08 | 0.36 |
| 180 | 1.8 | 0.18 | 38.60 | 12.74 | 33.84 | 0.38 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | Cm | | | | |
| 200 | 2 | 0.2 | 40.00 | 13.20 | 33.60 | 0.39 |
| 220 | 2.2 | 0.22 | 41.00 | 13.53 | 33.36 | 0.41 |
| 240 | 2.4 | 0.24 | 42.10 | 13.89 | 33.12 | 0.42 |
| 260 | 2.6 | 0.26 | 43.00 | 14.19 | 32.88 | 0.43 |
| 280 | 2.8 | 0.28 | 43.80 | 14.45 | 32.64 | 0.44 |
| 300 | 3 | 0.3 | 44.60 | 14.72 | 32.40 | 0.45 |
| 320 | 3.2 | 0.32 | 45.40 | 14.98 | 32.16 | 0.47 |
| 340 | 3.4 | 0.34 | 46.00 | 15.18 | 31.92 | 0.48 |
| 360 | 3.6 | 0.36 | 46.40 | 15.31 | 31.68 | 0.48 |
| 380 | 3.8 | 0.38 | 46.80 | 15.44 | 31.44 | 0.49 |
| 400 | 4 | 0.4 | 47.20 | 15.58 | 31.20 | 0.50 |
| 420 | 4.2 | 0.42 | 47.50 | 15.68 | 30.96 | 0.51 |
| 440 | 4.4 | 0.44 | 47.60 | 15.71 | 30.72 | 0.51 |
| 460 | 4.6 | 0.46 | 47.80 | 15.77 | 30.48 | 0.52 |
| 480 | 4.8 | 0.48 | 47.80 | 15.77 | 30.24 | 0.52 |
| 500 | 5 | 0.5 | 47.80 | 15.77 | 30.00 | 0.53 |
| 520 | 5.2 | 0.52 | 47.80 | 15.77 | 29.76 | 0.53 |
| 540 | 5.4 | 0.54 | 47.80 | 15.77 | 29.52 | 0.53 |
| 560 | 5.6 | 0.56 | 47.80 | 15.77 | 29.28 | 0.54 |
| 580 | 5.8 | 0.58 | 48.00 | 15.84 | 29.04 | 0.55 |
| 600 | 6 | 0.6 | 47.80 | 15.77 | 28.80 | 0.55 |
| 620 | 6.2 | 0.62 | 47.80 | 15.77 | 28.56 | 0.55 |
| 640 | 6.4 | 0.64 | 47.60 | 15.71 | 28.32 | 0.55 |
| 660 | 6.6 | 0.66 | 47.40 | 15.64 | 28.08 | 0.56 |
| 680 | 6.8 | 0.68 | 47.20 | 15.58 | 27.84 | 0.56 |
| 700 | 7 | 0.7 | 47.00 | 15.51 | 27.60 | 0.56 |
| 720 | 7.2 | 0.72 | 46.60 | 15.38 | 27.36 | 0.56 |
| 740 | 7.4 | 0.74 | 46.40 | 15.31 | 27.12 | 0.56 |
| 760 | 7.6 | 0.76 | 46.20 | 15.25 | 26.88 | 0.57 |
| 780 | 7.8 | 0.78 | 46.00 | 15.18 | 26.64 | 0.57 |
| 800 | 8 | 0.8 | 45.80 | 15.11 | 26.40 | 0.57 |
| 820 | 8.2 | 0.82 | 45.60 | 15.05 | 26.16 | 0.58 |
| 840 | 8.4 | 0.84 | 45.40 | 14.98 | 25.92 | 0.58 |
| 860 | 8.6 | 0.86 | 45.20 | 14.92 | 25.68 | 0.58 |
| 880 | 8.8 | 0.88 | 45.00 | 14.85 | 25.44 | 0.58 |
| 900 | 9 | 0.9 | 44.80 | 14.78 | 25.20 | 0.59 |
| 920 | 9.2 | 0.92 | 44.60 | 14.72 | 24.96 | 0.59 |
| 940 | 9.4 | 0.94 | 44.40 | 14.65 | 24.72 | 0.59 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | Cm | | | | |
| 960 | 9.6 | 0.96 | 44.20 | 14.59 | 24.48 | 0.60 |
| 980 | 9.8 | 0.98 | 44.00 | 14.52 | 24.24 | 0.60 |
| 1000 | 10 | 1 | 43.80 | 14.45 | 24.00 | 0.60 |
| 1020 | 10.2 | 1.02 | 43.60 | 14.39 | 23.76 | 0.61 |
| 1040 | 10.4 | 1.04 | 43.40 | 14.32 | 23.52 | 0.61 |
| 1060 | 10.6 | 1.06 | 43.20 | 14.26 | 23.28 | 0.61 |
| 1080 | 10.8 | 1.08 | 43.00 | 14.19 | 23.04 | 0.62 |
| 1100 | 11 | 1.1 | 42.80 | 14.12 | 22.80 | 0.62 |
| 1120 | 11.2 | 1.12 | 42.60 | 14.06 | 22.56 | 0.62 |
| 1140 | 11.4 | 1.14 | 42.40 | 13.99 | 22.32 | 0.63 |
| 1160 | 11.6 | 1.16 | 42.20 | 13.93 | 22.08 | 0.63 |
| 1180 | 11.8 | 1.18 | 42.00 | 13.86 | 21.84 | 0.63 |
| 1200 | 12 | 1.2 | 41.80 | 13.79 | 21.60 | 0.64 |
| 1220 | 12.2 | 1.22 | 41.60 | 13.73 | 21.36 | 0.64 |

**Table:D15** Direct Shear Test Readings for ( Soil +3 % cement + 1.5 $kg/m^3$ ZB) at 1.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | Cm | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 10.20 | 3.37 | 35.76 | 0.09 |
| 40 | 0.4 | 0.04 | 14.20 | 4.69 | 35.52 | 0.13 |
| 60 | 0.6 | 0.06 | 25.60 | 8.45 | 35.28 | 0.24 |
| 80 | 0.8 | 0.08 | 35.60 | 11.75 | 35.04 | 0.34 |
| 100 | 1 | 0.1 | 39.20 | 12.94 | 34.80 | 0.37 |
| 120 | 1.2 | 0.12 | 45.80 | 15.11 | 34.56 | 0.44 |
| 140 | 1.4 | 0.14 | 48.00 | 15.84 | 34.32 | 0.46 |
| 160 | 1.6 | 0.16 | 50.60 | 16.70 | 34.08 | 0.49 |
| 180 | 1.8 | 0.18 | 52.10 | 17.19 | 33.84 | 0.51 |
| 200 | 2 | 0.2 | 53.80 | 17.75 | 33.60 | 0.53 |
| 220 | 2.2 | 0.22 | 55.00 | 18.15 | 33.36 | 0.54 |
| 240 | 2.4 | 0.24 | 56.00 | 18.48 | 33.12 | 0.56 |
| 260 | 2.6 | 0.26 | 57.00 | 18.81 | 32.88 | 0.57 |
| 280 | 2.8 | 0.28 | 57.40 | 18.94 | 32.64 | 0.58 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | Cm | | | | |
| 300 | 3 | 0.3 | 58.40 | 19.27 | 32.40 | 0.59 |
| 320 | 3.2 | 0.32 | 59.20 | 19.54 | 32.16 | 0.61 |
| 340 | 3.4 | 0.34 | 60.00 | 19.80 | 31.92 | 0.62 |
| 360 | 3.6 | 0.36 | 61.00 | 20.13 | 31.68 | 0.64 |
| 380 | 3.8 | 0.38 | 61.60 | 20.33 | 31.44 | 0.65 |
| 400 | 4 | 0.4 | 62.40 | 20.59 | 31.20 | 0.66 |
| 420 | 4.2 | 0.42 | 63.20 | 20.86 | 30.96 | 0.67 |
| 440 | 4.4 | 0.44 | 63.90 | 21.09 | 30.72 | 0.69 |
| 460 | 4.6 | 0.46 | 64.40 | 21.25 | 30.48 | 0.70 |
| 480 | 4.8 | 0.48 | 65.00 | 21.45 | 30.24 | 0.71 |
| 500 | 5 | 0.5 | 65.40 | 21.58 | 30.00 | 0.72 |
| 520 | 5.2 | 0.52 | 66.00 | 21.78 | 29.76 | 0.73 |
| 540 | 5.4 | 0.54 | 66.40 | 21.91 | 29.52 | 0.74 |
| 560 | 5.6 | 0.56 | 66.80 | 22.04 | 29.28 | 0.75 |
| 580 | 5.8 | 0.58 | 67.80 | 22.37 | 29.04 | 0.77 |
| 600 | 6 | 0.6 | 67.80 | 22.37 | 28.80 | 0.78 |
| 620 | 6.2 | 0.62 | 68.00 | 22.44 | 28.56 | 0.79 |
| 640 | 6.4 | 0.64 | 68.20 | 22.51 | 28.32 | 0.79 |
| 660 | 6.6 | 0.66 | 68.40 | 22.57 | 28.08 | 0.80 |
| 680 | 6.8 | 0.68 | 68.20 | 22.51 | 27.84 | 0.81 |
| 700 | 7 | 0.7 | 68.60 | 22.64 | 27.60 | 0.82 |
| 720 | 7.2 | 0.72 | 68.60 | 22.64 | 27.36 | 0.83 |
| 740 | 7.4 | 0.74 | 68.60 | 22.64 | 27.12 | 0.83 |
| 760 | 7.6 | 0.76 | 68.60 | 22.64 | 26.88 | 0.84 |
| 780 | 7.8 | 0.78 | 68.60 | 22.64 | 26.64 | 0.85 |
| 800 | 8 | 0.8 | 68.70 | 22.67 | 26.40 | 0.86 |
| 820 | 8.2 | 0.82 | 68.50 | 22.61 | 26.16 | 0.86 |
| 840 | 8.4 | 0.84 | 68.60 | 22.64 | 25.92 | 0.87 |
| 860 | 8.6 | 0.86 | 68.30 | 22.54 | 25.68 | 0.88 |
| 880 | 8.8 | 0.88 | 68.20 | 22.51 | 25.44 | 0.88 |
| 900 | 9 | 0.9 | 68.00 | 22.44 | 25.20 | 0.89 |
| 920 | 9.2 | 0.92 | 67.80 | 22.37 | 24.96 | 0.90 |
| 940 | 9.4 | 0.94 | 67.60 | 22.31 | 24.72 | 0.90 |
| 960 | 9.6 | 0.96 | 67.40 | 22.24 | 24.48 | 0.91 |
| 980 | 9.8 | 0.98 | 67.20 | 22.18 | 24.24 | 0.91 |
| 1000 | 10 | 1 | 67.20 | 22.18 | 24.00 | 0.92 |
| 1020 | 10.2 | 1.02 | 67.00 | 22.11 | 23.76 | 0.93 |
| 1040 | 10.4 | 1.04 | 67.10 | 22.14 | 23.52 | 0.94 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | Cm | | | | |
| 1060 | 10.6 | 1.06 | 67.00 | 22.11 | 23.28 | 0.95 |
| 1080 | 10.8 | 1.08 | 67.00 | 22.11 | 23.04 | 0.96 |
| 1100 | 11 | 1.1 | 67.10 | 22.14 | 22.80 | 0.97 |
| 1120 | 11.2 | 1.12 | 66.80 | 22.04 | 22.56 | 0.98 |
| 1140 | 11.4 | 1.14 | 66.70 | 22.01 | 22.32 | 0.99 |
| 1160 | 11.6 | 1.16 | 66.60 | 21.98 | 22.08 | 1.00 |
| 1180 | 11.8 | 1.18 | 66.60 | 21.98 | 21.84 | 1.01 |
| 1200 | 12 | 1.2 | 66.60 | 21.98 | 21.60 | 1.02 |
| 1220 | 12.2 | 1.22 | 66.00 | 21.78 | 21.36 | 1.02 |

## Appendix E

**Table:E1** Direct Shear Test Readings for ( Soil +4 % cement + 0.5 kg/$m^3$ ZB) at 0.5 kg/$cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| | | | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 3.80 | 1.25 | 35.76 | 0.04 |
| 40 | 0.4 | 0.04 | 8.00 | 2.64 | 35.52 | 0.07 |
| 60 | 0.6 | 0.06 | 12.00 | 3.96 | 35.28 | 0.11 |
| 80 | 0.8 | 0.08 | 14.60 | 4.82 | 35.04 | 0.14 |
| 100 | 1 | 0.1 | 16.60 | 5.48 | 34.80 | 0.16 |
| 120 | 1.2 | 0.12 | 17.60 | 5.81 | 34.56 | 0.17 |
| 140 | 1.4 | 0.14 | 18.40 | 6.07 | 34.32 | 0.18 |
| 160 | 1.6 | 0.16 | 19.00 | 6.27 | 34.08 | 0.18 |
| 180 | 1.8 | 0.18 | 19.60 | 6.47 | 33.84 | 0.19 |
| 200 | 2 | 0.2 | 20.20 | 6.67 | 33.60 | 0.20 |
| 220 | 2.2 | 0.22 | 20.60 | 6.80 | 33.36 | 0.20 |
| 240 | 2.4 | 0.24 | 20.80 | 6.86 | 33.12 | 0.21 |
| 260 | 2.6 | 0.26 | 21.00 | 6.93 | 32.88 | 0.21 |
| 280 | 2.8 | 0.28 | 21.00 | 6.93 | 32.64 | 0.21 |
| 300 | 3 | 0.3 | 21.20 | 7.00 | 32.40 | 0.22 |
| 320 | 3.2 | 0.32 | 21.20 | 7.00 | 32.16 | 0.22 |
| 340 | 3.4 | 0.34 | 21.20 | 7.00 | 31.92 | 0.22 |
| 360 | 3.6 | 0.36 | 21.10 | 6.96 | 31.68 | 0.22 |
| 380 | 3.8 | 0.38 | 21.00 | 6.93 | 31.44 | 0.22 |
| 400 | 4 | 0.4 | 20.80 | 6.86 | 31.20 | 0.22 |
| 420 | 4.2 | 0.42 | 20.80 | 6.86 | 30.96 | 0.22 |
| 440 | 4.4 | 0.44 | 20.40 | 6.73 | 30.72 | 0.22 |
| 460 | 4.6 | 0.46 | 20.40 | 6.73 | 30.48 | 0.22 |
| 480 | 4.8 | 0.48 | 20.20 | 6.67 | 30.24 | 0.22 |
| 500 | 5 | 0.5 | 20.10 | 6.63 | 30.00 | 0.22 |
| 520 | 5.2 | 0.52 | 20.00 | 6.60 | 29.76 | 0.22 |
| 540 | 5.4 | 0.54 | 19.90 | 6.57 | 29.52 | 0.22 |
| 560 | 5.6 | 0.56 | 19.90 | 6.57 | 29.28 | 0.22 |
| 580 | 5.8 | 0.58 | 19.80 | 6.53 | 29.04 | 0.23 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 600 | 6 | 0.6 | 19.80 | 6.53 | 28.80 | 0.23 |
| 620 | 6.2 | 0.62 | 19.80 | 6.53 | 28.56 | 0.23 |
| 640 | 6.4 | 0.64 | 19.80 | 6.53 | 28.32 | 0.23 |
| 660 | 6.6 | 0.66 | 19.80 | 6.53 | 28.08 | 0.23 |
| 680 | 6.8 | 0.68 | 19.80 | 6.53 | 27.84 | 0.23 |
| 700 | 7 | 0.7 | 19.80 | 6.53 | 27.60 | 0.24 |
| 720 | 7.2 | 0.72 | 19.80 | 6.53 | 27.36 | 0.24 |
| 740 | 7.4 | 0.74 | 19.80 | 6.53 | 27.12 | 0.24 |
| 760 | 7.6 | 0.76 | 19.80 | 6.53 | 26.88 | 0.24 |
| 780 | 7.8 | 0.78 | 19.80 | 6.53 | 26.64 | 0.25 |
| 800 | 8 | 0.8 | 19.80 | 6.53 | 26.40 | 0.25 |
| 820 | 8.2 | 0.82 | 19.70 | 6.50 | 26.16 | 0.25 |
| 840 | 8.4 | 0.84 | 19.70 | 6.50 | 25.92 | 0.25 |
| 860 | 8.6 | 0.86 | 19.70 | 6.50 | 25.68 | 0.25 |
| 880 | 8.8 | 0.88 | 19.50 | 6.44 | 25.44 | 0.25 |
| 900 | 9 | 0.9 | 19.50 | 6.44 | 25.20 | 0.26 |
| 920 | 9.2 | 0.92 | 19.60 | 6.47 | 24.96 | 0.26 |
| 940 | 9.4 | 0.94 | 19.50 | 6.44 | 24.72 | 0.26 |
| 960 | 9.6 | 0.96 | 19.20 | 6.34 | 24.48 | 0.26 |
| 980 | 9.8 | 0.98 | 19.20 | 6.34 | 24.24 | 0.26 |
| 1000 | 10 | 1 | 19.20 | 6.34 | 24.00 | 0.26 |
| 1020 | 10.2 | 1.02 | 19.20 | 6.34 | 23.76 | 0.27 |
| 1040 | 10.4 | 1.04 | 19.20 | 6.34 | 23.52 | 0.27 |
| 1060 | 10.6 | 1.06 | 19.20 | 6.34 | 23.28 | 0.27 |
| 1080 | 10.8 | 1.08 | 19.20 | 6.34 | 23.04 | 0.28 |
| 1100 | 11 | 1.1 | 19.20 | 6.34 | 22.80 | 0.28 |
| 1120 | 11.2 | 1.12 | 19.20 | 6.34 | 22.56 | 0.28 |
| 1140 | 11.4 | 1.14 | 19.00 | 6.27 | 22.32 | 0.28 |
| 1160 | 11.6 | 1.16 | 19.00 | 6.27 | 22.08 | 0.28 |
| 1180 | 11.8 | 1.18 | 19.00 | 6.27 | 21.84 | 0.29 |
| 1200 | 12 | 1.2 | 19.00 | 6.27 | 21.60 | 0.29 |
| 1220 | 12.2 | 1.22 | 19.00 | 6.27 | 21.36 | 0.29 |

**Table:E2** Direct Shear Test Readings for ( Soil +4 % cement + 0.5 kg/$m^3$ ZB) at 1.0 kg/$cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 12.00 | 3.96 | 35.76 | 0.11 |
| 40 | 0.4 | 0.04 | 17.20 | 5.68 | 35.52 | 0.16 |
| 60 | 0.6 | 0.06 | 20.20 | 6.67 | 35.28 | 0.19 |
| 80 | 0.8 | 0.08 | 25.40 | 8.38 | 35.04 | 0.24 |
| 100 | 1 | 0.1 | 28.20 | 9.31 | 34.80 | 0.27 |
| 120 | 1.2 | 0.12 | 30.20 | 9.97 | 34.56 | 0.29 |
| 140 | 1.4 | 0.14 | 32.00 | 10.56 | 34.32 | 0.31 |
| 160 | 1.6 | 0.16 | 33.20 | 10.96 | 34.08 | 0.32 |
| 180 | 1.8 | 0.18 | 34.40 | 11.35 | 33.84 | 0.34 |
| 200 | 2 | 0.2 | 35.60 | 11.75 | 33.60 | 0.35 |
| 220 | 2.2 | 0.22 | 36.40 | 12.01 | 33.36 | 0.36 |
| 240 | 2.4 | 0.24 | 37.20 | 12.28 | 33.12 | 0.37 |
| 260 | 2.6 | 0.26 | 38.00 | 12.54 | 32.88 | 0.38 |
| 280 | 2.8 | 0.28 | 38.40 | 12.67 | 32.64 | 0.39 |
| 300 | 3 | 0.3 | 39.00 | 12.87 | 32.40 | 0.40 |
| 320 | 3.2 | 0.32 | 39.20 | 12.94 | 32.16 | 0.40 |
| 340 | 3.4 | 0.34 | 39.80 | 13.13 | 31.92 | 0.41 |
| 360 | 3.6 | 0.36 | 40.00 | 13.20 | 31.68 | 0.42 |
| 380 | 3.8 | 0.38 | 40.20 | 13.27 | 31.44 | 0.42 |
| 400 | 4 | 0.4 | 40.40 | 13.33 | 31.20 | 0.43 |
| 420 | 4.2 | 0.42 | 40.60 | 13.40 | 30.96 | 0.43 |
| 440 | 4.4 | 0.44 | 40.60 | 13.40 | 30.72 | 0.44 |
| 460 | 4.6 | 0.46 | 40.60 | 13.40 | 30.48 | 0.44 |
| 480 | 4.8 | 0.48 | 40.70 | 13.43 | 30.24 | 0.44 |
| 500 | 5 | 0.5 | 40.80 | 13.46 | 30.00 | 0.45 |
| 520 | 5.2 | 0.52 | 40.80 | 13.46 | 29.76 | 0.45 |
| 540 | 5.4 | 0.54 | 40.80 | 13.46 | 29.52 | 0.46 |
| 560 | 5.6 | 0.56 | 40.70 | 13.43 | 29.28 | 0.46 |
| 580 | 5.8 | 0.58 | 40.60 | 13.40 | 29.04 | 0.46 |
| 600 | 6 | 0.6 | 40.70 | 13.43 | 28.80 | 0.47 |
| 620 | 6.2 | 0.62 | 40.70 | 13.43 | 28.56 | 0.47 |
| 640 | 6.4 | 0.64 | 40.70 | 13.43 | 28.32 | 0.47 |
| 660 | 6.6 | 0.66 | 40.70 | 13.43 | 28.08 | 0.48 |
| 680 | 6.8 | 0.68 | 40.60 | 13.40 | 27.84 | 0.48 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 700 | 7 | 0.7 | 40.60 | 13.40 | 27.60 | 0.49 |
| 720 | 7.2 | 0.72 | 40.60 | 13.40 | 27.36 | 0.49 |
| 740 | 7.4 | 0.74 | 40.80 | 13.46 | 27.12 | 0.50 |
| 760 | 7.6 | 0.76 | 41.00 | 13.53 | 26.88 | 0.50 |
| 780 | 7.8 | 0.78 | 41.00 | 13.53 | 26.64 | 0.51 |
| 800 | 8 | 0.8 | 41.00 | 13.53 | 26.40 | 0.51 |
| 820 | 8.2 | 0.82 | 41.00 | 13.53 | 26.16 | 0.52 |
| 840 | 8.4 | 0.84 | 41.00 | 13.53 | 25.92 | 0.52 |
| 860 | 8.6 | 0.86 | 41.20 | 13.60 | 25.68 | 0.53 |
| 880 | 8.8 | 0.88 | 41.00 | 13.53 | 25.44 | 0.53 |
| 900 | 9 | 0.9 | 41.10 | 13.56 | 25.20 | 0.54 |
| 920 | 9.2 | 0.92 | 41.00 | 13.53 | 24.96 | 0.54 |
| 940 | 9.4 | 0.94 | 40.80 | 13.46 | 24.72 | 0.54 |
| 960 | 9.6 | 0.96 | 40.67 | 13.42 | 24.48 | 0.55 |
| 980 | 9.8 | 0.98 | 40.52 | 13.37 | 24.24 | 0.55 |
| 1000 | 10 | 1 | 40.37 | 13.32 | 24.00 | 0.56 |
| 1020 | 10.2 | 1.02 | 40.22 | 13.27 | 23.76 | 0.56 |
| 1040 | 10.4 | 1.04 | 40.07 | 13.22 | 23.52 | 0.56 |
| 1060 | 10.6 | 1.06 | 39.92 | 13.17 | 23.28 | 0.57 |
| 1080 | 10.8 | 1.08 | 39.77 | 13.12 | 23.04 | 0.57 |
| 1100 | 11 | 1.1 | 39.62 | 13.07 | 22.80 | 0.57 |
| 1120 | 11.2 | 1.12 | 39.47 | 13.02 | 22.56 | 0.58 |
| 1140 | 11.4 | 1.14 | 39.32 | 12.97 | 22.32 | 0.58 |
| 1160 | 11.6 | 1.16 | 39.17 | 12.93 | 22.08 | 0.59 |
| 1180 | 11.8 | 1.18 | 39.02 | 12.88 | 21.84 | 0.59 |
| 1200 | 12 | 1.2 | 38.87 | 12.83 | 21.60 | 0.59 |

**Table:E3** Direct Shear Test Readings for ( Soil +4 % cement + 0.5 $kg/m^3$ ZB) at 1.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 11.20 | 3.70 | 35.76 | 0.10 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 40 | 0.4 | 0.04 | 16.40 | 5.41 | 35.52 | 0.15 |
| 60 | 0.6 | 0.06 | 24.60 | 8.12 | 35.28 | 0.23 |
| 80 | 0.8 | 0.08 | 35.40 | 11.68 | 35.04 | 0.33 |
| 100 | 1 | 0.1 | 42.00 | 13.86 | 34.80 | 0.40 |
| 120 | 1.2 | 0.12 | 47.80 | 15.77 | 34.56 | 0.46 |
| 140 | 1.4 | 0.14 | 49.20 | 16.24 | 34.32 | 0.47 |
| 160 | 1.6 | 0.16 | 50.80 | 16.76 | 34.08 | 0.49 |
| 180 | 1.8 | 0.18 | 52.00 | 17.16 | 33.84 | 0.51 |
| 200 | 2 | 0.2 | 53.40 | 17.62 | 33.60 | 0.52 |
| 220 | 2.2 | 0.22 | 54.80 | 18.08 | 33.36 | 0.54 |
| 240 | 2.4 | 0.24 | 55.60 | 18.35 | 33.12 | 0.55 |
| 260 | 2.6 | 0.26 | 56.40 | 18.61 | 32.88 | 0.57 |
| 280 | 2.8 | 0.28 | 57.20 | 18.88 | 32.64 | 0.58 |
| 300 | 3 | 0.3 | 57.80 | 19.07 | 32.40 | 0.59 |
| 320 | 3.2 | 0.32 | 58.20 | 19.21 | 32.16 | 0.60 |
| 340 | 3.4 | 0.34 | 58.40 | 19.27 | 31.92 | 0.60 |
| 360 | 3.6 | 0.36 | 59.00 | 19.47 | 31.68 | 0.61 |
| 380 | 3.8 | 0.38 | 59.10 | 19.50 | 31.44 | 0.62 |
| 400 | 4 | 0.4 | 59.20 | 19.54 | 31.20 | 0.63 |
| 420 | 4.2 | 0.42 | 59.40 | 19.60 | 30.96 | 0.63 |
| 440 | 4.4 | 0.44 | 59.40 | 19.60 | 30.72 | 0.64 |
| 460 | 4.6 | 0.46 | 59.40 | 19.60 | 30.48 | 0.64 |
| 480 | 4.8 | 0.48 | 59.20 | 19.54 | 30.24 | 0.65 |
| 500 | 5 | 0.5 | 59.40 | 19.60 | 30.00 | 0.65 |
| 520 | 5.2 | 0.52 | 59.30 | 19.57 | 29.76 | 0.66 |
| 540 | 5.4 | 0.54 | 59.20 | 19.54 | 29.52 | 0.66 |
| 560 | 5.6 | 0.56 | 59.00 | 19.47 | 29.28 | 0.66 |
| 580 | 5.8 | 0.58 | 58.90 | 19.44 | 29.04 | 0.67 |
| 600 | 6 | 0.6 | 59.00 | 19.47 | 28.80 | 0.68 |
| 620 | 6.2 | 0.62 | 59.00 | 19.47 | 28.56 | 0.68 |
| 640 | 6.4 | 0.64 | 59.00 | 19.47 | 28.32 | 0.69 |
| 660 | 6.6 | 0.66 | 59.00 | 19.47 | 28.08 | 0.69 |
| 680 | 6.8 | 0.68 | 59.00 | 19.47 | 27.84 | 0.70 |
| 700 | 7 | 0.7 | 59.00 | 19.47 | 27.60 | 0.71 |
| 720 | 7.2 | 0.72 | 59.00 | 19.47 | 27.36 | 0.71 |
| 740 | 7.4 | 0.74 | 59.00 | 19.47 | 27.12 | 0.72 |
| 760 | 7.6 | 0.76 | 59.00 | 19.47 | 26.88 | 0.72 |
| 780 | 7.8 | 0.78 | 58.90 | 19.44 | 26.64 | 0.73 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 800 | 8 | 0.8 | 58.80 | 19.40 | 26.40 | 0.74 |
| 820 | 8.2 | 0.82 | 58.80 | 19.40 | 26.16 | 0.74 |
| 840 | 8.4 | 0.84 | 58.80 | 19.40 | 25.92 | 0.75 |
| 860 | 8.6 | 0.86 | 58.80 | 19.40 | 25.68 | 0.76 |
| 880 | 8.8 | 0.88 | 58.80 | 19.40 | 25.44 | 0.76 |
| 900 | 9 | 0.9 | 58.80 | 19.40 | 25.20 | 0.77 |
| 920 | 9.2 | 0.92 | 58.80 | 19.40 | 24.96 | 0.78 |
| 940 | 9.4 | 0.94 | 58.80 | 19.40 | 24.72 | 0.78 |
| 960 | 9.6 | 0.96 | 58.80 | 19.40 | 24.48 | 0.79 |
| 980 | 9.8 | 0.98 | 58.80 | 19.40 | 24.24 | 0.80 |
| 1000 | 10 | 1 | 58.80 | 19.40 | 24.00 | 0.81 |
| 1020 | 10.2 | 1.02 | 58.80 | 19.40 | 23.76 | 0.82 |
| 1040 | 10.4 | 1.04 | 58.80 | 19.40 | 23.52 | 0.83 |
| 1060 | 10.6 | 1.06 | 58.80 | 19.40 | 23.28 | 0.83 |
| 1080 | 10.8 | 1.08 | 58.80 | 19.40 | 23.04 | 0.84 |
| 1100 | 11 | 1.1 | 58.80 | 19.40 | 22.80 | 0.85 |
| 1120 | 11.2 | 1.12 | 58.80 | 19.40 | 22.56 | 0.86 |
| 1140 | 11.4 | 1.14 | 58.80 | 19.40 | 22.32 | 0.87 |
| 1160 | 11.6 | 1.16 | 58.80 | 19.40 | 22.08 | 0.88 |
| 1180 | 11.8 | 1.18 | 58.80 | 19.40 | 21.84 | 0.89 |
| 1200 | 12 | 1.2 | 58.80 | 19.40 | 21.60 | 0.90 |
| 1220 | 12.2 | 1.22 | 58.80 | 19.40 | 21.36 | 0.90 |

**Table:E4** Direct Shear Test Readings for ( Soil +4 % cement + 0.75 $kg/m^3$ ZB) at 0.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 3.20 | 1.06 | 35.76 | 0.03 |
| 40 | 0.4 | 0.04 | 5.90 | 1.95 | 35.52 | 0.05 |
| 60 | 0.6 | 0.06 | 9.80 | 3.23 | 35.28 | 0.09 |
| 80 | 0.8 | 0.08 | 12.80 | 4.22 | 35.04 | 0.12 |
| 100 | 1 | 0.1 | 13.20 | 4.36 | 34.80 | 0.13 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 120 | 1.2 | 0.12 | 13.60 | 4.49 | 34.56 | 0.13 |
| 140 | 1.4 | 0.14 | 15.00 | 4.95 | 34.32 | 0.14 |
| 160 | 1.6 | 0.16 | 16.20 | 5.35 | 34.08 | 0.16 |
| 180 | 1.8 | 0.18 | 16.80 | 5.54 | 33.84 | 0.16 |
| 200 | 2 | 0.2 | 17.40 | 5.74 | 33.60 | 0.17 |
| 220 | 2.2 | 0.22 | 17.80 | 5.87 | 33.36 | 0.18 |
| 240 | 2.4 | 0.24 | 18.20 | 6.01 | 33.12 | 0.18 |
| 260 | 2.6 | 0.26 | 18.60 | 6.14 | 32.88 | 0.19 |
| 280 | 2.8 | 0.28 | 19.00 | 6.27 | 32.64 | 0.19 |
| 300 | 3 | 0.3 | 19.00 | 6.27 | 32.40 | 0.19 |
| 320 | 3.2 | 0.32 | 19.40 | 6.40 | 32.16 | 0.20 |
| 340 | 3.4 | 0.34 | 19.80 | 6.53 | 31.92 | 0.20 |
| 360 | 3.6 | 0.36 | 20.00 | 6.60 | 31.68 | 0.21 |
| 380 | 3.8 | 0.38 | 20.20 | 6.67 | 31.44 | 0.21 |
| 400 | 4 | 0.4 | 20.40 | 6.73 | 31.20 | 0.22 |
| 420 | 4.2 | 0.42 | 20.60 | 6.80 | 30.96 | 0.22 |
| 440 | 4.4 | 0.44 | 20.60 | 6.80 | 30.72 | 0.22 |
| 460 | 4.6 | 0.46 | 20.60 | 6.80 | 30.48 | 0.22 |
| 480 | 4.8 | 0.48 | 20.60 | 6.80 | 30.24 | 0.22 |
| 500 | 5 | 0.5 | 20.60 | 6.80 | 30.00 | 0.23 |
| 520 | 5.2 | 0.52 | 20.60 | 6.80 | 29.76 | 0.23 |
| 540 | 5.4 | 0.54 | 20.60 | 6.80 | 29.52 | 0.23 |
| 560 | 5.6 | 0.56 | 20.60 | 6.80 | 29.28 | 0.23 |
| 580 | 5.8 | 0.58 | 20.40 | 6.73 | 29.04 | 0.23 |
| 600 | 6 | 0.6 | 20.40 | 6.73 | 28.80 | 0.23 |
| 620 | 6.2 | 0.62 | 20.40 | 6.73 | 28.56 | 0.24 |
| 640 | 6.4 | 0.64 | 20.40 | 6.73 | 28.32 | 0.24 |
| 660 | 6.6 | 0.66 | 20.30 | 6.70 | 28.08 | 0.24 |
| 680 | 6.8 | 0.68 | 20.30 | 6.70 | 27.84 | 0.24 |
| 700 | 7 | 0.7 | 20.30 | 6.70 | 27.60 | 0.24 |
| 720 | 7.2 | 0.72 | 20.30 | 6.70 | 27.36 | 0.24 |
| 740 | 7.4 | 0.74 | 20.20 | 6.67 | 27.12 | 0.25 |
| 760 | 7.6 | 0.76 | 20.20 | 6.67 | 26.88 | 0.25 |
| 780 | 7.8 | 0.78 | 20.20 | 6.67 | 26.64 | 0.25 |
| 800 | 8 | 0.8 | 20.20 | 6.67 | 26.40 | 0.25 |
| 820 | 8.2 | 0.82 | 20.00 | 6.60 | 26.16 | 0.25 |
| 840 | 8.4 | 0.84 | 20.00 | 6.60 | 25.92 | 0.25 |
| 860 | 8.6 | 0.86 | 20.00 | 6.60 | 25.68 | 0.26 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 880 | 8.8 | 0.88 | 20.00 | 6.60 | 25.44 | 0.26 |
| 900 | 9 | 0.9 | 19.80 | 6.53 | 25.20 | 0.26 |
| 920 | 9.2 | 0.92 | 19.80 | 6.53 | 24.96 | 0.26 |
| 940 | 9.4 | 0.94 | 19.70 | 6.50 | 24.72 | 0.26 |
| 960 | 9.6 | 0.96 | 19.70 | 6.50 | 24.48 | 0.27 |
| 980 | 9.8 | 0.98 | 19.60 | 6.47 | 24.24 | 0.27 |
| 1000 | 10 | 1 | 19.60 | 6.47 | 24.00 | 0.27 |
| 1020 | 10.2 | 1.02 | 19.70 | 6.50 | 23.76 | 0.27 |
| 1040 | 10.4 | 1.04 | 19.60 | 6.47 | 23.52 | 0.28 |
| 1060 | 10.6 | 1.06 | 19.40 | 6.40 | 23.28 | 0.28 |
| 1080 | 10.8 | 1.08 | 19.40 | 6.40 | 23.04 | 0.28 |
| 1100 | 11 | 1.1 | 19.30 | 6.37 | 22.80 | 0.28 |
| 1120 | 11.2 | 1.12 | 19.30 | 6.37 | 22.56 | 0.28 |
| 1140 | 11.4 | 1.14 | 19.40 | 6.40 | 22.32 | 0.29 |
| 1160 | 11.6 | 1.16 | 19.30 | 6.37 | 22.08 | 0.29 |
| 1180 | 11.8 | 1.18 | 19.30 | 6.37 | 21.84 | 0.29 |
| 1200 | 12 | 1.2 | 19.30 | 6.37 | 21.60 | 0.29 |
| 1220 | 12.2 | 1.22 | 19.20 | 6.34 | 21.36 | 0.30 |

**Table:E5** Direct Shear Test Readings for ( Soil +4 % cement + 0.75 $kg/m^3$ ZB) at 1.0 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| | | | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 10.00 | 3.30 | 35.76 | 0.09 |
| 40 | 0.4 | 0.04 | 14.20 | 4.69 | 35.52 | 0.13 |
| 60 | 0.6 | 0.06 | 16.20 | 5.35 | 35.28 | 0.15 |
| 80 | 0.8 | 0.08 | 19.00 | 6.27 | 35.04 | 0.18 |
| 100 | 1 | 0.1 | 20.40 | 6.73 | 34.80 | 0.19 |
| 120 | 1.2 | 0.12 | 21.80 | 7.19 | 34.56 | 0.21 |
| 140 | 1.4 | 0.14 | 23.80 | 7.85 | 34.32 | 0.23 |
| 160 | 1.6 | 0.16 | 25.40 | 8.38 | 34.08 | 0.25 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 180 | 1.8 | 0.18 | 26.80 | 8.84 | 33.84 | 0.26 |
| 200 | 2 | 0.2 | 27.60 | 9.11 | 33.60 | 0.27 |
| 220 | 2.2 | 0.22 | 28.80 | 9.50 | 33.36 | 0.28 |
| 240 | 2.4 | 0.24 | 29.40 | 9.70 | 33.12 | 0.29 |
| 260 | 2.6 | 0.26 | 30.20 | 9.97 | 32.88 | 0.30 |
| 280 | 2.8 | 0.28 | 30.80 | 10.16 | 32.64 | 0.31 |
| 300 | 3 | 0.3 | 31.80 | 10.49 | 32.40 | 0.32 |
| 320 | 3.2 | 0.32 | 32.20 | 10.63 | 32.16 | 0.33 |
| 340 | 3.4 | 0.34 | 32.90 | 10.86 | 31.92 | 0.34 |
| 360 | 3.6 | 0.36 | 33.60 | 11.09 | 31.68 | 0.35 |
| 380 | 3.8 | 0.38 | 34.20 | 11.29 | 31.44 | 0.36 |
| 400 | 4 | 0.4 | 34.80 | 11.48 | 31.20 | 0.37 |
| 420 | 4.2 | 0.42 | 35.20 | 11.62 | 30.96 | 0.38 |
| 440 | 4.4 | 0.44 | 35.60 | 11.75 | 30.72 | 0.38 |
| 460 | 4.6 | 0.46 | 36.00 | 11.88 | 30.48 | 0.39 |
| 480 | 4.8 | 0.48 | 36.40 | 12.01 | 30.24 | 0.40 |
| 500 | 5 | 0.5 | 36.60 | 12.08 | 30.00 | 0.40 |
| 520 | 5.2 | 0.52 | 36.80 | 12.14 | 29.76 | 0.41 |
| 540 | 5.4 | 0.54 | 36.90 | 12.18 | 29.52 | 0.41 |
| 560 | 5.6 | 0.56 | 37.00 | 12.21 | 29.28 | 0.42 |
| 580 | 5.8 | 0.58 | 37.00 | 12.21 | 29.04 | 0.42 |
| 600 | 6 | 0.6 | 36.80 | 12.14 | 28.80 | 0.42 |
| 620 | 6.2 | 0.62 | 36.60 | 12.08 | 28.56 | 0.42 |
| 640 | 6.4 | 0.64 | 36.60 | 12.08 | 28.32 | 0.43 |
| 660 | 6.6 | 0.66 | 36.40 | 12.01 | 28.08 | 0.43 |
| 680 | 6.8 | 0.68 | 36.30 | 11.98 | 27.84 | 0.43 |
| 700 | 7 | 0.7 | 36.10 | 11.91 | 27.60 | 0.43 |
| 720 | 7.2 | 0.72 | 36.00 | 11.88 | 27.36 | 0.43 |
| 740 | 7.4 | 0.74 | 35.80 | 11.81 | 27.12 | 0.44 |
| 760 | 7.6 | 0.76 | 35.60 | 11.75 | 26.88 | 0.44 |
| 780 | 7.8 | 0.78 | 35.40 | 11.68 | 26.64 | 0.44 |
| 800 | 8 | 0.8 | 35.40 | 11.68 | 26.40 | 0.44 |
| 820 | 8.2 | 0.82 | 35.20 | 11.62 | 26.16 | 0.44 |
| 840 | 8.4 | 0.84 | 35.20 | 11.62 | 25.92 | 0.45 |
| 860 | 8.6 | 0.86 | 35.20 | 11.62 | 25.68 | 0.45 |
| 880 | 8.8 | 0.88 | 35.00 | 11.55 | 25.44 | 0.45 |
| 900 | 9 | 0.9 | 35.00 | 11.55 | 25.20 | 0.46 |
| 920 | 9.2 | 0.92 | 35.00 | 11.55 | 24.96 | 0.46 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 940 | 9.4 | 0.94 | 35.00 | 11.55 | 24.72 | 0.47 |
| 960 | 9.6 | 0.96 | 35.00 | 11.55 | 24.48 | 0.47 |
| 980 | 9.8 | 0.98 | 34.90 | 11.52 | 24.24 | 0.48 |
| 1000 | 10 | 1 | 34.80 | 11.48 | 24.00 | 0.48 |
| 1020 | 10.2 | 1.02 | 34.80 | 11.48 | 23.76 | 0.48 |
| 1040 | 10.4 | 1.04 | 34.80 | 11.48 | 23.52 | 0.49 |
| 1060 | 10.6 | 1.06 | 34.70 | 11.45 | 23.28 | 0.49 |
| 1080 | 10.8 | 1.08 | 34.50 | 11.39 | 23.04 | 0.49 |
| 1100 | 11 | 1.1 | 34.50 | 11.39 | 22.80 | 0.50 |
| 1120 | 11.2 | 1.12 | 34.60 | 11.42 | 22.56 | 0.51 |
| 1140 | 11.4 | 1.14 | 34.60 | 11.42 | 22.32 | 0.51 |
| 1160 | 11.6 | 1.16 | 34.60 | 11.42 | 22.08 | 0.52 |
| 1180 | 11.8 | 1.18 | 34.60 | 11.42 | 21.84 | 0.52 |
| 1200 | 12 | 1.2 | 34.60 | 11.42 | 21.60 | 0.53 |
| 1220 | 12.2 | 1.22 | 34.60 | 11.42 | 21.36 | 0.53 |

**Table:E6** Direct Shear Test Readings for ( Soil +4 % cement + 0.75 $kg/m^3$ ZB) at 1.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | Cm | | | | |
| | | | | | | |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20.00 | 0.20 | 0.02 | 12.00 | 3.96 | 35.76 | 0.11 |
| 40.00 | 0.40 | 0.04 | 16.20 | 5.35 | 35.52 | 0.15 |
| 60.00 | 0.60 | 0.06 | 24.60 | 8.12 | 35.28 | 0.23 |
| 80.00 | 0.80 | 0.08 | 30.00 | 9.90 | 35.04 | 0.28 |
| 100.00 | 1.00 | 0.10 | 32.80 | 10.82 | 34.80 | 0.31 |
| 120.00 | 1.20 | 0.12 | 38.00 | 12.54 | 34.56 | 0.36 |
| 140.00 | 1.40 | 0.14 | 41.00 | 13.53 | 34.32 | 0.39 |
| 160.00 | 1.60 | 0.16 | 43.90 | 14.49 | 34.08 | 0.43 |
| 180.00 | 1.80 | 0.18 | 45.20 | 14.92 | 33.84 | 0.44 |
| 200.00 | 2.00 | 0.20 | 46.20 | 15.25 | 33.60 | 0.45 |
| 220.00 | 2.20 | 0.22 | 47.00 | 15.51 | 33.36 | 0.46 |
| 240.00 | 2.40 | 0.24 | 47.80 | 15.77 | 33.12 | 0.48 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | Cm | | | | |
| 260.00 | 2.60 | 0.26 | 48.60 | 16.04 | 32.88 | 0.49 |
| 280.00 | 2.80 | 0.28 | 49.20 | 16.24 | 32.64 | 0.50 |
| 300.00 | 3.00 | 0.30 | 49.90 | 16.47 | 32.40 | 0.51 |
| 320.00 | 3.20 | 0.32 | 50.40 | 16.63 | 32.16 | 0.52 |
| 340.00 | 3.40 | 0.34 | 51.20 | 16.90 | 31.92 | 0.53 |
| 360.00 | 3.60 | 0.36 | 51.80 | 17.09 | 31.68 | 0.54 |
| 380.00 | 3.80 | 0.38 | 52.40 | 17.29 | 31.44 | 0.55 |
| 400.00 | 4.00 | 0.40 | 53.00 | 17.49 | 31.20 | 0.56 |
| 420.00 | 4.20 | 0.42 | 53.40 | 17.62 | 30.96 | 0.57 |
| 440.00 | 4.40 | 0.44 | 54.00 | 17.82 | 30.72 | 0.58 |
| 460.00 | 4.60 | 0.46 | 54.20 | 17.89 | 30.48 | 0.59 |
| 480.00 | 4.80 | 0.48 | 54.40 | 17.95 | 30.24 | 0.59 |
| 500.00 | 5.00 | 0.50 | 54.80 | 18.08 | 30.00 | 0.60 |
| 520.00 | 5.20 | 0.52 | 55.00 | 18.15 | 29.76 | 0.61 |
| 540.00 | 5.40 | 0.54 | 55.00 | 18.15 | 29.52 | 0.61 |
| 560.00 | 5.60 | 0.56 | 55.20 | 18.22 | 29.28 | 0.62 |
| 580.00 | 5.80 | 0.58 | 55.40 | 18.28 | 29.04 | 0.63 |
| 600.00 | 6.00 | 0.60 | 55.30 | 18.25 | 28.80 | 0.63 |
| 620.00 | 6.20 | 0.62 | 55.40 | 18.28 | 28.56 | 0.64 |
| 640.00 | 6.40 | 0.64 | 55.60 | 18.35 | 28.32 | 0.65 |
| 660.00 | 6.60 | 0.66 | 55.60 | 18.35 | 28.08 | 0.65 |
| 680.00 | 6.80 | 0.68 | 55.80 | 18.41 | 27.84 | 0.66 |
| 700.00 | 7.00 | 0.70 | 55.90 | 18.45 | 27.60 | 0.67 |
| 720.00 | 7.20 | 0.72 | 56.00 | 18.48 | 27.36 | 0.68 |
| 740.00 | 7.40 | 0.74 | 56.00 | 18.48 | 27.12 | 0.68 |
| 760.00 | 7.60 | 0.76 | 55.60 | 18.35 | 26.88 | 0.68 |
| 780.00 | 7.80 | 0.78 | 55.60 | 18.35 | 26.64 | 0.69 |
| 800.00 | 8.00 | 0.80 | 55.40 | 18.28 | 26.40 | 0.69 |
| 820.00 | 8.20 | 0.82 | 55.20 | 18.22 | 26.16 | 0.70 |
| 840.00 | 8.40 | 0.84 | 55.00 | 18.15 | 25.92 | 0.70 |
| 860.00 | 8.60 | 0.86 | 55.00 | 18.15 | 25.68 | 0.71 |
| 880.00 | 8.80 | 0.88 | 55.00 | 18.15 | 25.44 | 0.71 |
| 900.00 | 9.00 | 0.90 | 55.00 | 18.15 | 25.20 | 0.72 |
| 920.00 | 9.20 | 0.92 | 55.00 | 18.15 | 24.96 | 0.73 |
| 940.00 | 9.40 | 0.94 | 54.80 | 18.08 | 24.72 | 0.73 |
| 960.00 | 9.60 | 0.96 | 54.80 | 18.08 | 24.48 | 0.74 |
| 980.00 | 9.80 | 0.98 | 54.63 | 18.03 | 24.24 | 0.74 |
| 1000.00 | 10.00 | 1.00 | 54.40 | 17.95 | 24.00 | 0.75 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | Cm | | | | |
| 1020.00 | 10.20 | 1.02 | 54.00 | 17.82 | 23.76 | 0.75 |
| 1040.00 | 10.40 | 1.04 | 54.10 | 17.85 | 23.52 | 0.76 |
| 1060.00 | 10.60 | 1.06 | 54.00 | 17.82 | 23.28 | 0.77 |
| 1080.00 | 10.80 | 1.08 | 54.13 | 17.86 | 23.04 | 0.78 |
| 1100.00 | 11.00 | 1.10 | 54.03 | 17.83 | 22.80 | 0.78 |
| 1120.00 | 11.20 | 1.12 | 54.03 | 17.83 | 22.56 | 0.79 |
| 1140.00 | 11.40 | 1.14 | 54.03 | 17.83 | 22.32 | 0.80 |
| 1160.00 | 11.60 | 1.16 | 54.03 | 17.83 | 22.08 | 0.81 |
| 1180.00 | 11.80 | 1.18 | 54.03 | 17.83 | 21.84 | 0.82 |
| 1200.00 | 12.00 | 1.20 | 54.03 | 17.83 | 21.60 | 0.83 |
| 1220.00 | 12.20 | 1.22 | 54.03 | 17.83 | 21.36 | 0.83 |

**Table:E7** Direct Shear Test Readings for ( Soil +4 % cement + 1.0 $kg/m^3$ ZB) at 0.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| | | | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 3.00 | 0.99 | 35.76 | 0.03 |
| 40 | 0.4 | 0.04 | 6.40 | 2.11 | 35.52 | 0.06 |
| 60 | 0.6 | 0.06 | 9.80 | 3.23 | 35.28 | 0.09 |
| 80 | 0.8 | 0.08 | 13.20 | 4.36 | 35.04 | 0.12 |
| 100 | 1 | 0.1 | 15.00 | 4.95 | 34.80 | 0.14 |
| 120 | 1.2 | 0.12 | 16.40 | 5.41 | 34.56 | 0.16 |
| 140 | 1.4 | 0.14 | 18.60 | 6.14 | 34.32 | 0.18 |
| 160 | 1.6 | 0.16 | 20.00 | 6.60 | 34.08 | 0.19 |
| 180 | 1.8 | 0.18 | 21.40 | 7.06 | 33.84 | 0.21 |
| 200 | 2 | 0.2 | 22.20 | 7.33 | 33.60 | 0.22 |
| 220 | 2.2 | 0.22 | 22.80 | 7.52 | 33.36 | 0.23 |
| 240 | 2.4 | 0.24 | 23.60 | 7.79 | 33.12 | 0.24 |
| 260 | 2.6 | 0.26 | 24.00 | 7.92 | 32.88 | 0.24 |
| 280 | 2.8 | 0.28 | 24.40 | 8.05 | 32.64 | 0.25 |
| 300 | 3 | 0.3 | 24.80 | 8.18 | 32.40 | 0.25 |
| 320 | 3.2 | 0.32 | 24.90 | 8.22 | 32.16 | 0.26 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 340 | 3.4 | 0.34 | 25.20 | 8.32 | 31.92 | 0.26 |
| 360 | 3.6 | 0.36 | 25.10 | 8.28 | 31.68 | 0.26 |
| 380 | 3.8 | 0.38 | 25.10 | 8.28 | 31.44 | 0.26 |
| 400 | 4 | 0.4 | 25.00 | 8.25 | 31.20 | 0.26 |
| 420 | 4.2 | 0.42 | 24.80 | 8.18 | 30.96 | 0.26 |
| 440 | 4.4 | 0.44 | 24.80 | 8.18 | 30.72 | 0.27 |
| 460 | 4.6 | 0.46 | 24.60 | 8.12 | 30.48 | 0.27 |
| 480 | 4.8 | 0.48 | 24.40 | 8.05 | 30.24 | 0.27 |
| 500 | 5 | 0.5 | 24.20 | 7.99 | 30.00 | 0.27 |
| 520 | 5.2 | 0.52 | 24.20 | 7.99 | 29.76 | 0.27 |
| 540 | 5.4 | 0.54 | 24.00 | 7.92 | 29.52 | 0.27 |
| 560 | 5.6 | 0.56 | 23.80 | 7.85 | 29.28 | 0.27 |
| 580 | 5.8 | 0.58 | 23.80 | 7.85 | 29.04 | 0.27 |
| 600 | 6 | 0.6 | 23.80 | 7.85 | 28.80 | 0.27 |
| 620 | 6.2 | 0.62 | 23.80 | 7.85 | 28.56 | 0.28 |
| 640 | 6.4 | 0.64 | 23.80 | 7.85 | 28.32 | 0.28 |
| 660 | 6.6 | 0.66 | 23.60 | 7.79 | 28.08 | 0.28 |
| 680 | 6.8 | 0.68 | 23.60 | 7.79 | 27.84 | 0.28 |
| 700 | 7 | 0.7 | 23.60 | 7.79 | 27.60 | 0.28 |
| 720 | 7.2 | 0.72 | 23.70 | 7.82 | 27.36 | 0.29 |
| 740 | 7.4 | 0.74 | 23.80 | 7.85 | 27.12 | 0.29 |
| 760 | 7.6 | 0.76 | 23.70 | 7.82 | 26.88 | 0.29 |
| 780 | 7.8 | 0.78 | 23.60 | 7.79 | 26.64 | 0.29 |
| 800 | 8 | 0.8 | 23.60 | 7.79 | 26.40 | 0.30 |
| 820 | 8.2 | 0.82 | 23.60 | 7.79 | 26.16 | 0.30 |
| 840 | 8.4 | 0.84 | 23.60 | 7.79 | 25.92 | 0.30 |
| 860 | 8.6 | 0.86 | 23.60 | 7.79 | 25.68 | 0.30 |
| 880 | 8.8 | 0.88 | 23.50 | 7.76 | 25.44 | 0.30 |
| 900 | 9 | 0.9 | 23.50 | 7.76 | 25.20 | 0.31 |
| 920 | 9.2 | 0.92 | 23.50 | 7.76 | 24.96 | 0.31 |
| 940 | 9.4 | 0.94 | 23.50 | 7.76 | 24.72 | 0.31 |
| 960 | 9.6 | 0.96 | 23.20 | 7.66 | 24.48 | 0.31 |
| 980 | 9.8 | 0.98 | 23.20 | 7.66 | 24.24 | 0.32 |
| 1000 | 10 | 1 | 23.10 | 7.62 | 24.00 | 0.32 |
| 1020 | 10.2 | 1.02 | 23.20 | 7.66 | 23.76 | 0.32 |
| 1040 | 10.4 | 1.04 | 23.20 | 7.66 | 23.52 | 0.33 |
| 1060 | 10.6 | 1.06 | 23.00 | 7.59 | 23.28 | 0.33 |
| 1080 | 10.8 | 1.08 | 23.00 | 7.59 | 23.04 | 0.33 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 1100 | 11 | 1.1 | 23.00 | 7.59 | 22.80 | 0.33 |
| 1120 | 11.2 | 1.12 | 22.80 | 7.52 | 22.56 | 0.33 |
| 1140 | 11.4 | 1.14 | 22.70 | 7.49 | 22.32 | 0.34 |
| 1160 | 11.6 | 1.16 | 22.80 | 7.52 | 22.08 | 0.34 |
| 1180 | 11.8 | 1.18 | 22.60 | 7.46 | 21.84 | 0.34 |
| 1200 | 12 | 1.2 | 22.60 | 7.46 | 21.60 | 0.35 |
| 1220 | 12.2 | 1.22 | 22.60 | 7.46 | 21.36 | 0.35 |

**Table:E8** Direct Shear Test Readings for ( Soil +4 % cement + 1.0 $kg/m^3$ ZB) at 1.0 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 9.80 | 3.23 | 35.76 | 0.09 |
| 40 | 0.4 | 0.04 | 14.00 | 4.62 | 35.52 | 0.13 |
| 60 | 0.6 | 0.06 | 19.20 | 6.34 | 35.28 | 0.18 |
| 80 | 0.8 | 0.08 | 21.40 | 7.06 | 35.04 | 0.20 |
| 100 | 1 | 0.1 | 22.80 | 7.52 | 34.80 | 0.22 |
| 120 | 1.2 | 0.12 | 23.60 | 7.79 | 34.56 | 0.23 |
| 140 | 1.4 | 0.14 | 26.20 | 8.65 | 34.32 | 0.25 |
| 160 | 1.6 | 0.16 | 28.40 | 9.37 | 34.08 | 0.28 |
| 180 | 1.8 | 0.18 | 29.90 | 9.87 | 33.84 | 0.29 |
| 200 | 2 | 0.2 | 31.40 | 10.36 | 33.60 | 0.31 |
| 220 | 2.2 | 0.22 | 32.80 | 10.82 | 33.36 | 0.32 |
| 240 | 2.4 | 0.24 | 34.20 | 11.29 | 33.12 | 0.34 |
| 260 | 2.6 | 0.26 | 35.40 | 11.68 | 32.88 | 0.36 |
| 280 | 2.8 | 0.28 | 36.60 | 12.08 | 32.64 | 0.37 |
| 300 | 3 | 0.3 | 37.20 | 12.28 | 32.40 | 0.38 |
| 320 | 3.2 | 0.32 | 38.00 | 12.54 | 32.16 | 0.39 |
| 340 | 3.4 | 0.34 | 39.00 | 12.87 | 31.92 | 0.40 |
| 360 | 3.6 | 0.36 | 39.80 | 13.13 | 31.68 | 0.41 |
| 380 | 3.8 | 0.38 | 40.80 | 13.46 | 31.44 | 0.43 |
| 400 | 4 | 0.4 | 41.20 | 13.60 | 31.20 | 0.44 |
| 420 | 4.2 | 0.42 | 41.80 | 13.79 | 30.96 | 0.45 |
| 440 | 4.4 | 0.44 | 42.00 | 13.86 | 30.72 | 0.45 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 460 | 4.6 | 0.46 | 42.40 | 13.99 | 30.48 | 0.46 |
| 480 | 4.8 | 0.48 | 42.80 | 14.12 | 30.24 | 0.47 |
| 500 | 5 | 0.5 | 43.00 | 14.19 | 30.00 | 0.47 |
| 520 | 5.2 | 0.52 | 43.40 | 14.32 | 29.76 | 0.48 |
| 540 | 5.4 | 0.54 | 43.40 | 14.32 | 29.52 | 0.49 |
| 560 | 5.6 | 0.56 | 43.40 | 14.32 | 29.28 | 0.49 |
| 580 | 5.8 | 0.58 | 43.20 | 14.26 | 29.04 | 0.49 |
| 600 | 6 | 0.6 | 43.00 | 14.19 | 28.80 | 0.49 |
| 620 | 6.2 | 0.62 | 42.80 | 14.12 | 28.56 | 0.49 |
| 640 | 6.4 | 0.64 | 42.60 | 14.06 | 28.32 | 0.50 |
| 660 | 6.6 | 0.66 | 42.60 | 14.06 | 28.08 | 0.50 |
| 680 | 6.8 | 0.68 | 42.60 | 14.06 | 27.84 | 0.50 |
| 700 | 7 | 0.7 | 42.40 | 13.99 | 27.60 | 0.51 |
| 720 | 7.2 | 0.72 | 42.20 | 13.93 | 27.36 | 0.51 |
| 740 | 7.4 | 0.74 | 42.00 | 13.86 | 27.12 | 0.51 |
| 760 | 7.6 | 0.76 | 41.80 | 13.79 | 26.88 | 0.51 |
| 780 | 7.8 | 0.78 | 41.80 | 13.79 | 26.64 | 0.52 |
| 800 | 8 | 0.8 | 41.60 | 13.73 | 26.40 | 0.52 |
| 820 | 8.2 | 0.82 | 41.60 | 13.73 | 26.16 | 0.52 |
| 840 | 8.4 | 0.84 | 41.40 | 13.66 | 25.92 | 0.53 |
| 860 | 8.6 | 0.86 | 41.20 | 13.60 | 25.68 | 0.53 |
| 880 | 8.8 | 0.88 | 41.10 | 13.56 | 25.44 | 0.53 |
| 900 | 9 | 0.9 | 41.14 | 13.58 | 25.20 | 0.54 |
| 920 | 9.2 | 0.92 | 41.00 | 13.53 | 24.96 | 0.54 |
| 940 | 9.4 | 0.94 | 41.10 | 13.56 | 24.72 | 0.55 |
| 960 | 9.6 | 0.96 | 41.00 | 13.53 | 24.48 | 0.55 |
| 980 | 9.8 | 0.98 | 40.80 | 13.46 | 24.24 | 0.56 |
| 1000 | 10 | 1 | 40.80 | 13.46 | 24.00 | 0.56 |
| 1020 | 10.2 | 1.02 | 40.80 | 13.46 | 23.76 | 0.57 |
| 1040 | 10.4 | 1.04 | 40.90 | 13.50 | 23.52 | 0.57 |
| 1060 | 10.6 | 1.06 | 40.60 | 13.40 | 23.28 | 0.58 |
| 1080 | 10.8 | 1.08 | 40.60 | 13.40 | 23.04 | 0.58 |
| 1100 | 11 | 1.1 | 40.20 | 13.27 | 22.80 | 0.58 |
| 1120 | 11.2 | 1.12 | 40.40 | 13.33 | 22.56 | 0.59 |
| 1140 | 11.4 | 1.14 | 40.20 | 13.27 | 22.32 | 0.59 |
| 1160 | 11.6 | 1.16 | 40.20 | 13.27 | 22.08 | 0.60 |
| 1180 | 11.8 | 1.18 | 40.30 | 13.30 | 21.84 | 0.61 |
| 1200 | 12 | 1.2 | 40.20 | 13.27 | 21.60 | 0.61 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 1220 | 12.2 | 1.22 | 40.00 | 13.20 | 21.36 | 0.62 |

**Table:E9** Direct Shear Test Readings for ( Soil +4 % cement + 1.0 $kg/m^3$ ZB) at 1.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 13.20 | 4.36 | 35.76 | 0.12 |
| 40 | 0.4 | 0.04 | 19.20 | 6.34 | 35.52 | 0.18 |
| 60 | 0.6 | 0.06 | 26.20 | 8.65 | 35.28 | 0.25 |
| 80 | 0.8 | 0.08 | 33.60 | 11.09 | 35.04 | 0.32 |
| 100 | 1 | 0.1 | 38.00 | 12.54 | 34.80 | 0.36 |
| 120 | 1.2 | 0.12 | 42.00 | 13.86 | 34.56 | 0.40 |
| 140 | 1.4 | 0.14 | 46.40 | 15.31 | 34.32 | 0.45 |
| 160 | 1.6 | 0.16 | 49.60 | 16.37 | 34.08 | 0.48 |
| 180 | 1.8 | 0.18 | 51.80 | 17.09 | 33.84 | 0.51 |
| 200 | 2 | 0.2 | 53.20 | 17.56 | 33.60 | 0.52 |
| 220 | 2.2 | 0.22 | 55.20 | 18.22 | 33.36 | 0.55 |
| 240 | 2.4 | 0.24 | 56.00 | 18.48 | 33.12 | 0.56 |
| 260 | 2.6 | 0.26 | 57.20 | 18.88 | 32.88 | 0.57 |
| 280 | 2.8 | 0.28 | 59.00 | 19.47 | 32.64 | 0.60 |
| 300 | 3 | 0.3 | 60.00 | 19.80 | 32.40 | 0.61 |
| 320 | 3.2 | 0.32 | 60.40 | 19.93 | 32.16 | 0.62 |
| 340 | 3.4 | 0.34 | 61.00 | 20.13 | 31.92 | 0.63 |
| 360 | 3.6 | 0.36 | 61.80 | 20.39 | 31.68 | 0.64 |
| 380 | 3.8 | 0.38 | 62.40 | 20.59 | 31.44 | 0.65 |
| 400 | 4 | 0.4 | 62.80 | 20.72 | 31.20 | 0.66 |
| 420 | 4.2 | 0.42 | 63.40 | 20.92 | 30.96 | 0.68 |
| 440 | 4.4 | 0.44 | 63.40 | 20.92 | 30.72 | 0.68 |
| 460 | 4.6 | 0.46 | 64.00 | 21.12 | 30.48 | 0.69 |
| 480 | 4.8 | 0.48 | 64.20 | 21.19 | 30.24 | 0.70 |
| 500 | 5 | 0.5 | 64.40 | 21.25 | 30.00 | 0.71 |
| 520 | 5.2 | 0.52 | 64.20 | 21.19 | 29.76 | 0.71 |
| 540 | 5.4 | 0.54 | 64.00 | 21.12 | 29.52 | 0.72 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 560 | 5.6 | 0.56 | 63.80 | 21.05 | 29.28 | 0.72 |
| 580 | 5.8 | 0.58 | 63.60 | 20.99 | 29.04 | 0.72 |
| 600 | 6 | 0.6 | 63.20 | 20.86 | 28.80 | 0.72 |
| 620 | 6.2 | 0.62 | 62.80 | 20.72 | 28.56 | 0.73 |
| 640 | 6.4 | 0.64 | 62.40 | 20.59 | 28.32 | 0.73 |
| 660 | 6.6 | 0.66 | 62.20 | 20.53 | 28.08 | 0.73 |
| 680 | 6.8 | 0.68 | 62.00 | 20.46 | 27.84 | 0.73 |
| 700 | 7 | 0.7 | 61.80 | 20.39 | 27.60 | 0.74 |
| 720 | 7.2 | 0.72 | 61.40 | 20.26 | 27.36 | 0.74 |
| 740 | 7.4 | 0.74 | 61.20 | 20.20 | 27.12 | 0.74 |
| 760 | 7.6 | 0.76 | 61.20 | 20.20 | 26.88 | 0.75 |
| 780 | 7.6 | 0.78 | 61.00 | 20.13 | 26.64 | 0.76 |
| 800 | 7.6 | 0.8 | 60.80 | 20.06 | 26.40 | 0.76 |
| 820 | 7.6 | 0.82 | 60.80 | 20.06 | 26.16 | 0.77 |
| 840 | 7.6 | 0.84 | 60.80 | 20.06 | 25.92 | 0.77 |
| 860 | 7.6 | 0.86 | 60.70 | 20.03 | 25.68 | 0.78 |
| 880 | 7.6 | 0.88 | 60.70 | 20.03 | 25.44 | 0.79 |
| 900 | 7.6 | 0.9 | 60.60 | 20.00 | 25.20 | 0.79 |
| 920 | 7.6 | 0.92 | 60.60 | 20.00 | 24.96 | 0.80 |
| 940 | 7.6 | 0.94 | 60.40 | 19.93 | 24.72 | 0.81 |
| 960 | 7.6 | 0.96 | 60.50 | 19.97 | 24.48 | 0.82 |
| 980 | 7.6 | 0.98 | 60.40 | 19.93 | 24.24 | 0.82 |
| 1000 | 7.6 | 1 | 60.40 | 19.93 | 24.00 | 0.83 |
| 1020 | 7.6 | 1.02 | 60.60 | 20.00 | 23.76 | 0.84 |
| 1040 | 7.6 | 1.04 | 60.40 | 19.93 | 23.52 | 0.85 |
| 1060 | 7.6 | 1.06 | 60.40 | 19.93 | 23.28 | 0.86 |
| 1080 | 7.6 | 1.08 | 60.30 | 19.90 | 23.04 | 0.86 |
| 1100 | 7.6 | 1.1 | 60.20 | 19.87 | 22.80 | 0.87 |
| 1120 | 7.6 | 1.12 | 60.20 | 19.87 | 22.56 | 0.88 |
| 1140 | 7.6 | 1.14 | 60.20 | 19.87 | 22.32 | 0.89 |
| 1160 | 7.6 | 1.16 | 60.10 | 19.83 | 22.08 | 0.90 |
| 1180 | 7.6 | 1.18 | 60.00 | 19.80 | 21.84 | 0.91 |
| 1200 | 7.6 | 1.2 | 60.00 | 19.80 | 21.60 | 0.92 |
| 1220 | 7.6 | 1.22 | 59.80 | 19.73 | 21.36 | 0.92 |

**Table: E10** Direct Shear Test Readings for ( Soil +4 % cement + 1.25 kg/$m^3$ ZB) at 0.5 kg/$cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| | | | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 3.80 | 1.25 | 35.76 | 0.04 |
| 40 | 0.4 | 0.04 | 9.40 | 3.10 | 35.52 | 0.09 |
| 60 | 0.6 | 0.06 | 12.20 | 4.03 | 35.28 | 0.11 |
| 80 | 0.8 | 0.08 | 15.00 | 4.95 | 35.04 | 0.14 |
| 100 | 1 | 0.1 | 17.40 | 5.74 | 34.80 | 0.17 |
| 120 | 1.2 | 0.12 | 18.80 | 6.20 | 34.56 | 0.18 |
| 140 | 1.4 | 0.14 | 20.20 | 6.67 | 34.32 | 0.19 |
| 160 | 1.6 | 0.16 | 21.20 | 7.00 | 34.08 | 0.21 |
| 180 | 1.8 | 0.18 | 22.00 | 7.26 | 33.84 | 0.21 |
| 200 | 2 | 0.2 | 22.60 | 7.46 | 33.60 | 0.22 |
| 220 | 2.2 | 0.22 | 23.20 | 7.66 | 33.36 | 0.23 |
| 240 | 2.4 | 0.24 | 23.80 | 7.85 | 33.12 | 0.24 |
| 260 | 2.6 | 0.26 | 24.20 | 7.99 | 32.88 | 0.24 |
| 280 | 2.8 | 0.28 | 24.40 | 8.05 | 32.64 | 0.25 |
| 300 | 3 | 0.3 | 25.00 | 8.25 | 32.40 | 0.25 |
| 320 | 3.2 | 0.32 | 25.20 | 8.32 | 32.16 | 0.26 |
| 340 | 3.4 | 0.34 | 25.30 | 8.35 | 31.92 | 0.26 |
| 360 | 3.6 | 0.36 | 25.60 | 8.45 | 31.68 | 0.27 |
| 380 | 3.8 | 0.38 | 25.70 | 8.48 | 31.44 | 0.27 |
| 400 | 4 | 0.4 | 25.80 | 8.51 | 31.20 | 0.27 |
| 420 | 4.2 | 0.42 | 25.80 | 8.51 | 30.96 | 0.28 |
| 440 | 4.4 | 0.44 | 25.80 | 8.51 | 30.72 | 0.28 |
| 460 | 4.6 | 0.46 | 25.70 | 8.48 | 30.48 | 0.28 |
| 480 | 4.8 | 0.48 | 25.60 | 8.45 | 30.24 | 0.28 |
| 500 | 5 | 0.5 | 25.60 | 8.45 | 30.00 | 0.28 |
| 520 | 5.2 | 0.52 | 25.60 | 8.45 | 29.76 | 0.28 |
| 540 | 5.4 | 0.54 | 25.60 | 8.45 | 29.52 | 0.29 |
| 560 | 5.6 | 0.56 | 25.40 | 8.38 | 29.28 | 0.29 |
| 580 | 5.8 | 0.58 | 25.30 | 8.35 | 29.04 | 0.29 |
| 600 | 6 | 0.6 | 25.20 | 8.32 | 28.80 | 0.29 |
| 620 | 6.2 | 0.62 | 25.20 | 8.32 | 28.56 | 0.29 |
| 640 | 6.4 | 0.64 | 25.00 | 8.25 | 28.32 | 0.29 |
| 660 | 6.6 | 0.66 | 25.00 | 8.25 | 28.08 | 0.29 |
| 680 | 6.8 | 0.68 | 25.00 | 8.25 | 27.84 | 0.30 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 700 | 7 | 0.7 | 24.80 | 8.18 | 27.60 | 0.30 |
| 720 | 7.2 | 0.72 | 24.80 | 8.18 | 27.36 | 0.30 |
| 740 | 7.4 | 0.74 | 24.80 | 8.18 | 27.12 | 0.30 |
| 760 | 7.6 | 0.76 | 24.60 | 8.12 | 26.88 | 0.30 |
| 780 | 7.8 | 0.78 | 24.50 | 8.09 | 26.64 | 0.30 |
| 800 | 8 | 0.8 | 24.60 | 8.12 | 26.40 | 0.31 |
| 820 | 8.2 | 0.82 | 24.50 | 8.09 | 26.16 | 0.31 |
| 840 | 8.4 | 0.84 | 24.40 | 8.05 | 25.92 | 0.31 |
| 860 | 8.6 | 0.86 | 24.30 | 8.02 | 25.68 | 0.31 |
| 880 | 8.8 | 0.88 | 24.20 | 7.99 | 25.44 | 0.31 |
| 900 | 9 | 0.9 | 24.20 | 7.99 | 25.20 | 0.32 |
| 920 | 9.2 | 0.92 | 24.20 | 7.99 | 24.96 | 0.32 |
| 940 | 9.4 | 0.94 | 24.10 | 7.95 | 24.72 | 0.32 |
| 960 | 9.6 | 0.96 | 24.00 | 7.92 | 24.48 | 0.32 |
| 980 | 9.8 | 0.98 | 24.00 | 7.92 | 24.24 | 0.33 |
| 1000 | 10 | 1 | 24.00 | 7.92 | 24.00 | 0.33 |
| 1020 | 10.2 | 1.02 | 23.60 | 7.79 | 23.76 | 0.33 |
| 1040 | 10.4 | 1.04 | 23.70 | 7.82 | 23.52 | 0.33 |
| 1060 | 10.6 | 1.06 | 23.50 | 7.76 | 23.28 | 0.33 |
| 1080 | 10.8 | 1.08 | 23.40 | 7.72 | 23.04 | 0.34 |
| 1100 | 11 | 1.1 | 23.40 | 7.72 | 22.80 | 0.34 |
| 1120 | 11.2 | 1.12 | 23.30 | 7.69 | 22.56 | 0.34 |
| 1140 | 11.4 | 1.14 | 23.20 | 7.66 | 22.32 | 0.34 |
| 1160 | 11.6 | 1.16 | 23.00 | 7.59 | 22.08 | 0.34 |
| 1180 | 11.8 | 1.18 | 22.80 | 7.52 | 21.84 | 0.34 |
| 1200 | 12 | 1.2 | 22.40 | 7.39 | 21.60 | 0.34 |
| 1220 | 12.2 | 1.22 | 22.40 | 7.39 | 21.36 | 0.35 |
| 1240 | 12.4 | 1.24 | 22.40 | 7.39 | 21.12 | 0.35 |

**Table:E11** Direct Shear Test Readings for ( Soil +4 % cement + 1.25 $kg/m^3$ ZB) at 1.0 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 20 | 0.2 | 0.02 | 10.00 | 3.30 | 35.76 | 0.09 |
| 40 | 0.4 | 0.04 | 16.20 | 5.35 | 35.52 | 0.15 |
| 60 | 0.6 | 0.06 | 21.20 | 7.00 | 35.28 | 0.20 |
| 80 | 0.8 | 0.08 | 28.20 | 9.31 | 35.04 | 0.27 |
| 100 | 1 | 0.1 | 31.60 | 10.43 | 34.80 | 0.30 |
| 120 | 1.2 | 0.12 | 34.00 | 11.22 | 34.56 | 0.32 |
| 140 | 1.4 | 0.14 | 35.40 | 11.68 | 34.32 | 0.34 |
| 160 | 1.6 | 0.16 | 37.00 | 12.21 | 34.08 | 0.36 |
| 180 | 1.8 | 0.18 | 38.00 | 12.54 | 33.84 | 0.37 |
| 200 | 2 | 0.2 | 39.00 | 12.87 | 33.60 | 0.38 |
| 220 | 2.2 | 0.22 | 40.00 | 13.20 | 33.36 | 0.40 |
| 240 | 2.4 | 0.24 | 40.80 | 13.46 | 33.12 | 0.41 |
| 260 | 2.6 | 0.26 | 41.80 | 13.79 | 32.88 | 0.42 |
| 280 | 2.8 | 0.28 | 42.20 | 13.93 | 32.64 | 0.43 |
| 300 | 3 | 0.3 | 43.40 | 14.32 | 32.40 | 0.44 |
| 320 | 3.2 | 0.32 | 44.20 | 14.59 | 32.16 | 0.45 |
| 340 | 3.4 | 0.34 | 44.20 | 14.59 | 31.92 | 0.46 |
| 360 | 3.6 | 0.36 | 45.00 | 14.85 | 31.68 | 0.47 |
| 380 | 3.8 | 0.38 | 45.40 | 14.98 | 31.44 | 0.48 |
| 400 | 4 | 0.4 | 45.80 | 15.11 | 31.20 | 0.48 |
| 420 | 4.2 | 0.42 | 46.20 | 15.25 | 30.96 | 0.49 |
| 440 | 4.4 | 0.44 | 46.80 | 15.44 | 30.72 | 0.50 |
| 460 | 4.6 | 0.46 | 47.00 | 15.51 | 30.48 | 0.51 |
| 480 | 4.8 | 0.48 | 47.20 | 15.58 | 30.24 | 0.52 |
| 500 | 5 | 0.5 | 47.20 | 15.58 | 30.00 | 0.52 |
| 520 | 5.2 | 0.52 | 47.20 | 15.58 | 29.76 | 0.52 |
| 540 | 5.4 | 0.54 | 47.10 | 15.54 | 29.52 | 0.53 |
| 560 | 5.6 | 0.56 | 47.00 | 15.51 | 29.28 | 0.53 |
| 580 | 5.8 | 0.58 | 46.80 | 15.44 | 29.04 | 0.53 |
| 600 | 6 | 0.6 | 46.60 | 15.38 | 28.80 | 0.53 |
| 620 | 6.2 | 0.62 | 46.20 | 15.25 | 28.56 | 0.53 |
| 640 | 6.4 | 0.64 | 46.00 | 15.18 | 28.32 | 0.54 |
| 660 | 6.6 | 0.66 | 45.80 | 15.11 | 28.08 | 0.54 |
| 680 | 6.8 | 0.68 | 45.60 | 15.05 | 27.84 | 0.54 |
| 700 | 7 | 0.7 | 45.20 | 14.92 | 27.60 | 0.54 |
| 720 | 7.2 | 0.72 | 45.00 | 14.85 | 27.36 | 0.54 |
| 740 | 7.4 | 0.74 | 45.00 | 14.85 | 27.12 | 0.55 |
| 760 | 7.6 | 0.76 | 45.00 | 14.85 | 26.88 | 0.55 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 780 | 7.8 | 0.78 | 45.00 | 14.85 | 26.64 | 0.56 |
| 800 | 8 | 0.8 | 45.00 | 14.85 | 26.40 | 0.56 |
| 820 | 8.2 | 0.82 | 45.00 | 14.85 | 26.16 | 0.57 |
| 840 | 8.4 | 0.84 | 44.60 | 14.72 | 25.92 | 0.57 |
| 860 | 8.6 | 0.86 | 44.60 | 14.72 | 25.68 | 0.57 |
| 880 | 8.8 | 0.88 | 44.20 | 14.59 | 25.44 | 0.57 |
| 900 | 9 | 0.9 | 44.00 | 14.52 | 25.20 | 0.58 |
| 920 | 9.2 | 0.92 | 44.00 | 14.52 | 24.96 | 0.58 |
| 940 | 9.4 | 0.94 | 43.80 | 14.45 | 24.72 | 0.58 |
| 960 | 9.6 | 0.96 | 43.40 | 14.32 | 24.48 | 0.59 |
| 980 | 9.8 | 0.98 | 43.10 | 14.22 | 24.24 | 0.59 |
| 1000 | 10 | 1 | 43.00 | 14.19 | 24.00 | 0.59 |
| 1020 | 10.2 | 1.02 | 42.80 | 14.12 | 23.76 | 0.59 |
| 1040 | 10.4 | 1.04 | 42.60 | 14.06 | 23.52 | 0.60 |
| 1060 | 10.6 | 1.06 | 42.30 | 13.96 | 23.28 | 0.60 |
| 1080 | 10.8 | 1.08 | 42.00 | 13.86 | 23.04 | 0.60 |
| 1100 | 11 | 1.1 | 41.80 | 13.79 | 22.80 | 0.61 |
| 1120 | 11.2 | 1.12 | 41.80 | 13.79 | 22.56 | 0.61 |
| 1140 | 11.4 | 1.14 | 41.00 | 13.53 | 22.32 | 0.61 |
| 1160 | 11.6 | 1.16 | 41.00 | 13.53 | 22.08 | 0.61 |
| 1180 | 11.8 | 1.18 | 41.00 | 13.53 | 21.84 | 0.62 |
| 1200 | 12 | 1.2 | 41.10 | 13.56 | 21.60 | 0.63 |
| 1220 | 12.2 | 1.22 | 40.80 | 13.46 | 21.36 | 0.63 |

**Table:E12** Direct Shear Test Readings for ( Soil +4 % cement + 1.25 $kg/m^3$ ZB) at 1.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| | | | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 12.00 | 3.96 | 35.76 | 0.11 |
| 40 | 0.4 | 0.04 | 24.50 | 8.09 | 35.52 | 0.23 |
| 60 | 0.6 | 0.06 | 32.40 | 10.69 | 35.28 | 0.30 |
| 80 | 0.8 | 0.08 | 41.00 | 13.53 | 35.04 | 0.39 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 100 | 1 | 0.1 | 45.60 | 15.05 | 34.80 | 0.43 |
| 120 | 1.2 | 0.12 | 48.20 | 15.91 | 34.56 | 0.46 |
| 140 | 1.4 | 0.14 | 50.00 | 16.50 | 34.32 | 0.48 |
| 160 | 1.6 | 0.16 | 52.30 | 17.26 | 34.08 | 0.51 |
| 180 | 1.8 | 0.18 | 54.00 | 17.82 | 33.84 | 0.53 |
| 200 | 2 | 0.2 | 55.00 | 18.15 | 33.60 | 0.54 |
| 220 | 2.2 | 0.22 | 56.40 | 18.61 | 33.36 | 0.56 |
| 240 | 2.4 | 0.24 | 57.40 | 18.94 | 33.12 | 0.57 |
| 260 | 2.6 | 0.26 | 58.50 | 19.31 | 32.88 | 0.59 |
| 280 | 2.8 | 0.28 | 59.00 | 19.47 | 32.64 | 0.60 |
| 300 | 3 | 0.3 | 59.80 | 19.73 | 32.40 | 0.61 |
| 320 | 3.2 | 0.32 | 60.60 | 20.00 | 32.16 | 0.62 |
| 340 | 3.4 | 0.34 | 61.20 | 20.20 | 31.92 | 0.63 |
| 360 | 3.6 | 0.36 | 61.80 | 20.39 | 31.68 | 0.64 |
| 380 | 3.8 | 0.38 | 62.20 | 20.53 | 31.44 | 0.65 |
| 400 | 4 | 0.4 | 62.60 | 20.66 | 31.20 | 0.66 |
| 420 | 4.2 | 0.42 | 63.00 | 20.79 | 30.96 | 0.67 |
| 440 | 4.4 | 0.44 | 63.40 | 20.92 | 30.72 | 0.68 |
| 460 | 4.6 | 0.46 | 63.60 | 20.99 | 30.48 | 0.69 |
| 480 | 4.8 | 0.48 | 63.80 | 21.05 | 30.24 | 0.70 |
| 500 | 5 | 0.5 | 63.90 | 21.09 | 30.00 | 0.70 |
| 520 | 5.2 | 0.52 | 64.00 | 21.12 | 29.76 | 0.71 |
| 540 | 5.4 | 0.54 | 64.00 | 21.12 | 29.52 | 0.72 |
| 560 | 5.6 | 0.56 | 63.80 | 21.05 | 29.28 | 0.72 |
| 580 | 5.8 | 0.58 | 63.80 | 21.05 | 29.04 | 0.73 |
| 600 | 6 | 0.6 | 63.80 | 21.05 | 28.80 | 0.73 |
| 620 | 6.2 | 0.62 | 63.80 | 21.05 | 28.56 | 0.74 |
| 640 | 6.4 | 0.64 | 63.60 | 20.99 | 28.32 | 0.74 |
| 660 | 6.6 | 0.66 | 63.60 | 20.99 | 28.08 | 0.75 |
| 680 | 6.8 | 0.68 | 63.40 | 20.92 | 27.84 | 0.75 |
| 700 | 7 | 0.7 | 63.20 | 20.86 | 27.60 | 0.76 |
| 720 | 7.2 | 0.72 | 63.00 | 20.79 | 27.36 | 0.76 |
| 740 | 7.4 | 0.74 | 62.80 | 20.72 | 27.12 | 0.76 |
| 760 | 7.6 | 0.76 | 62.80 | 20.72 | 26.88 | 0.77 |
| 780 | 7.8 | 0.78 | 62.60 | 20.66 | 26.64 | 0.78 |
| 800 | 8 | 0.8 | 62.50 | 20.63 | 26.40 | 0.78 |
| 820 | 8.2 | 0.82 | 62.60 | 20.66 | 26.16 | 0.79 |
| 840 | 8.4 | 0.84 | 62.40 | 20.59 | 25.92 | 0.79 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 860 | 8.6 | 0.86 | 62.40 | 20.59 | 25.68 | 0.80 |
| 880 | 8.8 | 0.88 | 62.20 | 20.53 | 25.44 | 0.81 |
| 900 | 9 | 0.9 | 62.20 | 20.53 | 25.20 | 0.81 |
| 920 | 9.2 | 0.92 | 62.00 | 20.46 | 24.96 | 0.82 |
| 940 | 9.4 | 0.94 | 62.00 | 20.46 | 24.72 | 0.83 |
| 960 | 9.6 | 0.96 | 62.10 | 20.49 | 24.48 | 0.84 |
| 980 | 9.8 | 0.98 | 62.20 | 20.53 | 24.24 | 0.85 |
| 1000 | 10 | 1 | 62.20 | 20.53 | 24.00 | 0.86 |
| 1020 | 10.2 | 1.02 | 62.20 | 20.53 | 23.76 | 0.86 |
| 1040 | 10.4 | 1.04 | 62.00 | 20.46 | 23.52 | 0.87 |
| 1060 | 10.6 | 1.06 | 62.00 | 20.46 | 23.28 | 0.88 |
| 1080 | 10.8 | 1.08 | 62.10 | 20.49 | 23.04 | 0.89 |
| 1100 | 11 | 1.1 | 61.60 | 20.33 | 22.80 | 0.89 |
| 1120 | 11.2 | 1.12 | 62.00 | 20.46 | 22.56 | 0.91 |
| 1140 | 11.4 | 1.14 | 61.80 | 20.39 | 22.32 | 0.91 |
| 1160 | 11.6 | 1.16 | 61.80 | 20.39 | 22.08 | 0.92 |
| 1180 | 11.8 | 1.18 | 61.80 | 20.39 | 21.84 | 0.93 |
| 1200 | 12 | 1.2 | 61.80 | 20.39 | 21.60 | 0.94 |
| 1220 | 12.2 | 1.22 | 61.80 | 20.39 | 21.36 | 0.95 |
| 1240 | 12.4 | 1.24 | 61.80 | 20.39 | 21.12 | 0.97 |

**Table:E13** Direct Shear Test Readings for ( Soil +4 % cement + 1.5 $kg/m^3$ ZB) at 0.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| | | | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 9.20 | 3.04 | 35.76 | 0.08 |
| 40 | 0.4 | 0.04 | 12.20 | 4.03 | 35.52 | 0.11 |
| 60 | 0.6 | 0.06 | 14.80 | 4.88 | 35.28 | 0.14 |
| 80 | 0.8 | 0.08 | 14.80 | 4.88 | 35.04 | 0.14 |
| 100 | 1 | 0.1 | 16.80 | 5.54 | 34.80 | 0.16 |
| 120 | 1.2 | 0.12 | 18.20 | 6.01 | 34.56 | 0.17 |
| 140 | 1.4 | 0.14 | 19.20 | 6.34 | 34.32 | 0.18 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 160 | 1.6 | 0.16 | 20.40 | 6.73 | 34.08 | 0.20 |
| 180 | 1.8 | 0.18 | 20.80 | 6.86 | 33.84 | 0.20 |
| 200 | 2 | 0.2 | 21.20 | 7.00 | 33.60 | 0.21 |
| 220 | 2.2 | 0.22 | 21.80 | 7.19 | 33.36 | 0.22 |
| 240 | 2.4 | 0.24 | 21.80 | 7.19 | 33.12 | 0.22 |
| 260 | 2.6 | 0.26 | 22.00 | 7.26 | 32.88 | 0.22 |
| 280 | 2.8 | 0.28 | 22.40 | 7.39 | 32.64 | 0.23 |
| 300 | 3 | 0.3 | 22.80 | 7.52 | 32.40 | 0.23 |
| 320 | 3.2 | 0.32 | 23.00 | 7.59 | 32.16 | 0.24 |
| 340 | 3.4 | 0.34 | 23.40 | 7.72 | 31.92 | 0.24 |
| 360 | 3.6 | 0.36 | 23.80 | 7.85 | 31.68 | 0.25 |
| 380 | 3.8 | 0.38 | 24.20 | 7.99 | 31.44 | 0.25 |
| 400 | 4 | 0.4 | 24.60 | 8.12 | 31.20 | 0.26 |
| 420 | 4.2 | 0.42 | 24.80 | 8.18 | 30.96 | 0.26 |
| 440 | 4.4 | 0.44 | 25.00 | 8.25 | 30.72 | 0.27 |
| 460 | 4.6 | 0.46 | 25.20 | 8.32 | 30.48 | 0.27 |
| 480 | 4.8 | 0.48 | 25.40 | 8.38 | 30.24 | 0.28 |
| 500 | 5 | 0.5 | 25.40 | 8.38 | 30.00 | 0.28 |
| 520 | 5.2 | 0.52 | 25.30 | 8.35 | 29.76 | 0.28 |
| 540 | 5.4 | 0.54 | 25.20 | 8.32 | 29.52 | 0.28 |
| 560 | 5.6 | 0.56 | 24.80 | 8.18 | 29.28 | 0.28 |
| 580 | 5.8 | 0.58 | 24.60 | 8.12 | 29.04 | 0.28 |
| 600 | 6 | 0.6 | 24.40 | 8.05 | 28.80 | 0.28 |
| 620 | 6.2 | 0.62 | 24.20 | 7.99 | 28.56 | 0.28 |
| 640 | 6.4 | 0.64 | 24.20 | 7.99 | 28.32 | 0.28 |
| 660 | 6.6 | 0.66 | 24.00 | 7.92 | 28.08 | 0.28 |
| 680 | 6.8 | 0.68 | 23.80 | 7.85 | 27.84 | 0.28 |
| 700 | 7 | 0.7 | 23.80 | 7.85 | 27.60 | 0.28 |
| 720 | 7.2 | 0.72 | 23.80 | 7.85 | 27.36 | 0.29 |
| 740 | 7.4 | 0.74 | 23.80 | 7.85 | 27.12 | 0.29 |
| 760 | 7.6 | 0.76 | 23.80 | 7.85 | 26.88 | 0.29 |
| 780 | 7.8 | 0.78 | 23.60 | 7.79 | 26.64 | 0.29 |
| 800 | 8 | 0.8 | 23.60 | 7.79 | 26.40 | 0.30 |
| 820 | 8.2 | 0.82 | 23.50 | 7.76 | 26.16 | 0.30 |
| 840 | 8.4 | 0.84 | 23.40 | 7.72 | 25.92 | 0.30 |
| 860 | 8.6 | 0.86 | 23.40 | 7.72 | 25.68 | 0.30 |
| 880 | 8.8 | 0.88 | 23.20 | 7.66 | 25.44 | 0.30 |
| 900 | 9 | 0.9 | 23.30 | 7.69 | 25.20 | 0.31 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 920 | 9.2 | 0.92 | 23.20 | 7.66 | 24.96 | 0.31 |
| 940 | 9.4 | 0.94 | 23.20 | 7.66 | 24.72 | 0.31 |
| 960 | 9.6 | 0.96 | 23.00 | 7.59 | 24.48 | 0.31 |
| 980 | 9.8 | 0.98 | 22.80 | 7.52 | 24.24 | 0.31 |
| 1000 | 10 | 1 | 22.60 | 7.46 | 24.00 | 0.31 |
| 1020 | 10.2 | 1.02 | 22.40 | 7.39 | 23.76 | 0.31 |
| 1040 | 10.4 | 1.04 | 22.20 | 7.33 | 23.52 | 0.31 |
| 1060 | 10.6 | 1.06 | 22.00 | 7.26 | 23.28 | 0.31 |
| 1080 | 10.8 | 1.08 | 21.80 | 7.19 | 23.04 | 0.31 |
| 1100 | 11 | 1.1 | 21.60 | 7.13 | 22.80 | 0.31 |
| 1120 | 11.2 | 1.12 | 21.40 | 7.06 | 22.56 | 0.31 |
| 1140 | 11.4 | 1.14 | 21.20 | 7.00 | 22.32 | 0.31 |
| 1160 | 11.6 | 1.16 | 21.00 | 6.93 | 22.08 | 0.31 |
| 1180 | 11.8 | 1.18 | 20.80 | 6.86 | 21.84 | 0.31 |
| 1200 | 12 | 1.2 | 20.60 | 6.80 | 21.60 | 0.31 |
| 1220 | 12.2 | 1.22 | 20.40 | 6.73 | 21.36 | 0.32 |

**Table:E14** Direct Shear Test Readings for ( Soil +4 % cement + 1.5 $kg/m^3$ ZB) at 1.0 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 11.00 | 3.63 | 35.76 | 0.10 |
| 40 | 0.4 | 0.04 | 14.60 | 4.82 | 35.52 | 0.14 |
| 60 | 0.6 | 0.06 | 19.20 | 6.34 | 35.28 | 0.18 |
| 80 | 0.8 | 0.08 | 24.60 | 8.12 | 35.04 | 0.23 |
| 100 | 1 | 0.1 | 28.00 | 9.24 | 34.80 | 0.27 |
| 120 | 1.2 | 0.12 | 29.40 | 9.70 | 34.56 | 0.28 |
| 140 | 1.4 | 0.14 | 30.40 | 10.03 | 34.32 | 0.29 |
| 160 | 1.6 | 0.16 | 32.00 | 10.56 | 34.08 | 0.31 |
| 180 | 1.8 | 0.18 | 33.00 | 10.89 | 33.84 | 0.32 |
| 200 | 2 | 0.2 | 34.00 | 11.22 | 33.60 | 0.33 |
| 220 | 2.2 | 0.22 | 34.70 | 11.45 | 33.36 | 0.34 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 240 | 2.4 | 0.24 | 35.40 | 11.68 | 33.12 | 0.35 |
| 260 | 2.6 | 0.26 | 36.10 | 11.91 | 32.88 | 0.36 |
| 280 | 2.8 | 0.28 | 36.80 | 12.14 | 32.64 | 0.37 |
| 300 | 3 | 0.3 | 37.20 | 12.28 | 32.40 | 0.38 |
| 320 | 3.2 | 0.32 | 37.80 | 12.47 | 32.16 | 0.39 |
| 340 | 3.4 | 0.34 | 38.20 | 12.61 | 31.92 | 0.39 |
| 360 | 3.6 | 0.36 | 38.80 | 12.80 | 31.68 | 0.40 |
| 380 | 3.8 | 0.38 | 39.40 | 13.00 | 31.44 | 0.41 |
| 400 | 4 | 0.4 | 40.00 | 13.20 | 31.20 | 0.42 |
| 420 | 4.2 | 0.42 | 40.20 | 13.27 | 30.96 | 0.43 |
| 440 | 4.4 | 0.44 | 40.80 | 13.46 | 30.72 | 0.44 |
| 460 | 4.6 | 0.46 | 41.20 | 13.60 | 30.48 | 0.45 |
| 480 | 4.8 | 0.48 | 41.40 | 13.66 | 30.24 | 0.45 |
| 500 | 5 | 0.5 | 41.80 | 13.79 | 30.00 | 0.46 |
| 520 | 5.2 | 0.52 | 42.00 | 13.86 | 29.76 | 0.47 |
| 540 | 5.4 | 0.54 | 42.20 | 13.93 | 29.52 | 0.47 |
| 560 | 5.6 | 0.56 | 42.40 | 13.99 | 29.28 | 0.48 |
| 580 | 5.8 | 0.58 | 42.60 | 14.06 | 29.04 | 0.48 |
| 600 | 6 | 0.6 | 42.80 | 14.12 | 28.80 | 0.49 |
| 620 | 6.2 | 0.62 | 42.80 | 14.12 | 28.56 | 0.49 |
| 640 | 6.4 | 0.64 | 43.00 | 14.19 | 28.32 | 0.50 |
| 660 | 6.6 | 0.66 | 43.00 | 14.19 | 28.08 | 0.51 |
| 680 | 6.8 | 0.68 | 43.00 | 14.19 | 27.84 | 0.51 |
| 700 | 7 | 0.7 | 43.00 | 14.19 | 27.60 | 0.51 |
| 720 | 7.2 | 0.72 | 43.00 | 14.19 | 27.36 | 0.52 |
| 740 | 7.4 | 0.74 | 43.00 | 14.19 | 27.12 | 0.52 |
| 760 | 7.6 | 0.76 | 42.80 | 14.12 | 26.88 | 0.53 |
| 780 | 7.8 | 0.78 | 42.70 | 14.09 | 26.64 | 0.53 |
| 800 | 8 | 0.8 | 42.40 | 13.99 | 26.40 | 0.53 |
| 820 | 8.2 | 0.82 | 42.20 | 13.93 | 26.16 | 0.53 |
| 840 | 8.4 | 0.84 | 42.20 | 13.93 | 25.92 | 0.54 |
| 860 | 8.6 | 0.86 | 42.20 | 13.93 | 25.68 | 0.54 |
| 880 | 8.8 | 0.88 | 42.20 | 13.93 | 25.44 | 0.55 |
| 900 | 9 | 0.9 | 42.20 | 13.93 | 25.20 | 0.55 |
| 920 | 9.2 | 0.92 | 42.00 | 13.86 | 24.96 | 0.56 |
| 940 | 9.4 | 0.94 | 42.00 | 13.86 | 24.72 | 0.56 |
| 960 | 9.6 | 0.96 | 42.00 | 13.86 | 24.48 | 0.57 |
| 980 | 9.8 | 0.98 | 41.80 | 13.79 | 24.24 | 0.57 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 1000 | 10 | 1 | 41.60 | 13.73 | 24.00 | 0.57 |
| 1020 | 10.2 | 1.02 | 41.50 | 13.70 | 23.76 | 0.58 |
| 1040 | 10.4 | 1.04 | 41.40 | 13.66 | 23.52 | 0.58 |
| 1060 | 10.6 | 1.06 | 41.20 | 13.60 | 23.28 | 0.58 |
| 1080 | 10.8 | 1.08 | 41.20 | 13.60 | 23.04 | 0.59 |
| 1100 | 11 | 1.1 | 41.00 | 13.53 | 22.80 | 0.59 |
| 1120 | 11.2 | 1.12 | 41.00 | 13.53 | 22.56 | 0.60 |
| 1140 | 11.4 | 1.14 | 41.00 | 13.53 | 22.32 | 0.61 |
| 1160 | 11.6 | 1.16 | 40.90 | 13.50 | 22.08 | 0.61 |
| 1180 | 11.8 | 1.18 | 40.80 | 13.46 | 21.84 | 0.62 |
| 1200 | 12 | 1.2 | 40.80 | 13.46 | 21.60 | 0.62 |

**Table:E15** Direct Shear Test Readings for ( Soil +4 % cement + 1.5 $kg/m^3$ ZB) at 1.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 12.00 | 3.96 | 35.76 | 0.11 |
| 40 | 0.4 | 0.04 | 16.20 | 5.35 | 35.52 | 0.15 |
| 60 | 0.6 | 0.06 | 21.40 | 7.06 | 35.28 | 0.20 |
| 80 | 0.8 | 0.08 | 32.00 | 10.56 | 35.04 | 0.30 |
| 100 | 1 | 0.1 | 35.60 | 11.75 | 34.80 | 0.34 |
| 120 | 1.2 | 0.12 | 42.20 | 13.93 | 34.56 | 0.40 |
| 140 | 1.4 | 0.14 | 45.20 | 14.92 | 34.32 | 0.43 |
| 160 | 1.6 | 0.16 | 47.40 | 15.64 | 34.08 | 0.46 |
| 180 | 1.8 | 0.18 | 48.40 | 15.97 | 33.84 | 0.47 |
| 200 | 2 | 0.2 | 49.40 | 16.30 | 33.60 | 0.49 |
| 220 | 2.2 | 0.22 | 50.80 | 16.76 | 33.36 | 0.50 |
| 240 | 2.4 | 0.24 | 51.60 | 17.03 | 33.12 | 0.51 |
| 260 | 2.6 | 0.26 | 52.60 | 17.36 | 32.88 | 0.53 |
| 280 | 2.8 | 0.28 | 53.40 | 17.62 | 32.64 | 0.54 |
| 300 | 3 | 0.3 | 54.20 | 17.89 | 32.40 | 0.55 |
| 320 | 3.2 | 0.32 | 55.20 | 18.22 | 32.16 | 0.57 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 340 | 3.4 | 0.34 | 56.20 | 18.55 | 31.92 | 0.58 |
| 360 | 3.6 | 0.36 | 57.00 | 18.81 | 31.68 | 0.59 |
| 380 | 3.8 | 0.38 | 57.80 | 19.07 | 31.44 | 0.61 |
| 400 | 4 | 0.4 | 58.40 | 19.27 | 31.20 | 0.62 |
| 420 | 4.2 | 0.42 | 58.80 | 19.40 | 30.96 | 0.63 |
| 440 | 4.4 | 0.44 | 59.40 | 19.60 | 30.72 | 0.64 |
| 460 | 4.6 | 0.46 | 60.00 | 19.80 | 30.48 | 0.65 |
| 480 | 4.8 | 0.48 | 60.60 | 20.00 | 30.24 | 0.66 |
| 500 | 5 | 0.5 | 60.80 | 20.06 | 30.00 | 0.67 |
| 520 | 5.2 | 0.52 | 61.20 | 20.20 | 29.76 | 0.68 |
| 540 | 5.4 | 0.54 | 61.40 | 20.26 | 29.52 | 0.69 |
| 560 | 5.6 | 0.56 | 61.60 | 20.33 | 29.28 | 0.69 |
| 580 | 5.8 | 0.58 | 62.00 | 20.46 | 29.04 | 0.70 |
| 600 | 6 | 0.6 | 62.20 | 20.53 | 28.80 | 0.71 |
| 620 | 6.2 | 0.62 | 62.40 | 20.59 | 28.56 | 0.72 |
| 640 | 6.4 | 0.64 | 62.40 | 20.59 | 28.32 | 0.73 |
| 660 | 6.6 | 0.66 | 62.40 | 20.59 | 28.08 | 0.73 |
| 680 | 6.8 | 0.68 | 62.60 | 20.66 | 27.84 | 0.74 |
| 700 | 7 | 0.7 | 62.60 | 20.66 | 27.60 | 0.75 |
| 720 | 7.2 | 0.72 | 62.60 | 20.66 | 27.36 | 0.76 |
| 740 | 7.4 | 0.74 | 62.60 | 20.66 | 27.12 | 0.76 |
| 760 | 7.6 | 0.76 | 62.60 | 20.66 | 26.88 | 0.77 |
| 780 | 7.8 | 0.78 | 62.60 | 20.66 | 26.64 | 0.78 |
| 800 | 8 | 0.8 | 62.60 | 20.66 | 26.40 | 0.78 |
| 820 | 8.2 | 0.82 | 62.60 | 20.66 | 26.16 | 0.79 |
| 840 | 8.4 | 0.84 | 62.60 | 20.66 | 25.92 | 0.80 |
| 860 | 8.6 | 0.86 | 62.70 | 20.69 | 25.68 | 0.81 |
| 880 | 8.8 | 0.88 | 62.60 | 20.66 | 25.44 | 0.81 |
| 900 | 9 | 0.9 | 62.60 | 20.66 | 25.20 | 0.82 |
| 920 | 9.2 | 0.92 | 62.60 | 20.66 | 24.96 | 0.83 |
| 940 | 9.4 | 0.94 | 62.50 | 20.63 | 24.72 | 0.83 |
| 960 | 9.6 | 0.96 | 62.40 | 20.59 | 24.48 | 0.84 |
| 980 | 9.8 | 0.98 | 62.20 | 20.53 | 24.24 | 0.85 |
| 1000 | 10 | 1 | 62.20 | 20.53 | 24.00 | 0.86 |
| 1020 | 10.2 | 1.02 | 62.00 | 20.46 | 23.76 | 0.86 |
| 1040 | 10.4 | 1.04 | 61.80 | 20.39 | 23.52 | 0.87 |
| 1060 | 10.6 | 1.06 | 61.60 | 20.33 | 23.28 | 0.87 |
| 1080 | 10.8 | 1.08 | 61.20 | 20.20 | 23.04 | 0.88 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 1100 | 11 | 1.1 | 61.00 | 20.13 | 22.80 | 0.88 |
| 1120 | 11.2 | 1.12 | 61.00 | 20.13 | 22.56 | 0.89 |
| 1140 | 11.4 | 1.14 | 60.80 | 20.06 | 22.32 | 0.90 |
| 1160 | 11.6 | 1.16 | 60.60 | 20.00 | 22.08 | 0.91 |
| 1180 | 11.8 | 1.18 | 60.40 | 19.93 | 21.84 | 0.91 |
| 1200 | 12 | 1.2 | 59.60 | 19.67 | 21.60 | 0.91 |
| 1220 | 12.2 | 1.22 | 59.20 | 19.54 | 21.36 | 0.91 |

## Appendix F

**Table:F1** Direct Shear Test Readings for ( Soil +5 % cement + 0.5 $kg/m^3$ ZB) at 0.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 6.40 | 2.11 | 35.76 | 0.06 |
| 40 | 0.4 | 0.04 | 11.60 | 3.83 | 35.52 | 0.11 |
| 60 | 0.6 | 0.06 | 14.10 | 4.65 | 35.28 | 0.13 |
| 80 | 0.8 | 0.08 | 15.60 | 5.15 | 35.04 | 0.15 |
| 100 | 1 | 0.1 | 16.80 | 5.54 | 34.80 | 0.16 |
| 120 | 1.2 | 0.12 | 17.40 | 5.74 | 34.56 | 0.17 |
| 140 | 1.4 | 0.14 | 18.00 | 5.94 | 34.32 | 0.17 |
| 160 | 1.6 | 0.16 | 18.60 | 6.14 | 34.08 | 0.18 |
| 180 | 1.8 | 0.18 | 19.20 | 6.34 | 33.84 | 0.19 |
| 200 | 2 | 0.2 | 19.80 | 6.53 | 33.60 | 0.19 |
| 220 | 2.2 | 0.22 | 20.20 | 6.67 | 33.36 | 0.20 |
| 240 | 2.4 | 0.24 | 20.40 | 6.73 | 33.12 | 0.20 |
| 260 | 2.6 | 0.26 | 20.80 | 6.86 | 32.88 | 0.21 |
| 280 | 2.8 | 0.28 | 21.00 | 6.93 | 32.64 | 0.21 |
| 300 | 3 | 0.3 | 21.30 | 7.03 | 32.40 | 0.22 |
| 320 | 3.2 | 0.32 | 21.60 | 7.13 | 32.16 | 0.22 |
| 340 | 3.4 | 0.34 | 21.80 | 7.19 | 31.92 | 0.23 |
| 360 | 3.6 | 0.36 | 22.00 | 7.26 | 31.68 | 0.23 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 380 | 3.8 | 0.38 | 22.00 | 7.26 | 31.44 | 0.23 |
| 400 | 4 | 0.4 | 22.20 | 7.33 | 31.20 | 0.23 |
| 420 | 4.2 | 0.42 | 22.40 | 7.39 | 30.96 | 0.24 |
| 440 | 4.4 | 0.44 | 22.50 | 7.43 | 30.72 | 0.24 |
| 460 | 4.6 | 0.46 | 22.60 | 7.46 | 30.48 | 0.24 |
| 480 | 4.8 | 0.48 | 22.60 | 7.46 | 30.24 | 0.25 |
| 500 | 5 | 0.5 | 22.70 | 7.49 | 30.00 | 0.25 |
| 520 | 5.2 | 0.52 | 22.70 | 7.49 | 29.76 | 0.25 |
| 540 | 5.4 | 0.54 | 22.70 | 7.49 | 29.52 | 0.25 |
| 560 | 5.6 | 0.56 | 22.60 | 7.46 | 29.28 | 0.25 |
| 580 | 5.8 | 0.58 | 22.40 | 7.39 | 29.04 | 0.25 |
| 600 | 6 | 0.6 | 22.40 | 7.39 | 28.80 | 0.26 |
| 620 | 6.2 | 0.62 | 22.40 | 7.39 | 28.56 | 0.26 |
| 640 | 6.4 | 0.64 | 22.40 | 7.39 | 28.32 | 0.26 |
| 660 | 6.6 | 0.66 | 22.40 | 7.39 | 28.08 | 0.26 |
| 680 | 6.8 | 0.68 | 22.00 | 7.26 | 27.84 | 0.26 |
| 700 | 7 | 0.7 | 22.00 | 7.26 | 27.60 | 0.26 |
| 720 | 7.2 | 0.72 | 22.10 | 7.29 | 27.36 | 0.27 |
| 740 | 7.4 | 0.74 | 22.00 | 7.26 | 27.12 | 0.27 |
| 760 | 7.6 | 0.76 | 21.90 | 7.23 | 26.88 | 0.27 |
| 780 | 7.8 | 0.78 | 21.80 | 7.19 | 26.64 | 0.27 |
| 800 | 8 | 0.8 | 21.70 | 7.16 | 26.40 | 0.27 |
| 820 | 8.2 | 0.82 | 21.60 | 7.13 | 26.16 | 0.27 |
| 840 | 8.4 | 0.84 | 21.50 | 7.10 | 25.92 | 0.27 |
| 860 | 8.6 | 0.86 | 21.40 | 7.06 | 25.68 | 0.28 |
| 880 | 8.8 | 0.88 | 21.30 | 7.03 | 25.44 | 0.28 |
| 900 | 9 | 0.9 | 21.20 | 7.00 | 25.20 | 0.28 |
| 920 | 9.2 | 0.92 | 21.10 | 6.96 | 24.96 | 0.28 |
| 940 | 9.4 | 0.94 | 21.00 | 6.93 | 24.72 | 0.28 |
| 960 | 9.6 | 0.96 | 20.90 | 6.90 | 24.48 | 0.28 |
| 980 | 9.8 | 0.98 | 20.80 | 6.86 | 24.24 | 0.28 |
| 1000 | 10 | 1 | 20.70 | 6.83 | 24.00 | 0.28 |
| 1020 | 10.2 | 1.02 | 20.60 | 6.80 | 23.76 | 0.29 |
| 1040 | 10.4 | 1.04 | 20.50 | 6.77 | 23.52 | 0.29 |
| 1060 | 10.6 | 1.06 | 20.40 | 6.73 | 23.28 | 0.29 |
| 1080 | 10.8 | 1.08 | 20.30 | 6.70 | 23.04 | 0.29 |
| 1100 | 11 | 1.1 | 20.20 | 6.67 | 22.80 | 0.29 |
| 1120 | 11.2 | 1.12 | 20.10 | 6.63 | 22.56 | 0.29 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 1140 | 11.4 | 1.14 | 20.00 | 6.60 | 22.32 | 0.30 |
| 1160 | 11.6 | 1.16 | 19.90 | 6.57 | 22.08 | 0.30 |
| 1180 | 11.8 | 1.18 | 20.10 | 6.63 | 21.84 | 0.30 |
| 1200 | 12 | 1.2 | 20.00 | 6.60 | 21.60 | 0.31 |
| 1220 | 12.2 | 1.22 | 19.90 | 6.57 | 21.36 | 0.31 |

**Table:F2** Direct Shear Test Readings for ( Soil +5 % cement + 0.5 $kg/m^3$ ZB) at 1.0 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0.0 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 12.0 | 3.96 | 35.76 | 0.11 |
| 40 | 0.4 | 0.04 | 18.2 | 6.01 | 35.52 | 0.17 |
| 60 | 0.6 | 0.06 | 22.8 | 7.52 | 35.28 | 0.21 |
| 80 | 0.8 | 0.08 | 25.4 | 8.38 | 35.04 | 0.24 |
| 100 | 1 | 0.1 | 28.8 | 9.50 | 34.80 | 0.27 |
| 120 | 1.2 | 0.12 | 30.2 | 9.97 | 34.56 | 0.29 |
| 140 | 1.4 | 0.14 | 30.8 | 10.16 | 34.32 | 0.30 |
| 160 | 1.6 | 0.16 | 31.2 | 10.30 | 34.08 | 0.30 |
| 180 | 1.8 | 0.18 | 31.8 | 10.49 | 33.84 | 0.31 |
| 200 | 2 | 0.2 | 32.2 | 10.63 | 33.60 | 0.32 |
| 220 | 2.2 | 0.22 | 32.8 | 10.82 | 33.36 | 0.32 |
| 240 | 2.4 | 0.24 | 33.2 | 10.96 | 33.12 | 0.33 |
| 260 | 2.6 | 0.26 | 33.8 | 11.15 | 32.88 | 0.34 |
| 280 | 2.8 | 0.28 | 34.0 | 11.22 | 32.64 | 0.34 |
| 300 | 3 | 0.3 | 34.2 | 11.29 | 32.40 | 0.35 |
| 320 | 3.2 | 0.32 | 34.8 | 11.48 | 32.16 | 0.36 |
| 340 | 3.4 | 0.34 | 35.1 | 11.58 | 31.92 | 0.36 |
| 360 | 3.6 | 0.36 | 35.4 | 11.68 | 31.68 | 0.37 |
| 380 | 3.8 | 0.38 | 35.8 | 11.81 | 31.44 | 0.38 |
| 400 | 4 | 0.4 | 36.2 | 11.95 | 31.20 | 0.38 |
| 420 | 4.2 | 0.42 | 36.6 | 12.08 | 30.96 | 0.39 |
| 440 | 4.4 | 0.44 | 37.0 | 12.21 | 30.72 | 0.40 |
| 460 | 4.6 | 0.46 | 37.2 | 12.28 | 30.48 | 0.40 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 480 | 4.8 | 0.48 | 37.6 | 12.41 | 30.24 | 0.41 |
| 500 | 5 | 0.5 | 37.9 | 12.51 | 30.00 | 0.42 |
| 520 | 5.2 | 0.52 | 38.1 | 12.57 | 29.76 | 0.42 |
| 540 | 5.4 | 0.54 | 38.4 | 12.67 | 29.52 | 0.43 |
| 560 | 5.6 | 0.56 | 38.6 | 12.74 | 29.28 | 0.44 |
| 580 | 5.8 | 0.58 | 38.8 | 12.80 | 29.04 | 0.44 |
| 600 | 6 | 0.6 | 38.8 | 12.80 | 28.80 | 0.44 |
| 620 | 6.2 | 0.62 | 38.8 | 12.80 | 28.56 | 0.45 |
| 640 | 6.4 | 0.64 | 38.6 | 12.74 | 28.32 | 0.45 |
| 660 | 6.6 | 0.66 | 38.6 | 12.74 | 28.08 | 0.45 |
| 680 | 6.8 | 0.68 | 38.6 | 12.74 | 27.84 | 0.46 |
| 700 | 7 | 0.7 | 38.5 | 12.71 | 27.60 | 0.46 |
| 720 | 7.2 | 0.72 | 38.4 | 12.67 | 27.36 | 0.46 |
| 740 | 7.4 | 0.74 | 38.5 | 12.71 | 27.12 | 0.47 |
| 760 | 7.6 | 0.76 | 38.3 | 12.64 | 26.88 | 0.47 |
| 780 | 7.8 | 0.78 | 38.2 | 12.61 | 26.64 | 0.47 |
| 800 | 8 | 0.8 | 38.2 | 12.61 | 26.40 | 0.48 |
| 820 | 8.2 | 0.82 | 38.1 | 12.57 | 26.16 | 0.48 |
| 840 | 8.4 | 0.84 | 38.0 | 12.54 | 25.92 | 0.48 |
| 860 | 8.6 | 0.86 | 38.0 | 12.54 | 25.68 | 0.49 |
| 880 | 8.8 | 0.88 | 38.0 | 12.54 | 25.44 | 0.49 |
| 900 | 9 | 0.9 | 38.0 | 12.54 | 25.20 | 0.50 |
| 920 | 9.2 | 0.92 | 38.0 | 12.54 | 24.96 | 0.50 |
| 940 | 9.4 | 0.94 | 37.8 | 12.47 | 24.72 | 0.50 |
| 960 | 9.6 | 0.96 | 37.8 | 12.47 | 24.48 | 0.51 |
| 980 | 9.8 | 0.98 | 37.8 | 12.47 | 24.24 | 0.51 |
| 1000 | 10 | 1 | 37.8 | 12.47 | 24.00 | 0.52 |
| 1020 | 10.2 | 1.02 | 37.8 | 12.47 | 23.76 | 0.53 |
| 1040 | 10.4 | 1.04 | 37.8 | 12.47 | 23.52 | 0.53 |
| 1060 | 10.6 | 1.06 | 37.8 | 12.47 | 23.28 | 0.54 |
| 1080 | 10.8 | 1.08 | 37.8 | 12.47 | 23.04 | 0.54 |
| 1100 | 11 | 1.1 | 37.8 | 12.47 | 22.80 | 0.55 |
| 1120 | 11.2 | 1.12 | 37.8 | 12.47 | 22.56 | 0.55 |
| 1140 | 11.4 | 1.14 | 37.8 | 12.47 | 22.32 | 0.56 |
| 1160 | 11.6 | 1.16 | 37.8 | 12.47 | 22.08 | 0.56 |
| 1180 | 11.8 | 1.18 | 37.8 | 12.47 | 21.84 | 0.57 |
| 1200 | 12 | 1.2 | 37.8 | 12.47 | 21.60 | 0.58 |
| 1220 | 12.2 | 1.22 | 37.8 | 12.47 | 21.36 | 0.58 |

**Table:F3** Direct Shear Test Readings for ( Soil +5 % cement + 0.5 kg/$m^3$ ZB) at 1.5 kg/$cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 12.30 | 4.06 | 35.76 | 0.11 |
| 40 | 0.4 | 0.04 | 24.30 | 8.02 | 35.52 | 0.23 |
| 60 | 0.6 | 0.06 | 36.20 | 11.95 | 35.28 | 0.34 |
| 80 | 0.8 | 0.08 | 42.20 | 13.93 | 35.04 | 0.40 |
| 100 | 1 | 0.1 | 45.00 | 14.85 | 34.80 | 0.43 |
| 120 | 1.2 | 0.12 | 47.40 | 15.64 | 34.56 | 0.45 |
| 140 | 1.4 | 0.14 | 48.20 | 15.91 | 34.32 | 0.46 |
| 160 | 1.6 | 0.16 | 49.00 | 16.17 | 34.08 | 0.47 |
| 180 | 1.8 | 0.18 | 49.80 | 16.43 | 33.84 | 0.49 |
| 200 | 2 | 0.2 | 50.60 | 16.70 | 33.60 | 0.50 |
| 220 | 2.2 | 0.22 | 51.20 | 16.90 | 33.36 | 0.51 |
| 240 | 2.4 | 0.24 | 52.20 | 17.23 | 33.12 | 0.52 |
| 260 | 2.6 | 0.26 | 53.00 | 17.49 | 32.88 | 0.53 |
| 280 | 2.8 | 0.28 | 53.60 | 17.69 | 32.64 | 0.54 |
| 300 | 3 | 0.3 | 54.20 | 17.89 | 32.40 | 0.55 |
| 320 | 3.2 | 0.32 | 54.80 | 18.08 | 32.16 | 0.56 |
| 340 | 3.4 | 0.34 | 55.20 | 18.22 | 31.92 | 0.57 |
| 360 | 3.6 | 0.36 | 55.80 | 18.41 | 31.68 | 0.58 |
| 380 | 3.8 | 0.38 | 56.40 | 18.61 | 31.44 | 0.59 |
| 400 | 4 | 0.4 | 56.90 | 18.78 | 31.20 | 0.60 |
| 420 | 4.2 | 0.42 | 57.40 | 18.94 | 30.96 | 0.61 |
| 440 | 4.4 | 0.44 | 57.70 | 19.04 | 30.72 | 0.62 |
| 460 | 4.6 | 0.46 | 58.00 | 19.14 | 30.48 | 0.63 |
| 480 | 4.8 | 0.48 | 58.20 | 19.21 | 30.24 | 0.64 |
| 500 | 5 | 0.5 | 58.60 | 19.34 | 30.00 | 0.64 |
| 520 | 5.2 | 0.52 | 58.80 | 19.40 | 29.76 | 0.65 |
| 540 | 5.4 | 0.54 | 59.00 | 19.47 | 29.52 | 0.66 |
| 560 | 5.6 | 0.56 | 59.20 | 19.54 | 29.28 | 0.67 |
| 580 | 5.8 | 0.58 | 59.40 | 19.60 | 29.04 | 0.68 |
| 600 | 6 | 0.6 | 59.50 | 19.64 | 28.80 | 0.68 |
| 620 | 6.2 | 0.62 | 59.80 | 19.73 | 28.56 | 0.69 |
| 640 | 6.4 | 0.64 | 59.80 | 19.73 | 28.32 | 0.70 |
| 660 | 6.6 | 0.66 | 60.00 | 19.80 | 28.08 | 0.71 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 680 | 6.8 | 0.68 | 60.20 | 19.87 | 27.84 | 0.71 |
| 700 | 7 | 0.7 | 60.40 | 19.93 | 27.60 | 0.72 |
| 720 | 7.2 | 0.72 | 60.80 | 20.06 | 27.36 | 0.73 |
| 740 | 7.4 | 0.74 | 60.80 | 20.06 | 27.12 | 0.74 |
| 760 | 7.6 | 0.76 | 60.60 | 20.00 | 26.88 | 0.74 |
| 780 | 7.8 | 0.78 | 60.70 | 20.03 | 26.64 | 0.75 |
| 800 | 8 | 0.8 | 60.60 | 20.00 | 26.40 | 0.76 |
| 820 | 8.2 | 0.82 | 60.70 | 20.03 | 26.16 | 0.77 |
| 840 | 8.4 | 0.84 | 60.60 | 20.00 | 25.92 | 0.77 |
| 860 | 8.6 | 0.86 | 60.40 | 19.93 | 25.68 | 0.78 |
| 880 | 8.8 | 0.88 | 60.30 | 19.90 | 25.44 | 0.78 |
| 900 | 9 | 0.9 | 60.30 | 19.90 | 25.20 | 0.79 |
| 920 | 9.2 | 0.92 | 60.30 | 19.90 | 24.96 | 0.80 |
| 940 | 9.4 | 0.94 | 60.30 | 19.90 | 24.72 | 0.80 |
| 960 | 9.6 | 0.96 | 60.30 | 19.90 | 24.48 | 0.81 |
| 980 | 9.8 | 0.98 | 60.30 | 19.90 | 24.24 | 0.82 |
| 1000 | 10 | 1 | 60.30 | 19.90 | 24.00 | 0.83 |
| 1020 | 10.2 | 1.02 | 60.30 | 19.90 | 23.76 | 0.84 |
| 1040 | 10.4 | 1.04 | 60.30 | 19.90 | 23.52 | 0.85 |
| 1060 | 10.6 | 1.06 | 60.30 | 19.90 | 23.28 | 0.85 |
| 1080 | 10.8 | 1.08 | 60.30 | 19.90 | 23.04 | 0.86 |
| 1100 | 11 | 1.1 | 60.30 | 19.90 | 22.80 | 0.87 |
| 1120 | 11.2 | 1.12 | 60.30 | 19.90 | 22.56 | 0.88 |
| 1140 | 11.4 | 1.14 | 60.30 | 19.90 | 22.32 | 0.89 |
| 1160 | 11.6 | 1.16 | 60.30 | 19.90 | 22.08 | 0.90 |
| 1180 | 11.8 | 1.18 | 60.30 | 19.90 | 21.84 | 0.91 |
| 1200 | 12 | 1.2 | 60.30 | 19.90 | 21.60 | 0.92 |
| 1220 | 12.2 | 1.22 | 60.30 | 19.90 | 21.36 | 0.93 |

**Table:F4** Direct Shear Test Readings for ( Soil +5 % cement + 0.75 $kg/m^3$ ZB) at 0.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | Cm | | | | |
| | | | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 2.40 | 0.79 | 35.76 | 0.02 |
| 40 | 0.4 | 0.04 | 6.40 | 2.11 | 35.52 | 0.06 |
| 60 | 0.6 | 0.06 | 8.80 | 2.90 | 35.28 | 0.08 |
| 80 | 0.8 | 0.08 | 12.80 | 4.22 | 35.04 | 0.12 |
| 100 | 1 | 0.1 | 13.40 | 4.42 | 34.80 | 0.13 |
| 120 | 1.2 | 0.12 | 14.80 | 4.88 | 34.56 | 0.14 |
| 140 | 1.4 | 0.14 | 15.80 | 5.21 | 34.32 | 0.15 |
| 160 | 1.6 | 0.16 | 16.80 | 5.54 | 34.08 | 0.16 |
| 180 | 1.8 | 0.18 | 17.40 | 5.74 | 33.84 | 0.17 |
| 200 | 2 | 0.2 | 18.40 | 6.07 | 33.60 | 0.18 |
| 220 | 2.2 | 0.22 | 18.60 | 6.14 | 33.36 | 0.18 |
| 240 | 2.4 | 0.24 | 18.80 | 6.20 | 33.12 | 0.19 |
| 260 | 2.6 | 0.26 | 19.00 | 6.27 | 32.88 | 0.19 |
| 280 | 2.8 | 0.28 | 19.40 | 6.40 | 32.64 | 0.20 |
| 300 | 3 | 0.3 | 19.80 | 6.53 | 32.40 | 0.20 |
| 320 | 3.2 | 0.32 | 20.20 | 6.67 | 32.16 | 0.21 |
| 340 | 3.4 | 0.34 | 20.60 | 6.80 | 31.92 | 0.21 |
| 360 | 3.6 | 0.36 | 20.80 | 6.86 | 31.68 | 0.22 |
| 380 | 3.8 | 0.38 | 21.00 | 6.93 | 31.44 | 0.22 |
| 400 | 4 | 0.4 | 21.30 | 7.03 | 31.20 | 0.23 |
| 420 | 4.2 | 0.42 | 21.60 | 7.13 | 30.96 | 0.23 |
| 440 | 4.4 | 0.44 | 21.80 | 7.19 | 30.72 | 0.23 |
| 460 | 4.6 | 0.46 | 22.00 | 7.26 | 30.48 | 0.24 |
| 480 | 4.8 | 0.48 | 22.20 | 7.33 | 30.24 | 0.24 |
| 500 | 5 | 0.5 | 22.40 | 7.39 | 30.00 | 0.25 |
| 520 | 5.2 | 0.52 | 22.70 | 7.49 | 29.76 | 0.25 |
| 540 | 5.4 | 0.54 | 23.00 | 7.59 | 29.52 | 0.26 |
| 560 | 5.6 | 0.56 | 23.00 | 7.59 | 29.28 | 0.26 |
| 580 | 5.8 | 0.58 | 23.00 | 7.59 | 29.04 | 0.26 |
| 600 | 6 | 0.6 | 23.10 | 7.62 | 28.80 | 0.26 |
| 620 | 6.2 | 0.62 | 22.90 | 7.56 | 28.56 | 0.26 |
| 640 | 6.4 | 0.64 | 23.10 | 7.62 | 28.32 | 0.27 |
| 660 | 6.6 | 0.66 | 23.20 | 7.66 | 28.08 | 0.27 |
| 680 | 6.8 | 0.68 | 23.20 | 7.66 | 27.84 | 0.28 |
| 700 | 7 | 0.7 | 23.10 | 7.62 | 27.60 | 0.28 |
| 720 | 7.2 | 0.72 | 23.10 | 7.62 | 27.36 | 0.28 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | Cm | | | | |
| 740 | 7.4 | 0.74 | 23.00 | 7.59 | 27.12 | 0.28 |
| 760 | 7.6 | 0.76 | 22.80 | 7.52 | 26.88 | 0.28 |
| 780 | 7.8 | 0.78 | 22.80 | 7.52 | 26.64 | 0.28 |
| 800 | 8 | 0.8 | 22.60 | 7.46 | 26.40 | 0.28 |
| 820 | 8.2 | 0.82 | 22.60 | 7.46 | 26.16 | 0.29 |
| 840 | 8.4 | 0.84 | 22.60 | 7.46 | 25.92 | 0.29 |
| 860 | 8.6 | 0.86 | 22.40 | 7.39 | 25.68 | 0.29 |
| 880 | 8.8 | 0.88 | 22.20 | 7.33 | 25.44 | 0.29 |
| 900 | 9 | 0.9 | 22.00 | 7.26 | 25.20 | 0.29 |
| 920 | 9.2 | 0.92 | 22.00 | 7.26 | 24.96 | 0.29 |
| 940 | 9.4 | 0.94 | 22.00 | 7.26 | 24.72 | 0.29 |
| 960 | 9.6 | 0.96 | 22.00 | 7.26 | 24.48 | 0.30 |
| 980 | 9.8 | 0.98 | 22.00 | 7.26 | 24.24 | 0.30 |
| 1000 | 10 | 1 | 22.00 | 7.26 | 24.00 | 0.30 |
| 1020 | 10.2 | 1.02 | 21.80 | 7.19 | 23.76 | 0.30 |
| 1040 | 10.4 | 1.04 | 21.80 | 7.19 | 23.52 | 0.31 |
| 1060 | 10.6 | 1.06 | 21.60 | 7.13 | 23.28 | 0.31 |
| 1080 | 10.8 | 1.08 | 21.60 | 7.13 | 23.04 | 0.31 |
| 1100 | 11 | 1.1 | 21.70 | 7.16 | 22.80 | 0.31 |
| 1120 | 11.2 | 1.12 | 21.60 | 7.13 | 22.56 | 0.32 |
| 1140 | 11.4 | 1.14 | 21.60 | 7.13 | 22.32 | 0.32 |
| 1160 | 11.6 | 1.16 | 21.40 | 7.06 | 22.08 | 0.32 |
| 1180 | 11.8 | 1.18 | 21.40 | 7.06 | 21.84 | 0.32 |
| 1200 | 12 | 1.2 | 21.20 | 7.00 | 21.60 | 0.32 |
| 1220 | 12.2 | 1.22 | 21.30 | 7.03 | 21.36 | 0.33 |
| 1240 | 12.4 | 1.24 | 21.20 | 7.00 | 21.12 | 0.33 |

**Table:F5** Direct Shear Test Readings for ( Soil +5 % cement + 0.75 $kg/m^3$ ZB) at 1.0 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 6.00 | 1.98 | 35.76 | 0.06 |
| 40 | 0.4 | 0.04 | 10.00 | 3.30 | 35.52 | 0.09 |
| 60 | 0.6 | 0.06 | 16.20 | 5.35 | 35.28 | 0.15 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 80 | 0.8 | 0.08 | 22.20 | 7.33 | 35.04 | 0.21 |
| 100 | 1 | 0.1 | 23.60 | 7.79 | 34.80 | 0.22 |
| 120 | 1.2 | 0.12 | 26.20 | 8.65 | 34.56 | 0.25 |
| 140 | 1.4 | 0.14 | 28.20 | 9.31 | 34.32 | 0.27 |
| 160 | 1.6 | 0.16 | 29.60 | 9.77 | 34.08 | 0.29 |
| 180 | 1.8 | 0.18 | 30.40 | 10.03 | 33.84 | 0.30 |
| 200 | 2 | 0.2 | 31.20 | 10.30 | 33.60 | 0.31 |
| 220 | 2.2 | 0.22 | 32.00 | 10.56 | 33.36 | 0.32 |
| 240 | 2.4 | 0.24 | 32.80 | 10.82 | 33.12 | 0.33 |
| 260 | 2.6 | 0.26 | 33.40 | 11.02 | 32.88 | 0.34 |
| 280 | 2.8 | 0.28 | 33.80 | 11.15 | 32.64 | 0.34 |
| 300 | 3 | 0.3 | 34.40 | 11.35 | 32.40 | 0.35 |
| 320 | 3.2 | 0.32 | 34.90 | 11.52 | 32.16 | 0.36 |
| 340 | 3.4 | 0.34 | 35.20 | 11.62 | 31.92 | 0.36 |
| 360 | 3.6 | 0.36 | 35.60 | 11.75 | 31.68 | 0.37 |
| 380 | 3.8 | 0.38 | 36.00 | 11.88 | 31.44 | 0.38 |
| 400 | 4 | 0.4 | 36.40 | 12.01 | 31.20 | 0.39 |
| 420 | 4.2 | 0.42 | 36.80 | 12.14 | 30.96 | 0.39 |
| 440 | 4.4 | 0.44 | 37.20 | 12.28 | 30.72 | 0.40 |
| 460 | 4.6 | 0.46 | 37.40 | 12.34 | 30.48 | 0.40 |
| 480 | 4.8 | 0.48 | 37.80 | 12.47 | 30.24 | 0.41 |
| 500 | 5 | 0.5 | 37.90 | 12.51 | 30.00 | 0.42 |
| 520 | 5.2 | 0.52 | 38.20 | 12.61 | 29.76 | 0.42 |
| 540 | 5.4 | 0.54 | 38.40 | 12.67 | 29.52 | 0.43 |
| 560 | 5.6 | 0.56 | 38.60 | 12.74 | 29.28 | 0.44 |
| 580 | 5.8 | 0.58 | 38.80 | 12.80 | 29.04 | 0.44 |
| 600 | 6 | 0.6 | 39.00 | 12.87 | 28.80 | 0.45 |
| 620 | 6.2 | 0.62 | 39.20 | 12.94 | 28.56 | 0.45 |
| 640 | 6.4 | 0.64 | 39.20 | 12.94 | 28.32 | 0.46 |
| 660 | 6.6 | 0.66 | 39.20 | 12.94 | 28.08 | 0.46 |
| 680 | 6.8 | 0.68 | 39.30 | 12.97 | 27.84 | 0.47 |
| 700 | 7 | 0.7 | 39.30 | 12.97 | 27.60 | 0.47 |
| 720 | 7.2 | 0.72 | 39.20 | 12.94 | 27.36 | 0.47 |
| 740 | 7.4 | 0.74 | 39.20 | 12.94 | 27.12 | 0.48 |
| 760 | 7.6 | 0.76 | 39.20 | 12.94 | 26.88 | 0.48 |
| 780 | 7.8 | 0.78 | 39.20 | 12.94 | 26.64 | 0.49 |
| 800 | 8 | 0.8 | 39.20 | 12.94 | 26.40 | 0.49 |
| 820 | 8.2 | 0.82 | 39.20 | 12.94 | 26.16 | 0.49 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 840 | 8.4 | 0.84 | 39.40 | 13.00 | 25.92 | 0.50 |
| 860 | 8.6 | 0.86 | 39.00 | 12.87 | 25.68 | 0.50 |
| 880 | 8.8 | 0.88 | 38.80 | 12.80 | 25.44 | 0.50 |
| 900 | 9 | 0.9 | 38.80 | 12.80 | 25.20 | 0.51 |
| 920 | 9.2 | 0.92 | 38.80 | 12.80 | 24.96 | 0.51 |
| 940 | 9.4 | 0.94 | 38.70 | 12.77 | 24.72 | 0.52 |
| 960 | 9.6 | 0.96 | 38.60 | 12.74 | 24.48 | 0.52 |
| 980 | 9.8 | 0.98 | 38.60 | 12.74 | 24.24 | 0.53 |
| 1000 | 10 | 1 | 38.60 | 12.74 | 24.00 | 0.53 |
| 1020 | 10.2 | 1.02 | 38.50 | 12.71 | 23.76 | 0.53 |
| 1040 | 10.4 | 1.04 | 38.50 | 12.71 | 23.52 | 0.54 |
| 1060 | 10.6 | 1.06 | 38.50 | 12.71 | 23.28 | 0.55 |
| 1080 | 10.8 | 1.08 | 38.40 | 12.67 | 23.04 | 0.55 |
| 1100 | 11 | 1.1 | 38.40 | 12.67 | 22.80 | 0.56 |
| 1120 | 11.2 | 1.12 | 38.20 | 12.61 | 22.56 | 0.56 |
| 1140 | 11.4 | 1.14 | 38.20 | 12.61 | 22.32 | 0.56 |
| 1160 | 11.6 | 1.16 | 38.00 | 12.54 | 22.08 | 0.57 |
| 1180 | 11.8 | 1.18 | 38.00 | 12.54 | 21.84 | 0.57 |
| 1200 | 12 | 1.2 | 38.00 | 12.54 | 21.60 | 0.58 |
| 1220 | 12.2 | 1.22 | 38.00 | 12.54 | 21.36 | 0.59 |

**Table:F6** Direct Shear Test Readings for ( Soil +5 % cement + 0.75 $kg/m^3$ ZB) at 1.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 12.00 | 3.96 | 35.76 | 0.11 |
| 40 | 0.4 | 0.04 | 16.20 | 5.35 | 35.52 | 0.15 |
| 60 | 0.6 | 0.06 | 24.20 | 7.99 | 35.28 | 0.23 |
| 80 | 0.8 | 0.08 | 34.40 | 11.35 | 35.04 | 0.32 |
| 100 | 1 | 0.1 | 36.80 | 12.14 | 34.80 | 0.35 |
| 120 | 1.2 | 0.12 | 40.00 | 13.20 | 34.56 | 0.38 |
| 140 | 1.4 | 0.14 | 42.20 | 13.93 | 34.32 | 0.41 |
| 160 | 1.6 | 0.16 | 43.80 | 14.45 | 34.08 | 0.42 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 180 | 1.8 | 0.18 | 45.00 | 14.85 | 33.84 | 0.44 |
| 200 | 2 | 0.2 | 46.00 | 15.18 | 33.60 | 0.45 |
| 220 | 2.2 | 0.22 | 46.80 | 15.44 | 33.36 | 0.46 |
| 240 | 2.4 | 0.24 | 47.80 | 15.77 | 33.12 | 0.48 |
| 260 | 2.6 | 0.26 | 48.80 | 16.10 | 32.88 | 0.49 |
| 280 | 2.8 | 0.28 | 49.60 | 16.37 | 32.64 | 0.50 |
| 300 | 3 | 0.3 | 50.20 | 16.57 | 32.40 | 0.51 |
| 320 | 3.2 | 0.32 | 51.00 | 16.83 | 32.16 | 0.52 |
| 340 | 3.4 | 0.34 | 51.70 | 17.06 | 31.92 | 0.53 |
| 360 | 3.6 | 0.36 | 52.20 | 17.23 | 31.68 | 0.54 |
| 380 | 3.8 | 0.38 | 53.00 | 17.49 | 31.44 | 0.56 |
| 400 | 4 | 0.4 | 53.60 | 17.69 | 31.20 | 0.57 |
| 420 | 4.2 | 0.42 | 54.20 | 17.89 | 30.96 | 0.58 |
| 440 | 4.4 | 0.44 | 54.80 | 18.08 | 30.72 | 0.59 |
| 460 | 4.6 | 0.46 | 55.00 | 18.15 | 30.48 | 0.60 |
| 480 | 4.8 | 0.48 | 55.60 | 18.35 | 30.24 | 0.61 |
| 500 | 5 | 0.5 | 56.00 | 18.48 | 30.00 | 0.62 |
| 520 | 5.2 | 0.52 | 56.20 | 18.55 | 29.76 | 0.62 |
| 540 | 5.4 | 0.54 | 56.40 | 18.61 | 29.52 | 0.63 |
| 560 | 5.6 | 0.56 | 57.00 | 18.81 | 29.28 | 0.64 |
| 580 | 5.8 | 0.58 | 57.20 | 18.88 | 29.04 | 0.65 |
| 600 | 6 | 0.6 | 57.40 | 18.94 | 28.80 | 0.66 |
| 620 | 6.2 | 0.62 | 57.60 | 19.01 | 28.56 | 0.67 |
| 640 | 6.4 | 0.64 | 57.80 | 19.07 | 28.32 | 0.67 |
| 660 | 6.6 | 0.66 | 58.00 | 19.14 | 28.08 | 0.68 |
| 680 | 6.8 | 0.68 | 58.20 | 19.21 | 27.84 | 0.69 |
| 700 | 7 | 0.7 | 58.40 | 19.27 | 27.60 | 0.70 |
| 720 | 7.2 | 0.72 | 58.40 | 19.27 | 27.36 | 0.70 |
| 740 | 7.4 | 0.74 | 58.60 | 19.34 | 27.12 | 0.71 |
| 760 | 7.6 | 0.76 | 58.80 | 19.40 | 26.88 | 0.72 |
| 780 | 7.8 | 0.78 | 58.70 | 19.37 | 26.64 | 0.73 |
| 800 | 8 | 0.8 | 58.60 | 19.34 | 26.40 | 0.73 |
| 820 | 8.2 | 0.82 | 58.60 | 19.34 | 26.16 | 0.74 |
| 840 | 8.4 | 0.84 | 58.40 | 19.27 | 25.92 | 0.74 |
| 860 | 8.6 | 0.86 | 58.30 | 19.24 | 25.68 | 0.75 |
| 880 | 8.8 | 0.88 | 58.20 | 19.21 | 25.44 | 0.75 |
| 900 | 9 | 0.9 | 58.00 | 19.14 | 25.20 | 0.76 |
| 920 | 9.2 | 0.92 | 58.00 | 19.14 | 24.96 | 0.77 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 940 | 9.4 | 0.94 | 58.00 | 19.14 | 24.72 | 0.77 |
| 960 | 9.6 | 0.96 | 57.80 | 19.07 | 24.48 | 0.78 |
| 980 | 9.8 | 0.98 | 57.80 | 19.07 | 24.24 | 0.79 |
| 1000 | 10 | 1 | 57.60 | 19.01 | 24.00 | 0.79 |
| 1020 | 10.2 | 1.02 | 57.60 | 19.01 | 23.76 | 0.80 |
| 1040 | 10.4 | 1.04 | 57.60 | 19.01 | 23.52 | 0.81 |
| 1060 | 10.6 | 1.06 | 57.60 | 19.01 | 23.28 | 0.82 |
| 1080 | 10.8 | 1.08 | 57.40 | 18.94 | 23.04 | 0.82 |
| 1100 | 11 | 1.1 | 57.00 | 18.81 | 22.80 | 0.83 |
| 1120 | 11.2 | 1.12 | 57.20 | 18.88 | 22.56 | 0.84 |
| 1140 | 11.4 | 1.14 | 57.10 | 18.84 | 22.32 | 0.84 |
| 1160 | 11.6 | 1.16 | 57.10 | 18.84 | 22.08 | 0.85 |
| 1180 | 11.8 | 1.18 | 57.00 | 18.81 | 21.84 | 0.86 |
| 1200 | 12 | 1.2 | 57.00 | 18.81 | 21.60 | 0.87 |
| 1220 | 12.2 | 1.22 | 57.00 | 18.81 | 21.36 | 0.88 |

**Table:F7** Direct Shear Test Readings for ( Soil +5 % cement + 1.0 $kg/m^3$ ZB) at 0.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| | | | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 3.10 | 1.02 | 35.76 | 0.03 |
| 40 | 0.4 | 0.04 | 7.80 | 2.57 | 35.52 | 0.07 |
| 60 | 0.6 | 0.06 | 11.80 | 3.89 | 35.28 | 0.11 |
| 80 | 0.8 | 0.08 | 13.20 | 4.36 | 35.04 | 0.12 |
| 100 | 1 | 0.1 | 15.20 | 5.02 | 34.80 | 0.14 |
| 120 | 1.2 | 0.12 | 17.00 | 5.61 | 34.56 | 0.16 |
| 140 | 1.4 | 0.14 | 18.40 | 6.07 | 34.32 | 0.18 |
| 160 | 1.6 | 0.16 | 19.40 | 6.40 | 34.08 | 0.19 |
| 180 | 1.8 | 0.18 | 20.20 | 6.67 | 33.84 | 0.20 |
| 200 | 2 | 0.2 | 20.80 | 6.86 | 33.60 | 0.20 |
| 220 | 2.2 | 0.22 | 21.20 | 7.00 | 33.36 | 0.21 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 240 | 2.4 | 0.24 | 21.60 | 7.13 | 33.12 | 0.22 |
| 260 | 2.6 | 0.26 | 21.80 | 7.19 | 32.88 | 0.22 |
| 280 | 2.8 | 0.28 | 22.20 | 7.33 | 32.64 | 0.22 |
| 300 | 3 | 0.3 | 22.60 | 7.46 | 32.40 | 0.23 |
| 320 | 3.2 | 0.32 | 22.80 | 7.52 | 32.16 | 0.23 |
| 340 | 3.4 | 0.34 | 23.20 | 7.66 | 31.92 | 0.24 |
| 360 | 3.6 | 0.36 | 23.40 | 7.72 | 31.68 | 0.24 |
| 380 | 3.8 | 0.38 | 23.80 | 7.85 | 31.44 | 0.25 |
| 400 | 4 | 0.4 | 24.00 | 7.92 | 31.20 | 0.25 |
| 420 | 4.2 | 0.42 | 24.20 | 7.99 | 30.96 | 0.26 |
| 440 | 4.4 | 0.44 | 24.40 | 8.05 | 30.72 | 0.26 |
| 460 | 4.6 | 0.46 | 24.60 | 8.12 | 30.48 | 0.27 |
| 480 | 4.8 | 0.48 | 24.80 | 8.18 | 30.24 | 0.27 |
| 500 | 5 | 0.5 | 25.00 | 8.25 | 30.00 | 0.28 |
| 520 | 5.2 | 0.52 | 25.10 | 8.28 | 29.76 | 0.28 |
| 540 | 5.4 | 0.54 | 25.20 | 8.32 | 29.52 | 0.28 |
| 560 | 5.6 | 0.56 | 25.30 | 8.35 | 29.28 | 0.29 |
| 580 | 5.8 | 0.58 | 25.30 | 8.35 | 29.04 | 0.29 |
| 600 | 6 | 0.6 | 25.20 | 8.32 | 28.80 | 0.29 |
| 620 | 6.2 | 0.62 | 25.20 | 8.32 | 28.56 | 0.29 |
| 640 | 6.4 | 0.64 | 25.40 | 8.38 | 28.32 | 0.30 |
| 660 | 6.6 | 0.66 | 25.20 | 8.32 | 28.08 | 0.30 |
| 680 | 6.8 | 0.68 | 25.20 | 8.32 | 27.84 | 0.30 |
| 700 | 7 | 0.7 | 25.20 | 8.32 | 27.60 | 0.30 |
| 720 | 7.2 | 0.72 | 25.30 | 8.35 | 27.36 | 0.31 |
| 740 | 7.4 | 0.74 | 25.30 | 8.35 | 27.12 | 0.31 |
| 760 | 7.6 | 0.76 | 25.30 | 8.35 | 26.88 | 0.31 |
| 780 | 7.8 | 0.78 | 25.20 | 8.32 | 26.64 | 0.31 |
| 800 | 8 | 0.8 | 25.20 | 8.32 | 26.40 | 0.32 |
| 820 | 8.2 | 0.82 | 25.30 | 8.35 | 26.16 | 0.32 |
| 840 | 8.4 | 0.84 | 25.40 | 8.38 | 25.92 | 0.32 |
| 860 | 8.6 | 0.86 | 25.40 | 8.38 | 25.68 | 0.33 |
| 880 | 8.8 | 0.88 | 25.40 | 8.38 | 25.44 | 0.33 |
| 900 | 9 | 0.9 | 25.20 | 8.32 | 25.20 | 0.33 |
| 920 | 9.2 | 0.92 | 25.00 | 8.25 | 24.96 | 0.33 |
| 940 | 9.4 | 0.94 | 24.80 | 8.18 | 24.72 | 0.33 |
| 960 | 9.6 | 0.96 | 24.60 | 8.12 | 24.48 | 0.33 |
| 980 | 9.8 | 0.98 | 24.40 | 8.05 | 24.24 | 0.33 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 1000 | 10 | 1 | 24.20 | 7.99 | 24.00 | 0.33 |
| 1020 | 10.2 | 1.02 | 24.00 | 7.92 | 23.76 | 0.33 |
| 1040 | 10.4 | 1.04 | 23.80 | 7.85 | 23.52 | 0.33 |
| 1060 | 10.6 | 1.06 | 23.60 | 7.79 | 23.28 | 0.33 |
| 1080 | 10.8 | 1.08 | 23.40 | 7.72 | 23.04 | 0.34 |
| 1100 | 11 | 1.1 | 23.20 | 7.66 | 22.80 | 0.34 |
| 1120 | 11.2 | 1.12 | 23.00 | 7.59 | 22.56 | 0.34 |
| 1140 | 11.4 | 1.14 | 22.80 | 7.52 | 22.32 | 0.34 |
| 1160 | 11.6 | 1.16 | 22.60 | 7.46 | 22.08 | 0.34 |
| 1180 | 11.8 | 1.18 | 22.40 | 7.39 | 21.84 | 0.34 |
| 1200 | 12 | 1.2 | 22.20 | 7.33 | 21.60 | 0.34 |
| 1220 | 12.2 | 1.22 | 22.00 | 7.26 | 21.36 | 0.34 |
| 1240 | 12.4 | 1.24 | 21.80 | 7.19 | 21.12 | 0.34 |

**Table:F8** Direct Shear Test Readings for ( Soil +5 % cement + 1.0 $kg/m^3$ ZB) at 1.0 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| | | | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 5.20 | 1.72 | 35.76 | 0.05 |
| 40 | 0.4 | 0.04 | 9.80 | 3.23 | 35.52 | 0.09 |
| 60 | 0.6 | 0.06 | 15.40 | 5.08 | 35.28 | 0.14 |
| 80 | 0.8 | 0.08 | 19.00 | 6.27 | 35.04 | 0.18 |
| 100 | 1 | 0.1 | 22.40 | 7.39 | 34.80 | 0.21 |
| 120 | 1.2 | 0.12 | 24.00 | 7.92 | 34.56 | 0.23 |
| 140 | 1.4 | 0.14 | 25.40 | 8.38 | 34.32 | 0.24 |
| 160 | 1.6 | 0.16 | 27.00 | 8.91 | 34.08 | 0.26 |
| 180 | 1.8 | 0.18 | 28.00 | 9.24 | 33.84 | 0.27 |
| 200 | 2 | 0.2 | 28.80 | 9.50 | 33.60 | 0.28 |
| 220 | 2.2 | 0.22 | 29.40 | 9.70 | 33.36 | 0.29 |
| 240 | 2.4 | 0.24 | 30.00 | 9.90 | 33.12 | 0.30 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 260 | 2.6 | 0.26 | 30.40 | 10.03 | 32.88 | 0.31 |
| 280 | 2.8 | 0.28 | 31.00 | 10.23 | 32.64 | 0.31 |
| 300 | 3 | 0.3 | 31.30 | 10.33 | 32.40 | 0.32 |
| 320 | 3.2 | 0.32 | 31.80 | 10.49 | 32.16 | 0.33 |
| 340 | 3.4 | 0.34 | 32.20 | 10.63 | 31.92 | 0.33 |
| 360 | 3.6 | 0.36 | 32.80 | 10.82 | 31.68 | 0.34 |
| 380 | 3.8 | 0.38 | 33.00 | 10.89 | 31.44 | 0.35 |
| 400 | 4 | 0.4 | 33.20 | 10.96 | 31.20 | 0.35 |
| 420 | 4.2 | 0.42 | 34.00 | 11.22 | 30.96 | 0.36 |
| 440 | 4.4 | 0.44 | 34.40 | 11.35 | 30.72 | 0.37 |
| 460 | 4.6 | 0.46 | 34.80 | 11.48 | 30.48 | 0.38 |
| 480 | 4.8 | 0.48 | 35.00 | 11.55 | 30.24 | 0.38 |
| 500 | 5 | 0.5 | 35.00 | 11.55 | 30.00 | 0.39 |
| 520 | 5.2 | 0.52 | 36.00 | 11.88 | 29.76 | 0.40 |
| 540 | 5.4 | 0.54 | 36.20 | 11.95 | 29.52 | 0.40 |
| 560 | 5.6 | 0.56 | 36.60 | 12.08 | 29.28 | 0.41 |
| 580 | 5.8 | 0.58 | 37.00 | 12.21 | 29.04 | 0.42 |
| 600 | 6 | 0.6 | 37.20 | 12.28 | 28.80 | 0.43 |
| 620 | 6.2 | 0.62 | 37.40 | 12.34 | 28.56 | 0.43 |
| 640 | 6.4 | 0.64 | 37.60 | 12.41 | 28.32 | 0.44 |
| 660 | 6.6 | 0.66 | 37.80 | 12.47 | 28.08 | 0.44 |
| 680 | 6.8 | 0.68 | 38.00 | 12.54 | 27.84 | 0.45 |
| 700 | 7 | 0.7 | 38.20 | 12.61 | 27.60 | 0.46 |
| 720 | 7.2 | 0.72 | 38.20 | 12.61 | 27.36 | 0.46 |
| 740 | 7.4 | 0.74 | 38.40 | 12.67 | 27.12 | 0.47 |
| 760 | 7.6 | 0.76 | 38.50 | 12.71 | 26.88 | 0.47 |
| 780 | 7.8 | 0.78 | 38.60 | 12.74 | 26.64 | 0.48 |
| 800 | 8 | 0.8 | 38.80 | 12.80 | 26.40 | 0.49 |
| 820 | 8.2 | 0.82 | 38.80 | 12.80 | 26.16 | 0.49 |
| 840 | 8.4 | 0.84 | 38.60 | 12.74 | 25.92 | 0.49 |
| 860 | 8.6 | 0.86 | 38.60 | 12.74 | 25.68 | 0.50 |
| 880 | 8.8 | 0.88 | 38.50 | 12.71 | 25.44 | 0.50 |
| 900 | 9 | 0.9 | 38.40 | 12.67 | 25.20 | 0.50 |
| 920 | 9.2 | 0.92 | 38.40 | 12.67 | 24.96 | 0.51 |
| 940 | 9.4 | 0.94 | 38.40 | 12.67 | 24.72 | 0.51 |
| 960 | 9.6 | 0.96 | 38.20 | 12.61 | 24.48 | 0.51 |
| 980 | 9.8 | 0.98 | 38.20 | 12.61 | 24.24 | 0.52 |
| 1000 | 10 | 1 | 38.00 | 12.54 | 24.00 | 0.52 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 1020 | 10.2 | 1.02 | 38.00 | 12.54 | 23.76 | 0.53 |
| 1040 | 10.4 | 1.04 | 38.00 | 12.54 | 23.52 | 0.53 |
| 1060 | 10.6 | 1.06 | 37.80 | 12.47 | 23.28 | 0.54 |
| 1080 | 10.8 | 1.08 | 37.80 | 12.47 | 23.04 | 0.54 |
| 1100 | 11 | 1.1 | 37.80 | 12.47 | 22.80 | 0.55 |
| 1120 | 11.2 | 1.12 | 37.80 | 12.47 | 22.56 | 0.55 |
| 1140 | 11.4 | 1.14 | 37.60 | 12.41 | 22.32 | 0.56 |
| 1160 | 11.6 | 1.16 | 37.60 | 12.41 | 22.08 | 0.56 |
| 1180 | 11.8 | 1.18 | 37.60 | 12.41 | 21.84 | 0.57 |
| 1200 | 12 | 1.2 | 37.50 | 12.38 | 21.60 | 0.57 |
| 1220 | 12.2 | 1.22 | 37.44 | 12.36 | 21.36 | 0.58 |

**Table:F9** Direct Shear Test Readings for ( Soil +5 % cement + 1.0 $kg/m^3$ ZB) at 1.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 10.20 | 3.37 | 35.76 | 0.09 |
| 40 | 0.4 | 0.04 | 16.20 | 5.35 | 35.52 | 0.15 |
| 60 | 0.6 | 0.06 | 24.60 | 8.12 | 35.28 | 0.23 |
| 80 | 0.8 | 0.08 | 31.60 | 10.43 | 35.04 | 0.30 |
| 100 | 1 | 0.1 | 35.90 | 11.85 | 34.80 | 0.34 |
| 120 | 1.2 | 0.12 | 39.20 | 12.94 | 34.56 | 0.37 |
| 140 | 1.4 | 0.14 | 41.60 | 13.73 | 34.32 | 0.40 |
| 160 | 1.6 | 0.16 | 42.80 | 14.12 | 34.08 | 0.41 |
| 180 | 1.8 | 0.18 | 45.00 | 14.85 | 33.84 | 0.44 |
| 200 | 2 | 0.2 | 46.20 | 15.25 | 33.60 | 0.45 |
| 220 | 2.2 | 0.22 | 47.20 | 15.58 | 33.36 | 0.47 |
| 240 | 2.4 | 0.24 | 48.00 | 15.84 | 33.12 | 0.48 |
| 260 | 2.6 | 0.26 | 49.00 | 16.17 | 32.88 | 0.49 |
| 280 | 2.8 | 0.28 | 49.80 | 16.43 | 32.64 | 0.50 |
| 300 | 3 | 0.3 | 50.40 | 16.63 | 32.40 | 0.51 |
| 320 | 3.2 | 0.32 | 51.40 | 16.96 | 32.16 | 0.53 |
| 340 | 3.4 | 0.34 | 52.00 | 17.16 | 31.92 | 0.54 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 360 | 3.6 | 0.36 | 52.80 | 17.42 | 31.68 | 0.55 |
| 380 | 3.8 | 0.38 | 53.20 | 17.56 | 31.44 | 0.56 |
| 400 | 4 | 0.4 | 53.80 | 17.75 | 31.20 | 0.57 |
| 420 | 4.2 | 0.42 | 54.00 | 17.82 | 30.96 | 0.58 |
| 440 | 4.4 | 0.44 | 54.40 | 17.95 | 30.72 | 0.58 |
| 460 | 4.6 | 0.46 | 55.00 | 18.15 | 30.48 | 0.60 |
| 480 | 4.8 | 0.48 | 55.20 | 18.22 | 30.24 | 0.60 |
| 500 | 5 | 0.5 | 55.60 | 18.35 | 30.00 | 0.61 |
| 520 | 5.2 | 0.52 | 55.80 | 18.41 | 29.76 | 0.62 |
| 540 | 5.4 | 0.54 | 56.20 | 18.55 | 29.52 | 0.63 |
| 560 | 5.6 | 0.56 | 56.60 | 18.68 | 29.28 | 0.64 |
| 580 | 5.8 | 0.58 | 56.80 | 18.74 | 29.04 | 0.65 |
| 600 | 6 | 0.6 | 57.20 | 18.88 | 28.80 | 0.66 |
| 620 | 6.2 | 0.62 | 57.40 | 18.94 | 28.56 | 0.66 |
| 640 | 6.4 | 0.64 | 57.40 | 18.94 | 28.32 | 0.67 |
| 660 | 6.6 | 0.66 | 57.40 | 18.94 | 28.08 | 0.67 |
| 680 | 6.8 | 0.68 | 57.40 | 18.94 | 27.84 | 0.68 |
| 700 | 7 | 0.7 | 57.40 | 18.94 | 27.60 | 0.69 |
| 720 | 7.2 | 0.72 | 57.50 | 18.98 | 27.36 | 0.69 |
| 740 | 7.4 | 0.74 | 57.40 | 18.94 | 27.12 | 0.70 |
| 760 | 7.6 | 0.76 | 57.50 | 18.98 | 26.88 | 0.71 |
| 780 | 7.8 | 0.78 | 57.40 | 18.94 | 26.64 | 0.71 |
| 800 | 8 | 0.8 | 57.40 | 18.94 | 26.40 | 0.72 |
| 820 | 8.2 | 0.82 | 57.60 | 19.01 | 26.16 | 0.73 |
| 840 | 8.4 | 0.84 | 57.60 | 19.01 | 25.92 | 0.73 |
| 860 | 8.6 | 0.86 | 57.60 | 19.01 | 25.68 | 0.74 |
| 880 | 8.8 | 0.88 | 57.50 | 18.98 | 25.44 | 0.75 |
| 900 | 9 | 0.9 | 57.40 | 18.94 | 25.20 | 0.75 |
| 920 | 9.2 | 0.92 | 57.40 | 18.94 | 24.96 | 0.76 |
| 940 | 9.4 | 0.94 | 57.40 | 18.94 | 24.72 | 0.77 |
| 960 | 9.6 | 0.96 | 57.20 | 18.88 | 24.48 | 0.77 |
| 980 | 9.8 | 0.98 | 57.20 | 18.88 | 24.24 | 0.78 |
| 1000 | 10 | 1 | 57.20 | 18.88 | 24.00 | 0.79 |
| 1020 | 10.2 | 1.02 | 57.20 | 18.88 | 23.76 | 0.79 |
| 1040 | 10.4 | 1.04 | 57.00 | 18.81 | 23.52 | 0.80 |
| 1060 | 10.6 | 1.06 | 57.00 | 18.81 | 23.28 | 0.81 |
| 1080 | 10.8 | 1.08 | 57.10 | 18.84 | 23.04 | 0.82 |
| 1100 | 11 | 1.1 | 57.00 | 18.81 | 22.80 | 0.83 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 1120 | 11.2 | 1.12 | 57.10 | 18.84 | 22.56 | 0.84 |
| 1140 | 11.4 | 1.14 | 57.10 | 18.84 | 22.32 | 0.84 |
| 1160 | 11.6 | 1.16 | 57.10 | 18.84 | 22.08 | 0.85 |
| 1180 | 11.8 | 1.18 | 57.00 | 18.81 | 21.84 | 0.86 |
| 1200 | 12 | 1.2 | 57.00 | 18.81 | 21.60 | 0.87 |
| 1220 | 12.2 | 1.22 | 57.00 | 18.81 | 21.36 | 0.88 |

**Table:F10** Direct Shear Test Readings for ( Soil +5 % cement + 1.25 $kg/m^3$ ZB) at 0.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 4.80 | 1.58 | 35.76 | 0.04 |
| 40 | 0.4 | 0.04 | 11.40 | 3.76 | 35.52 | 0.11 |
| 60 | 0.6 | 0.06 | 14.20 | 4.69 | 35.28 | 0.13 |
| 80 | 0.8 | 0.08 | 16.20 | 5.35 | 35.04 | 0.15 |
| 100 | 1 | 0.1 | 17.60 | 5.81 | 34.80 | 0.17 |
| 120 | 1.2 | 0.12 | 19.00 | 6.27 | 34.56 | 0.18 |
| 140 | 1.4 | 0.14 | 20.20 | 6.67 | 34.32 | 0.19 |
| 160 | 1.6 | 0.16 | 20.60 | 6.80 | 34.08 | 0.20 |
| 180 | 1.8 | 0.18 | 21.00 | 6.93 | 33.84 | 0.20 |
| 200 | 2 | 0.2 | 21.40 | 7.06 | 33.60 | 0.21 |
| 220 | 2.2 | 0.22 | 21.60 | 7.13 | 33.36 | 0.21 |
| 240 | 2.4 | 0.24 | 21.80 | 7.19 | 33.12 | 0.22 |
| 260 | 2.6 | 0.26 | 22.00 | 7.26 | 32.88 | 0.22 |
| 280 | 2.8 | 0.28 | 22.20 | 7.33 | 32.64 | 0.22 |
| 300 | 3 | 0.3 | 22.60 | 7.46 | 32.40 | 0.23 |
| 320 | 3.2 | 0.32 | 22.90 | 7.56 | 32.16 | 0.23 |
| 340 | 3.4 | 0.34 | 23.10 | 7.62 | 31.92 | 0.24 |
| 360 | 3.6 | 0.36 | 23.20 | 7.66 | 31.68 | 0.24 |
| 380 | 3.8 | 0.38 | 23.30 | 7.69 | 31.44 | 0.24 |
| 400 | 4 | 0.4 | 23.40 | 7.72 | 31.20 | 0.25 |
| 420 | 4.2 | 0.42 | 23.60 | 7.79 | 30.96 | 0.25 |
| 440 | 4.4 | 0.44 | 23.80 | 7.85 | 30.72 | 0.26 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 460 | 4.6 | 0.46 | 23.90 | 7.89 | 30.48 | 0.26 |
| 480 | 4.8 | 0.48 | 24.00 | 7.92 | 30.24 | 0.26 |
| 500 | 5 | 0.5 | 24.10 | 7.95 | 30.00 | 0.27 |
| 520 | 5.2 | 0.52 | 24.20 | 7.99 | 29.76 | 0.27 |
| 540 | 5.4 | 0.54 | 24.20 | 7.99 | 29.52 | 0.27 |
| 560 | 5.6 | 0.56 | 24.30 | 8.02 | 29.28 | 0.27 |
| 580 | 5.8 | 0.58 | 24.30 | 8.02 | 29.04 | 0.28 |
| 600 | 6 | 0.6 | 24.40 | 8.05 | 28.80 | 0.28 |
| 620 | 6.2 | 0.62 | 24.40 | 8.05 | 28.56 | 0.28 |
| 640 | 6.4 | 0.64 | 24.40 | 8.05 | 28.32 | 0.28 |
| 660 | 6.6 | 0.66 | 24.40 | 8.05 | 28.08 | 0.29 |
| 680 | 6.8 | 0.68 | 24.50 | 8.09 | 27.84 | 0.29 |
| 700 | 7 | 0.7 | 24.60 | 8.12 | 27.60 | 0.29 |
| 720 | 7.2 | 0.72 | 24.60 | 8.12 | 27.36 | 0.30 |
| 740 | 7.4 | 0.74 | 24.60 | 8.12 | 27.12 | 0.30 |
| 760 | 7.6 | 0.76 | 24.60 | 8.12 | 26.88 | 0.30 |
| 780 | 7.8 | 0.78 | 24.60 | 8.12 | 26.64 | 0.30 |
| 800 | 8 | 0.8 | 24.60 | 8.12 | 26.40 | 0.31 |
| 820 | 8.2 | 0.82 | 24.50 | 8.09 | 26.16 | 0.31 |
| 840 | 8.4 | 0.84 | 24.50 | 8.09 | 25.92 | 0.31 |
| 860 | 8.6 | 0.86 | 24.40 | 8.05 | 25.68 | 0.31 |
| 880 | 8.8 | 0.88 | 24.40 | 8.05 | 25.44 | 0.32 |
| 900 | 9 | 0.9 | 24.40 | 8.05 | 25.20 | 0.32 |
| 920 | 9.2 | 0.92 | 24.20 | 7.99 | 24.96 | 0.32 |
| 940 | 9.4 | 0.94 | 24.00 | 7.92 | 24.72 | 0.32 |
| 960 | 9.6 | 0.96 | 24.10 | 7.95 | 24.48 | 0.32 |
| 980 | 9.8 | 0.98 | 24.10 | 7.95 | 24.24 | 0.33 |
| 1000 | 10 | 1 | 24.10 | 7.95 | 24.00 | 0.33 |
| 1020 | 10.2 | 1.02 | 24.10 | 7.95 | 23.76 | 0.33 |
| 1040 | 10.4 | 1.04 | 24.00 | 7.92 | 23.52 | 0.34 |
| 1060 | 10.6 | 1.06 | 23.80 | 7.85 | 23.28 | 0.34 |
| 1080 | 10.8 | 1.08 | 23.80 | 7.85 | 23.04 | 0.34 |
| 1100 | 11 | 1.1 | 23.60 | 7.79 | 22.80 | 0.34 |
| 1120 | 11.2 | 1.12 | 23.50 | 7.76 | 22.56 | 0.34 |
| 1140 | 11.4 | 1.14 | 23.20 | 7.66 | 22.32 | 0.34 |
| 1160 | 11.6 | 1.16 | 23.00 | 7.59 | 22.08 | 0.34 |
| 1180 | 11.8 | 1.18 | 22.80 | 7.52 | 21.84 | 0.34 |
| 1200 | 12 | 1.2 | 22.40 | 7.39 | 21.60 | 0.34 |

**Table:F11** Direct Shear Test Readings for ( Soil +5 % cement + 1.25 kg/$m^3$ ZB) at 1.0 kg/$cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| | | | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 9.80 | 3.23 | 35.76 | 0.09 |
| 40 | 0.4 | 0.04 | 14.20 | 4.69 | 35.52 | 0.13 |
| 60 | 0.6 | 0.06 | 19.20 | 6.34 | 35.28 | 0.18 |
| 80 | 0.8 | 0.08 | 26.80 | 8.84 | 35.04 | 0.25 |
| 100 | 1 | 0.1 | 27.60 | 9.11 | 34.80 | 0.26 |
| 120 | 1.2 | 0.12 | 29.80 | 9.83 | 34.56 | 0.28 |
| 140 | 1.4 | 0.14 | 31.20 | 10.30 | 34.32 | 0.30 |
| 160 | 1.6 | 0.16 | 32.00 | 10.56 | 34.08 | 0.31 |
| 180 | 1.8 | 0.18 | 32.80 | 10.82 | 33.84 | 0.32 |
| 200 | 2 | 0.2 | 33.60 | 11.09 | 33.60 | 0.33 |
| 220 | 2.2 | 0.22 | 34.00 | 11.22 | 33.36 | 0.34 |
| 240 | 2.4 | 0.24 | 34.40 | 11.35 | 33.12 | 0.34 |
| 260 | 2.6 | 0.26 | 35.00 | 11.55 | 32.88 | 0.35 |
| 280 | 2.8 | 0.28 | 35.50 | 11.72 | 32.64 | 0.36 |
| 300 | 3 | 0.3 | 36.00 | 11.88 | 32.40 | 0.37 |
| 320 | 3.2 | 0.32 | 36.40 | 12.01 | 32.16 | 0.37 |
| 340 | 3.4 | 0.34 | 36.80 | 12.14 | 31.92 | 0.38 |
| 360 | 3.6 | 0.36 | 37.20 | 12.28 | 31.68 | 0.39 |
| 380 | 3.8 | 0.38 | 37.60 | 12.41 | 31.44 | 0.39 |
| 400 | 4 | 0.4 | 37.80 | 12.47 | 31.20 | 0.40 |
| 420 | 4.2 | 0.42 | 38.00 | 12.54 | 30.96 | 0.41 |
| 440 | 4.4 | 0.44 | 38.40 | 12.67 | 30.72 | 0.41 |
| 460 | 4.6 | 0.46 | 38.80 | 12.80 | 30.48 | 0.42 |
| 480 | 4.8 | 0.48 | 39.00 | 12.87 | 30.24 | 0.43 |
| 500 | 5 | 0.5 | 39.20 | 12.94 | 30.00 | 0.43 |
| 520 | 5.2 | 0.52 | 39.60 | 13.07 | 29.76 | 0.44 |
| 540 | 5.4 | 0.54 | 39.80 | 13.13 | 29.52 | 0.44 |
| 560 | 5.6 | 0.56 | 40.10 | 13.23 | 29.28 | 0.45 |
| 580 | 5.8 | 0.58 | 40.40 | 13.33 | 29.04 | 0.46 |
| 600 | 6 | 0.6 | 40.80 | 13.46 | 28.80 | 0.47 |
| 620 | 6.2 | 0.62 | 41.00 | 13.53 | 28.56 | 0.47 |
| 640 | 6.4 | 0.64 | 41.40 | 13.66 | 28.32 | 0.48 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 660 | 6.6 | 0.66 | 41.60 | 13.73 | 28.08 | 0.49 |
| 680 | 6.8 | 0.68 | 41.80 | 13.79 | 27.84 | 0.50 |
| 700 | 7 | 0.7 | 42.00 | 13.86 | 27.60 | 0.50 |
| 720 | 7.2 | 0.72 | 42.10 | 13.89 | 27.36 | 0.51 |
| 740 | 7.4 | 0.74 | 42.20 | 13.93 | 27.12 | 0.51 |
| 760 | 7.6 | 0.76 | 42.40 | 13.99 | 26.88 | 0.52 |
| 780 | 7.8 | 0.78 | 42.40 | 13.99 | 26.64 | 0.53 |
| 800 | 8 | 0.8 | 42.40 | 13.99 | 26.40 | 0.53 |
| 820 | 8.2 | 0.82 | 42.60 | 14.06 | 26.16 | 0.54 |
| 840 | 8.4 | 0.84 | 42.80 | 14.12 | 25.92 | 0.54 |
| 860 | 8.6 | 0.86 | 42.90 | 14.16 | 25.68 | 0.55 |
| 880 | 8.8 | 0.88 | 42.90 | 14.16 | 25.44 | 0.56 |
| 900 | 9 | 0.9 | 42.90 | 14.16 | 25.20 | 0.56 |
| 920 | 9.2 | 0.92 | 43.00 | 14.19 | 24.96 | 0.57 |
| 940 | 9.4 | 0.94 | 43.00 | 14.19 | 24.72 | 0.57 |
| 960 | 9.6 | 0.96 | 43.00 | 14.19 | 24.48 | 0.58 |
| 980 | 9.8 | 0.98 | 43.00 | 14.19 | 24.24 | 0.59 |
| 1000 | 10 | 1 | 43.10 | 14.22 | 24.00 | 0.59 |
| 1020 | 10.2 | 1.02 | 43.00 | 14.19 | 23.76 | 0.60 |
| 1040 | 10.4 | 1.04 | 42.90 | 14.16 | 23.52 | 0.60 |
| 1060 | 10.6 | 1.06 | 42.80 | 14.12 | 23.28 | 0.61 |
| 1080 | 10.8 | 1.08 | 42.90 | 14.16 | 23.04 | 0.61 |
| 1100 | 11 | 1.1 | 42.80 | 14.12 | 22.80 | 0.62 |
| 1120 | 11.2 | 1.12 | 42.80 | 14.12 | 22.56 | 0.63 |
| 1140 | 11.4 | 1.14 | 42.70 | 14.09 | 22.32 | 0.63 |
| 1160 | 11.6 | 1.16 | 42.00 | 13.86 | 22.08 | 0.63 |
| 1180 | 11.8 | 1.18 | 41.60 | 13.73 | 21.84 | 0.63 |
| 1200 | 12 | 1.2 | 41.20 | 13.60 | 21.60 | 0.63 |
| 1220 | 12.2 | 1.22 | 41.20 | 13.60 | 21.36 | 0.64 |

**Table:F12** Direct Shear Test Readings for ( Soil +5 % cement + 1.25 $kg/m^3$ ZB) at 1.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 18.80 | 6.20 | 35.76 | 0.17 |
| 40 | 0.4 | 0.04 | 32.60 | 10.76 | 35.52 | 0.30 |
| 60 | 0.6 | 0.06 | 38.40 | 12.67 | 35.28 | 0.36 |
| 80 | 0.8 | 0.08 | 42.00 | 13.86 | 35.04 | 0.40 |
| 100 | 1 | 0.1 | 45.20 | 14.92 | 34.80 | 0.43 |
| 120 | 1.2 | 0.12 | 49.20 | 16.24 | 34.56 | 0.47 |
| 140 | 1.4 | 0.14 | 52.20 | 17.23 | 34.32 | 0.50 |
| 160 | 1.6 | 0.16 | 53.20 | 17.56 | 34.08 | 0.52 |
| 180 | 1.8 | 0.18 | 54.20 | 17.89 | 33.84 | 0.53 |
| 200 | 2 | 0.2 | 55.10 | 18.18 | 33.60 | 0.54 |
| 220 | 2.2 | 0.22 | 56.00 | 18.48 | 33.36 | 0.55 |
| 240 | 2.4 | 0.24 | 56.60 | 18.68 | 33.12 | 0.56 |
| 260 | 2.6 | 0.26 | 56.90 | 18.78 | 32.88 | 0.57 |
| 280 | 2.8 | 0.28 | 57.40 | 18.94 | 32.64 | 0.58 |
| 300 | 3 | 0.3 | 58.00 | 19.14 | 32.40 | 0.59 |
| 320 | 3.2 | 0.32 | 58.40 | 19.27 | 32.16 | 0.60 |
| 340 | 3.4 | 0.34 | 59.20 | 19.54 | 31.92 | 0.61 |
| 360 | 3.6 | 0.36 | 60.10 | 19.83 | 31.68 | 0.63 |
| 380 | 3.8 | 0.38 | 61.00 | 20.13 | 31.44 | 0.64 |
| 400 | 4 | 0.4 | 61.40 | 20.26 | 31.20 | 0.65 |
| 420 | 4.2 | 0.42 | 61.80 | 20.39 | 30.96 | 0.66 |
| 440 | 4.4 | 0.44 | 62.00 | 20.46 | 30.72 | 0.67 |
| 460 | 4.6 | 0.46 | 62.60 | 20.66 | 30.48 | 0.68 |
| 480 | 4.8 | 0.48 | 63.20 | 20.86 | 30.24 | 0.69 |
| 500 | 5 | 0.5 | 63.80 | 21.05 | 30.00 | 0.70 |
| 520 | 5.2 | 0.52 | 64.20 | 21.19 | 29.76 | 0.71 |
| 540 | 5.4 | 0.54 | 64.60 | 21.32 | 29.52 | 0.72 |
| 560 | 5.6 | 0.56 | 65.00 | 21.45 | 29.28 | 0.73 |
| 580 | 5.8 | 0.58 | 65.20 | 21.52 | 29.04 | 0.74 |
| 600 | 6 | 0.6 | 65.40 | 21.58 | 28.80 | 0.75 |
| 620 | 6.2 | 0.62 | 65.80 | 21.71 | 28.56 | 0.76 |
| 640 | 6.4 | 0.64 | 65.80 | 21.71 | 28.32 | 0.77 |
| 660 | 6.6 | 0.66 | 66.00 | 21.78 | 28.08 | 0.78 |
| 680 | 6.8 | 0.68 | 66.20 | 21.85 | 27.84 | 0.78 |
| 700 | 7 | 0.7 | 66.20 | 21.85 | 27.60 | 0.79 |
| 720 | 7.2 | 0.72 | 66.20 | 21.85 | 27.36 | 0.80 |
| 740 | 7.4 | 0.74 | 66.40 | 21.91 | 27.12 | 0.81 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 760 | 7.6 | 0.76 | 66.40 | 21.91 | 26.88 | 0.82 |
| 780 | 7.8 | 0.78 | 66.20 | 21.85 | 26.64 | 0.82 |
| 800 | 8 | 0.8 | 66.30 | 21.88 | 26.40 | 0.83 |
| 820 | 8.2 | 0.82 | 66.30 | 21.88 | 26.16 | 0.84 |
| 840 | 8.4 | 0.84 | 66.20 | 21.85 | 25.92 | 0.84 |
| 860 | 8.6 | 0.86 | 66.20 | 21.85 | 25.68 | 0.85 |
| 880 | 8.8 | 0.88 | 66.00 | 21.78 | 25.44 | 0.86 |
| 900 | 9 | 0.9 | 66.00 | 21.78 | 25.20 | 0.86 |
| 920 | 9.2 | 0.92 | 66.00 | 21.78 | 24.96 | 0.87 |
| 940 | 9.4 | 0.94 | 65.80 | 21.71 | 24.72 | 0.88 |
| 960 | 9.6 | 0.96 | 65.70 | 21.68 | 24.48 | 0.89 |
| 980 | 9.8 | 0.98 | 65.60 | 21.65 | 24.24 | 0.89 |
| 1000 | 10 | 1 | 65.50 | 21.62 | 24.00 | 0.90 |
| 1020 | 10.2 | 1.02 | 65.40 | 21.58 | 23.76 | 0.91 |
| 1040 | 10.4 | 1.04 | 65.40 | 21.58 | 23.52 | 0.92 |
| 1060 | 10.6 | 1.06 | 65.20 | 21.52 | 23.28 | 0.92 |
| 1080 | 10.8 | 1.08 | 65.20 | 21.52 | 23.04 | 0.93 |
| 1100 | 11 | 1.1 | 65.20 | 21.52 | 22.80 | 0.94 |
| 1120 | 11.2 | 1.12 | 65.20 | 21.52 | 22.56 | 0.95 |
| 1140 | 11.4 | 1.14 | 65.00 | 21.45 | 22.32 | 0.96 |
| 1160 | 11.6 | 1.16 | 65.00 | 21.45 | 22.08 | 0.97 |
| 1180 | 11.8 | 1.18 | 65.00 | 21.45 | 21.84 | 0.98 |
| 1200 | 12 | 1.2 | 65.00 | 21.45 | 21.60 | 0.99 |
| 1220 | 12.2 | 1.22 | 65.00 | 21.45 | 21.36 | 1.00 |

**Table:F13** Direct Shear Test Readings for ( Soil +5 % cement + 1.5 $kg/m^3$ ZB) at 0.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| | | | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 4.60 | 1.52 | 35.76 | 0.04 |
| 40 | 0.4 | 0.04 | 9.80 | 3.23 | 35.52 | 0.09 |
| 60 | 0.6 | 0.06 | 12.00 | 3.96 | 35.28 | 0.11 |
| 80 | 0.8 | 0.08 | 14.60 | 4.82 | 35.04 | 0.14 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 100 | 1 | 0.1 | 16.20 | 5.35 | 34.80 | 0.15 |
| 120 | 1.2 | 0.12 | 17.20 | 5.68 | 34.56 | 0.16 |
| 140 | 1.4 | 0.14 | 18.00 | 5.94 | 34.32 | 0.17 |
| 160 | 1.6 | 0.16 | 18.30 | 6.04 | 34.08 | 0.18 |
| 180 | 1.8 | 0.18 | 18.60 | 6.14 | 33.84 | 0.18 |
| 200 | 2 | 0.2 | 18.80 | 6.20 | 33.60 | 0.18 |
| 220 | 2.2 | 0.22 | 19.20 | 6.34 | 33.36 | 0.19 |
| 240 | 2.4 | 0.24 | 19.40 | 6.40 | 33.12 | 0.19 |
| 260 | 2.6 | 0.26 | 19.70 | 6.50 | 32.88 | 0.20 |
| 280 | 2.8 | 0.28 | 20.00 | 6.60 | 32.64 | 0.20 |
| 300 | 3 | 0.3 | 20.00 | 6.60 | 32.40 | 0.20 |
| 320 | 3.2 | 0.32 | 20.20 | 6.67 | 32.16 | 0.21 |
| 340 | 3.4 | 0.34 | 20.40 | 6.73 | 31.92 | 0.21 |
| 360 | 3.6 | 0.36 | 20.60 | 6.80 | 31.68 | 0.21 |
| 380 | 3.8 | 0.38 | 20.70 | 6.83 | 31.44 | 0.22 |
| 400 | 4 | 0.4 | 20.80 | 6.86 | 31.20 | 0.22 |
| 420 | 4.2 | 0.42 | 21.00 | 6.93 | 30.96 | 0.22 |
| 440 | 4.4 | 0.44 | 21.20 | 7.00 | 30.72 | 0.23 |
| 460 | 4.6 | 0.46 | 21.40 | 7.06 | 30.48 | 0.23 |
| 480 | 4.8 | 0.48 | 21.60 | 7.13 | 30.24 | 0.24 |
| 500 | 5 | 0.5 | 21.60 | 7.13 | 30.00 | 0.24 |
| 520 | 5.2 | 0.52 | 21.70 | 7.16 | 29.76 | 0.24 |
| 540 | 5.4 | 0.54 | 21.80 | 7.19 | 29.52 | 0.24 |
| 560 | 5.6 | 0.56 | 21.80 | 7.19 | 29.28 | 0.25 |
| 580 | 5.8 | 0.58 | 21.80 | 7.19 | 29.04 | 0.25 |
| 600 | 6 | 0.6 | 21.80 | 7.19 | 28.80 | 0.25 |
| 620 | 6.2 | 0.62 | 21.80 | 7.19 | 28.56 | 0.25 |
| 640 | 6.4 | 0.64 | 21.80 | 7.19 | 28.32 | 0.25 |
| 660 | 6.6 | 0.66 | 21.80 | 7.19 | 28.08 | 0.26 |
| 680 | 6.8 | 0.68 | 21.60 | 7.13 | 27.84 | 0.26 |
| 700 | 7 | 0.7 | 21.60 | 7.13 | 27.60 | 0.26 |
| 720 | 7.2 | 0.72 | 21.60 | 7.13 | 27.36 | 0.26 |
| 740 | 7.4 | 0.74 | 21.40 | 7.06 | 27.12 | 0.26 |
| 760 | 7.6 | 0.76 | 21.40 | 7.06 | 26.88 | 0.26 |
| 780 | 7.8 | 0.78 | 21.20 | 7.00 | 26.64 | 0.26 |
| 800 | 8 | 0.8 | 21.20 | 7.00 | 26.40 | 0.27 |
| 820 | 8.2 | 0.82 | 21.20 | 7.00 | 26.16 | 0.27 |
| 840 | 8.4 | 0.84 | 21.20 | 7.00 | 25.92 | 0.27 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 860 | 8.6 | 0.86 | 21.00 | 6.93 | 25.68 | 0.27 |
| 880 | 8.8 | 0.88 | 21.00 | 6.93 | 25.44 | 0.27 |
| 900 | 9 | 0.9 | 21.00 | 6.93 | 25.20 | 0.28 |
| 920 | 9.2 | 0.92 | 20.80 | 6.86 | 24.96 | 0.28 |
| 940 | 9.4 | 0.94 | 20.60 | 6.80 | 24.72 | 0.28 |
| 960 | 9.6 | 0.96 | 20.60 | 6.80 | 24.48 | 0.28 |
| 980 | 9.8 | 0.98 | 20.70 | 6.83 | 24.24 | 0.28 |
| 1000 | 10 | 1 | 20.60 | 6.80 | 24.00 | 0.28 |
| 1020 | 10.2 | 1.02 | 20.60 | 6.80 | 23.76 | 0.29 |
| 1040 | 10.4 | 1.04 | 20.60 | 6.80 | 23.52 | 0.29 |
| 1060 | 10.6 | 1.06 | 20.50 | 6.77 | 23.28 | 0.29 |
| 1080 | 10.8 | 1.08 | 20.40 | 6.73 | 23.04 | 0.29 |
| 1100 | 11 | 1.1 | 20.20 | 6.67 | 22.80 | 0.29 |
| 1120 | 11.2 | 1.12 | 20.00 | 6.60 | 22.56 | 0.29 |
| 1140 | 11.4 | 1.14 | 20.00 | 6.60 | 22.32 | 0.30 |
| 1160 | 11.6 | 1.16 | 20.00 | 6.60 | 22.08 | 0.30 |
| 1180 | 11.8 | 1.18 | 19.80 | 6.53 | 21.84 | 0.30 |
| 1200 | 12 | 1.2 | 19.60 | 6.47 | 21.60 | 0.30 |
| 1220 | 12.2 | 1.22 | 19.20 | 6.34 | 21.36 | 0.30 |

**Table:F14** Direct Shear Test Readings for ( Soil +5 % cement + 1.5 $kg/m^3$ ZB) at 1 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| | | | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 9.80 | 3.23 | 35.76 | 0.09 |
| 40 | 0.4 | 0.04 | 14.60 | 4.82 | 35.52 | 0.14 |
| 60 | 0.6 | 0.06 | 19.80 | 6.53 | 35.28 | 0.19 |
| 80 | 0.8 | 0.08 | 22.20 | 7.33 | 35.04 | 0.21 |
| 100 | 1 | 0.1 | 24.60 | 8.12 | 34.80 | 0.23 |
| 120 | 1.2 | 0.12 | 25.40 | 8.38 | 34.56 | 0.24 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 140 | 1.4 | 0.14 | 27.80 | 9.17 | 34.32 | 0.27 |
| 160 | 1.6 | 0.16 | 29.20 | 9.64 | 34.08 | 0.28 |
| 180 | 1.8 | 0.18 | 30.20 | 9.97 | 33.84 | 0.29 |
| 200 | 2 | 0.2 | 31.10 | 10.26 | 33.60 | 0.31 |
| 220 | 2.2 | 0.22 | 32.00 | 10.56 | 33.36 | 0.32 |
| 240 | 2.4 | 0.24 | 32.60 | 10.76 | 33.12 | 0.32 |
| 260 | 2.6 | 0.26 | 33.20 | 10.96 | 32.88 | 0.33 |
| 280 | 2.8 | 0.28 | 34.10 | 11.25 | 32.64 | 0.34 |
| 300 | 3 | 0.3 | 34.60 | 11.42 | 32.40 | 0.35 |
| 320 | 3.2 | 0.32 | 35.20 | 11.62 | 32.16 | 0.36 |
| 340 | 3.4 | 0.34 | 35.80 | 11.81 | 31.92 | 0.37 |
| 360 | 3.6 | 0.36 | 36.60 | 12.08 | 31.68 | 0.38 |
| 380 | 3.8 | 0.38 | 37.00 | 12.21 | 31.44 | 0.39 |
| 400 | 4 | 0.4 | 37.40 | 12.34 | 31.20 | 0.40 |
| 420 | 4.2 | 0.42 | 38.00 | 12.54 | 30.96 | 0.41 |
| 440 | 4.4 | 0.44 | 38.40 | 12.67 | 30.72 | 0.41 |
| 460 | 4.6 | 0.46 | 38.80 | 12.80 | 30.48 | 0.42 |
| 480 | 4.8 | 0.48 | 39.20 | 12.94 | 30.24 | 0.43 |
| 500 | 5 | 0.5 | 39.80 | 13.13 | 30.00 | 0.44 |
| 520 | 5.2 | 0.52 | 40.00 | 13.20 | 29.76 | 0.44 |
| 540 | 5.4 | 0.54 | 40.00 | 13.20 | 29.52 | 0.45 |
| 560 | 5.6 | 0.56 | 40.20 | 13.27 | 29.28 | 0.45 |
| 580 | 5.8 | 0.58 | 40.20 | 13.27 | 29.04 | 0.46 |
| 600 | 6 | 0.6 | 40.40 | 13.33 | 28.80 | 0.46 |
| 620 | 6.2 | 0.62 | 40.60 | 13.40 | 28.56 | 0.47 |
| 640 | 6.4 | 0.64 | 40.60 | 13.40 | 28.32 | 0.47 |
| 660 | 6.6 | 0.66 | 40.70 | 13.43 | 28.08 | 0.48 |
| 680 | 6.8 | 0.68 | 40.70 | 13.43 | 27.84 | 0.48 |
| 700 | 7 | 0.7 | 40.60 | 13.40 | 27.60 | 0.49 |
| 720 | 7.2 | 0.72 | 40.60 | 13.40 | 27.36 | 0.49 |
| 740 | 7.4 | 0.74 | 40.50 | 13.37 | 27.12 | 0.49 |
| 760 | 7.6 | 0.76 | 40.50 | 13.37 | 26.88 | 0.50 |
| 780 | 7.8 | 0.78 | 40.40 | 13.33 | 26.64 | 0.50 |
| 800 | 8 | 0.8 | 40.40 | 13.33 | 26.40 | 0.51 |
| 820 | 8.2 | 0.82 | 40.30 | 13.30 | 26.16 | 0.51 |
| 840 | 8.4 | 0.84 | 40.00 | 13.20 | 25.92 | 0.51 |
| 860 | 8.6 | 0.86 | 39.80 | 13.13 | 25.68 | 0.51 |
| 880 | 8.8 | 0.88 | 39.80 | 13.13 | 25.44 | 0.52 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 900 | 9 | 0.9 | 39.60 | 13.07 | 25.20 | 0.52 |
| 920 | 9.2 | 0.92 | 39.40 | 13.00 | 24.96 | 0.52 |
| 940 | 9.4 | 0.94 | 39.20 | 12.94 | 24.72 | 0.52 |
| 960 | 9.6 | 0.96 | 39.20 | 12.94 | 24.48 | 0.53 |
| 980 | 9.8 | 0.98 | 39.00 | 12.87 | 24.24 | 0.53 |
| 1000 | 10 | 1 | 39.10 | 12.90 | 24.00 | 0.54 |
| 1020 | 10.2 | 1.02 | 39.00 | 12.87 | 23.76 | 0.54 |
| 1040 | 10.4 | 1.04 | 39.00 | 12.87 | 23.52 | 0.55 |
| 1060 | 10.6 | 1.06 | 39.00 | 12.87 | 23.28 | 0.55 |
| 1080 | 10.8 | 1.08 | 39.10 | 12.90 | 23.04 | 0.56 |
| 1100 | 11 | 1.1 | 39.00 | 12.87 | 22.80 | 0.56 |
| 1120 | 11.2 | 1.12 | 38.90 | 12.84 | 22.56 | 0.57 |
| 1140 | 11.4 | 1.14 | 38.90 | 12.84 | 22.32 | 0.58 |
| 1160 | 11.6 | 1.16 | 38.90 | 12.84 | 22.08 | 0.58 |
| 1180 | 11.8 | 1.18 | 38.20 | 12.61 | 21.84 | 0.58 |
| 1200 | 12 | 1.2 | 38.10 | 12.57 | 21.60 | 0.58 |
| 1220 | 12.2 | 1.22 | 38.00 | 12.54 | 21.36 | 0.59 |

**Table:F15** Direct Shear Test Readings for ( Soil +5 % cement + 1.5 $kg/m^3$ ZB) at 1.5 $kg/cm^2$

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| | | | | | | |
| 0 | 0 | 0 | 0.00 | 0.00 | 36.00 | 0.00 |
| 20 | 0.2 | 0.02 | 15.00 | 4.95 | 35.76 | 0.14 |
| 40 | 0.4 | 0.04 | 22.20 | 7.33 | 35.52 | 0.21 |
| 60 | 0.6 | 0.06 | 29.80 | 9.83 | 35.28 | 0.28 |
| 80 | 0.8 | 0.08 | 35.40 | 11.68 | 35.04 | 0.33 |
| 100 | 1 | 0.1 | 39.80 | 13.13 | 34.80 | 0.38 |
| 120 | 1.2 | 0.12 | 42.60 | 14.06 | 34.56 | 0.41 |
| 140 | 1.4 | 0.14 | 51.80 | 17.09 | 34.32 | 0.50 |
| 160 | 1.6 | 0.16 | 53.00 | 17.49 | 34.08 | 0.51 |
| 180 | 1.8 | 0.18 | 54.40 | 17.95 | 33.84 | 0.53 |
| 200 | 2 | 0.2 | 54.80 | 18.08 | 33.60 | 0.54 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 220 | 2.2 | 0.22 | 56.20 | 18.55 | 33.36 | 0.56 |
| 240 | 2.4 | 0.24 | 56.60 | 18.68 | 33.12 | 0.56 |
| 260 | 2.6 | 0.26 | 57.00 | 18.81 | 32.88 | 0.57 |
| 280 | 2.8 | 0.28 | 57.40 | 18.94 | 32.64 | 0.58 |
| 300 | 3 | 0.3 | 58.00 | 19.14 | 32.40 | 0.59 |
| 320 | 3.2 | 0.32 | 58.40 | 19.27 | 32.16 | 0.60 |
| 340 | 3.4 | 0.34 | 59.60 | 19.67 | 31.92 | 0.62 |
| 360 | 3.6 | 0.36 | 60.20 | 19.87 | 31.68 | 0.63 |
| 380 | 3.8 | 0.38 | 61.20 | 20.20 | 31.44 | 0.64 |
| 400 | 4 | 0.4 | 62.00 | 20.46 | 31.20 | 0.66 |
| 420 | 4.2 | 0.42 | 62.20 | 20.53 | 30.96 | 0.66 |
| 440 | 4.4 | 0.44 | 63.00 | 20.79 | 30.72 | 0.68 |
| 460 | 4.6 | 0.46 | 63.00 | 20.79 | 30.48 | 0.68 |
| 480 | 4.8 | 0.48 | 63.20 | 20.86 | 30.24 | 0.69 |
| 500 | 5 | 0.5 | 63.60 | 20.99 | 30.00 | 0.70 |
| 520 | 5.2 | 0.52 | 64.60 | 21.32 | 29.76 | 0.72 |
| 540 | 5.4 | 0.54 | 64.80 | 21.38 | 29.52 | 0.72 |
| 560 | 5.6 | 0.56 | 65.30 | 21.55 | 29.28 | 0.74 |
| 580 | 5.8 | 0.58 | 65.60 | 21.65 | 29.04 | 0.75 |
| 600 | 6 | 0.6 | 65.80 | 21.71 | 28.80 | 0.75 |
| 620 | 6.2 | 0.62 | 66.00 | 21.78 | 28.56 | 0.76 |
| 640 | 6.4 | 0.64 | 66.20 | 21.85 | 28.32 | 0.77 |
| 660 | 6.6 | 0.66 | 66.50 | 21.95 | 28.08 | 0.78 |
| 680 | 6.8 | 0.68 | 66.60 | 21.98 | 27.84 | 0.79 |
| 700 | 7 | 0.7 | 66.60 | 21.98 | 27.60 | 0.80 |
| 720 | 7.2 | 0.72 | 66.60 | 21.98 | 27.36 | 0.80 |
| 740 | 7.4 | 0.74 | 66.60 | 21.98 | 27.12 | 0.81 |
| 760 | 7.6 | 0.76 | 66.50 | 21.95 | 26.88 | 0.82 |
| 780 | 7.8 | 0.78 | 66.40 | 21.91 | 26.64 | 0.82 |
| 800 | 8 | 0.8 | 66.30 | 21.88 | 26.40 | 0.83 |
| 820 | 8.2 | 0.82 | 66.30 | 21.88 | 26.16 | 0.84 |
| 840 | 8.4 | 0.84 | 66.20 | 21.85 | 25.92 | 0.84 |
| 860 | 8.6 | 0.86 | 66.20 | 21.85 | 25.68 | 0.85 |
| 880 | 8.8 | 0.88 | 66.00 | 21.78 | 25.44 | 0.86 |
| 900 | 9 | 0.9 | 66.00 | 21.78 | 25.20 | 0.86 |
| 920 | 9.2 | 0.92 | 66.00 | 21.78 | 24.96 | 0.87 |
| 940 | 9.4 | 0.94 | 65.80 | 21.71 | 24.72 | 0.88 |
| 960 | 9.6 | 0.96 | 65.70 | 21.68 | 24.48 | 0.89 |

| Dial Gauge Reading (D) (div) | Horizontal Displacement (0.01 mm/div*D) | | Stress Dial Reading (div) | Shear Force (0.33*stress dial reading) (kg) | Corrected Area ($cm^2$) | Shear Stress ($kg/cm^2$) |
|---|---|---|---|---|---|---|
| | mm | cm | | | | |
| 980 | 9.8 | 0.98 | 65.60 | 21.65 | 24.24 | 0.89 |
| 1000 | 10 | 1 | 65.50 | 21.62 | 24.00 | 0.90 |
| 1020 | 10.2 | 1.02 | 65.40 | 21.58 | 23.76 | 0.91 |
| 1040 | 10.4 | 1.04 | 65.40 | 21.58 | 23.52 | 0.92 |
| 1060 | 10.6 | 1.06 | 65.20 | 21.52 | 23.28 | 0.92 |
| 1080 | 10.8 | 1.08 | 65.20 | 21.52 | 23.04 | 0.93 |
| 1100 | 11 | 1.1 | 65.00 | 21.45 | 22.80 | 0.94 |
| 1120 | 11.2 | 1.12 | 64.80 | 21.38 | 22.56 | 0.95 |
| 1140 | 11.4 | 1.14 | 64.50 | 21.29 | 22.32 | 0.95 |
| 1160 | 11.6 | 1.16 | 64.00 | 21.12 | 22.08 | 0.96 |
| 1180 | 11.8 | 1.18 | 64.00 | 21.12 | 21.84 | 0.97 |
| 1200 | 12 | 1.2 | 63.80 | 21.05 | 21.60 | 0.97 |
| 1220 | 12.2 | 1.22 | 63.60 | 20.99 | 21.36 | 0.98 |